THE CITY OF SAN DIEGO

Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (South Bay Water Reclamation Plant) 2003

Ocean Monitoring Program

Metropolitan Wastewater Department

Environmental Monitoring and Technical Services Division

July 2004

July 1, 2004

THE CITY OF SAN DIEGO

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 2003 Annual Receiving Waters Monitoring Report for NPDES Permit No. CA0109045, Order No. 2000-129, for the City of San Diego South Bay Water Reclamation Plant (SBWRP) discharge to the Pacific Ocean 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

dp

Enclosure

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

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2003

Prepared by:

The City of San Diego

Metropolitan Wastewater Department

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Executive Summary

Environmental Monitoring and Technical Services Laboratory
2392 Kincaid Road, San Diego, California

Executive Summary

The ocean monitoring program for the South Bay Ocean Outfall is conducted by the City of San Diego in accordance with requirements mandated by National Pollutant Discharge Elimination System (NPDES) permits for the International Wastewater Treatment Plant (Order No. 96-50, NPDES Permit No. CA0108928) and the South Bay Water Reclamation Plant (Order No. 2000-129, NPDES Permit No. CA0109045). These documents specify the terms and conditions that allow treated effluent to be discharged into the Pacific Ocean via the South Bay Ocean Outfall (SBOO). In addition, the Monitoring and Reporting Programs contained within the above permits define the requirements for monitoring the receiving waters environment surrounding the SBOO, including the sampling plan, compliance criteria, laboratory analyses, statistical analyses and reporting guidelines.

The South Bay monitoring program is designed to assess the impact of wastewater discharged through the SBOO on the marine environment off southern San Diego. The main objectives of the program are to provide data that satisfy the requirements of the NPDES permits, demonstrate compliance with the 2001 California Ocean Plan, track movement and dispersion of the wastewater field, and identify any biological or chemical changes that may be associated with the discharge of wastewater. These data are used to document the effects of the discharge on water quality, sediment conditions, and the marine biota. The study area is centered around the SBOO discharge site, which is located approximately 5.6 km offshore at a depth of about 27 m. Shoreline monitoring extends from Coronado southward to Playa Blanca, Mexico. Offshore monitoring is conducted in an adjacent area overlying the coastal shelf at sites ranging in depth from about nine to 55 m.

Prior to the initiation of wastewater discharge in January 1999, the City conducted a 3½-year baseline study designed to characterize background environmental conditions in the South Bay region and to provide information against which post-discharge data may be compared. In addition, each year a region-wide survey of benthic conditions is conducted at randomly selected sites off San Diego as part of the above NPDES permits. These surveys typically cover an area from about Del Mar to the U.S./Mexico border. Such regional studies help to evaluate patterns and trends over a broader geographic area, thus providing additional information to help distinguish sites impacted by anthropogenic influences from reference areas.

The receiving waters monitoring efforts for the South Bay region may be divided into several major components, each comprising a separate chapter of this report. These include analyses of oceanographic conditions, microbiology, sediment quality, benthic infauna, demersal fish and invertebrate communities, and the concentrations of contaminants in fish tissues. Data regarding various physical and chemical oceanographic parameters are evaluated to characterize water mass transport potential in the region. The microbiology portion of the program includes sampling at sites along the shoreline and in the adjacent offshore waters to detect and monitor various indicators of the wastewater plume. Benthic monitoring includes sampling and analyses of soft-bottom macrofaunal communities and their associated sediments, while demersal fish and megabenthic invertebrate communities are the focus of trawling activities. The monitoring of fish populations is supplemented by tissue burden analyses to determine whether contaminants are present in the tissues of “local” fish species. In addition to the above activities, other projects relevant to assessing ocean quality in the region are addressed. For example, results from the coastal remote sensing study of the San Diego/Tijuana region that is jointly funded by the City, the San Diego Regional Water Quality Control Board, and the International Boundary and

Water Commission have been incorporated into the interpretations of data from the oceanographic and microbiological surveys.

The present report focuses on the results of all sampling and analyses conducted in the South Bay region during calendar year 2003. An overview and summary of the main findings for each of the receiving waters monitoring components are included below. However, the 2003 survey of randomly selected benthic stations comprised part of the broader Southern California Bight Regional Monitoring Program (i.e., Bight'03), which involved numerous other agencies. The data from the Bight'03 project are not yet available and are therefore not included herein. These data are scheduled to be reported separately in 2006.

OCEANOGRAPHIC CONDITIONS

Oceanographic conditions in the South Bay region deviated only slightly from expected seasonal patterns in 2003. Conditions were relatively normal during January and February as indicated by a well-mixed water column with little depth-related variability in any physical parameter. Although bottom waters cooled rapidly prior to March as expected, surface temperatures remained low until June in contrast to patterns seen in previous years. Warming of the surface waters led to the establishment of a strong thermocline in July, which then weakened in August after the prevailing winds shifted from south/southwest to west. Thermal stratification remained weaker than normal throughout the fall months before breaking down in November. The late summer/early fall shift in wind direction likely spurred upwelling that in turn, fed extensive phytoplankton blooms throughout the months of August, September and October. Overall, water clarity (i.e., transmissivity) was generally diminished in the nearshore waters during 2003. Annual rainfall was double that of the previous year, and included one of the wettest Februarys on record. However, the effect of the rain events on nearshore transmissivity was inconsistent. As in years past, transmissivity did not appear strongly influenced by chlorophyll *a* concentrations except during September and October. At these times widespread red tide blooms led to increased chlorophyll *a* concentrations and depressed transmissivity values. In general, the patterns of lowered transmissivity in nearshore waters during 2003 overwhelmed the effects that are usually apparent from the Tijuana River. How much of the reduced water clarity was due to terrigenous input versus resuspended sediments or phytoplankton blooms was uncertain. Overall, data for the region's water column properties revealed little evidence of impact from the SBOO.

MICROBIOLOGY

The distribution of bacterial indicators in the SBOO region in 2003 was generally similar to that seen in previous years. These patterns appeared strongly influenced by seasonal oceanographic conditions, runoff from land-based and riverine sources, wastewater discharge, and other anthropogenic inputs. Nearshore water quality conditions in the South Bay appeared to be influenced by above average rainfall during the months of February and April. As a result, overall compliance with COP standards was slightly lower at the shore and kelp bed stations in 2003. For the most part, bacterial exceedences appeared related to contamination from shore-based discharges that occurred during and after storm events rather than from wastewater discharge via the outfall. In addition, data from the offshore monitoring sites suggested that the wastewater plume was confined below a stratified water column for most of the year, and then dispersed rapidly when transported laterally. Elevated bacterial counts were evident near the surface only during January and February when the water column was well mixed. Remote sensing observations during the year suggested a predominantly southward flow of the surface waters (i.e. 0–15 m) and a southwesterly movement of the wastewater plume. Concentrations of bacterial indicators from monthly sampling events indicated the presence of the wastewater plume at depths of 18 m and below, and predominantly offshore and northward of the discharge site. Overall, there was no evidence that any of the elevated bacterial counts detected near the shore in 2003 resulted from shoreward transport of the SBOO wastewater plume. Instead, the distribution and frequency of high bacterial counts at shore and nearshore stations appeared correlated with inputs from the Tijuana River and southward, particularly during the rainy season.

SEDIMENT QUALITY

The composition and quality of ocean sediments in the South Bay area were similar in 2003 to those observed during previous years. The sediments at most sites were dominated by fine sands with grain size tending to increase with depth. Stations located offshore and southward of the SBOO consisted of very coarse sediments, while sites located in shallower water and north of the outfall towards the mouth of San Diego Bay had finer sediments. Overall, there were fewer differences in particle size composition between surveys and sites than in years past. Spatial differences in sediment composition can be partly attributed to patches of sediments associated with different origins (e.g., relict red sands, other detrital material). For example, the deposition of sediments from the Tijuana River and to a lesser extent from San Diego Bay probably contributes to the higher content of silt at nearby stations.

Anthropogenic influences on sediment quality were not evident from this monitoring. Concentrations of several organic indicators (i.e., total organic carbon, total nitrogen, sulfides) and various trace metals were generally low in SBOO sediments compared to other coastal areas off southern California. Similar to other studies, the highest organic indicator and metal concentrations were associated with finer sediments. Other contaminants (e.g., pesticides) were detected infrequently in the region, which is similar to the results from 2002. For example, derivatives of the pesticide DDT were found in the sediments at only two sites in 2003. Pesticides were known to occur at these sites prior to construction of the outfall, and their presence in the sediments does not appear to be related to the SBOO. PAH compounds were detected in very low concentrations at only two sites and were unlikely to be related to wastewater discharge. PCBs were not detected at any station during 2003.

MACROBENTHIC INVERTEBRATE COMMUNITIES

Benthic communities in the SBOO region included macrofaunal assemblages that varied along gradients of sediment structure (e.g., grain size) and depth (e.g., shallow vs. mid-depth waters). During 2003, assemblages surrounding the SBOO were similar to those that occurred during previous years. Most sites were dominated by the spionid polychaete *Spiophanes bombyx*, a species characteristic of other shallow-water assemblages in the Southern California Bight. Another type of assemblage occurred in slightly deeper waters north of the outfall, at sites where the sediments contained finer particles. This assemblage was dominated by the ophiuroid *Amphiodia urtica*, and the polychaetes *Chloeia pinnata*, *Myriochele gracilis*, *Aricidea* (*acmira*) *simplex*, and *Sthenelanella uniformis*, and probably represents a transition between assemblages occurring in shallow sandy habitats and those occurring in finer mid-depth sediments off southern California. Finally, sites with sediments composed of relict red sands were also characterized by unique assemblages.

Patterns of species richness and abundance also varied with depth and sediment type in the region, although there were no clear patterns with respect to the SBOO. The range of values for most community parameters in 2003 was similar to that seen in previous years. In addition, values of environmental disturbance indices such as the benthic response index (BRI) and infaunal trophic index (ITI) were characteristic of undisturbed sediments. Finally, changes in benthic community structure near the SBOO that occurred in 2003 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, benthic assemblages in the region remain similar to those observed prior to discharge and to natural indigenous communities characteristic of similar habitats on the southern California continental shelf. The data from present monitoring efforts provide no evidence that the SBOO wastewater discharge has caused any significant degradation of the benthos in the area.

DEMERSAL FISH AND MEGABENTHIC INVERTEBRATE COMMUNITIES

Speckled sanddabs dominated fish assemblages surrounding the SBOO in 2003. The overall dominance of this species was similar to that seen in previous years, although the total catch has increased over the past several years. These fish occurred at all stations and accounted for 84% of the total catch and was the only species collected in every trawl. Such results are expected because the shallow depths and coarse sediments in the area represent the typical habitat for this species. Other characteristic, but less abundant, species included the California lizardfish, roughback sculpin, hornyhead turbot, English sole and California halibut. Most of these common fishes were relatively small, averaging less than 17 cm in length. Larger species included California skate, thornback, round stingray, shovelnose guitarfish, speckledfin midshipman, and barred sand bass.

As in previous years, the composition and structure of fish assemblages varied among stations. Differences in the total fish catch per haul were primarily due to variations in speckled sanddab populations. Although megabenthic community structure also varied between sites, these assemblages were generally characterized by low species richness, abundance, biomass and diversity.

Overall, results of trawl surveys conducted in 2003 provide no evidence that the discharge of wastewater has affected either fish or megabenthic invertebrate communities in the region. Although highly variable, patterns in the abundance, biomass and number of species for these communities were similar at stations located near the outfall and further away. In addition, no changes in these communities have been found to occur near the outfall that correspond to the initiation of the discharge. Finally, the absence of physical abnormalities on local fishes suggests that their populations remain healthy in the region.

TISSUE CONTAMINANTS IN FISHES

There were no clear spatial patterns among the SBOO trawl or rig fishing stations in terms of fish tissue contaminants in 2003, and there was no evidence to suggest that tissue contaminant loads were affected by the discharge of wastewater from the SBOO. Although various contaminants were detected in both liver and muscle tissues, concentrations were generally within ranges reported previously for fishes in the Southern California Bight. In addition, concentrations of most contaminants were not substantially different from those reported prior to discharge. Finally, samples of muscle tissues from sport fish collected in the area were found to be within FDA human consumption limits for both mercury and DDT.

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 accumulation and distribution of contaminants include the physiology and life history of different fish 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 that may contribute to contamination in the region.

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General Introduction

Chapter 1
General Introduction

The South Bay Ocean Outfall (SBOO) accepts treated effluent from two sources: the International Boundary and Water Commission International Wastewater Treatment Plant (IWTP), and the City of San Diego South Bay Water Reclamation Plant (SBWRP). Discharge from the IWTP began on January 13, 1999 and is performed under the terms and conditions set forth in Order No. 96–50, National Pollutant Discharge Elimination System (NPDES) Permit No. CA0108928 and Cease and Desist Order No. 96–52. Discharge from the SBWRP began on May 6, 2002 and is performed under NPDES Permit No. CA0109045, Order No. 2000–129. These NPDES permits define the requirements for monitoring receiving waters around the SBOO, including the sampling plan, compliance criteria, laboratory analyses, statistical analyses and reporting guidelines.

Receiving waters monitoring for the South Bay region with respect to the above referenced permits is performed by the City of San Diego. Prior to the initiation of discharge through the SBOO, the City conducted a 3½-year baseline monitoring program in order to characterize background environmental conditions surrounding the discharge site (City of San Diego 2000a). The results of this baseline study provide background information against which the post-discharge data may be compared. In addition, the City has conducted annual region-wide surveys off the coast of San Diego since 1994 (see City of San Diego 1999, 2000b, 2001). Such regional 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 discharge, stormwater input or other sources of contamination.

Finally, the City of San Diego, the United States International Boundary and Water Commission, and the San Diego Regional Water Quality Control Board have also contracted with Ocean Imaging Corporation (Solana Beach, CA) to conduct an aerial/satellite 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 produces a synoptic look at surface water clarity that is not possible using shipboard sampling alone. The major limitation of aerial and satellite images, however, is that they only provide information about surface waters (~0–15 m) without providing any direct information regarding the movements, color, or clarity of waters in deeper layers. In spite of these limitations, one objective of this multi-year project is to ascertain relationships between the various types of imagery data and field-collected data. With public health issues a paramount concern of ocean monitoring programs, any information that helps to provide a clearer and more complete picture of water conditions is of benefit 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 diagnosis of possible contamination conditions and add predictability to the impact that different oceanographic conditions events such as heavy rains have on shoreline water quality.

This report presents the results of monitoring conducted at fixed sites around the SBOO from January through December 2003. Results of the 2003 aerial/satellite remote sensing surveys have also been considered and integrated into the interpretations of oceanographic and water quality (e.g., microbiological, total suspended solids, oil and grease) data. Comparisons are also made to conditions during previous years in order to assess any outfall related changes that may have occurred (see City of San Diego 2000a, b, 2001, 2002, 2003). Each major component of the monitoring program is covered in a separate chapter: Oceanographic Conditions, Water Quality, Sediment Characteristics, Macrobenthic Communities, Demersal Fishes and Megabenthic Invertebrates, and Bioaccumulation of Contaminants in Fish Tissues. Detailed information concerning station locations, sampling equipment, analytical techniques and quality assurance procedures are included in the Quality Assurance Manual for the City's Ocean Monitoring Program (City of San Diego 2004). General and more specific details of these monitoring programs and sampling designs are given below and in subsequent chapters and appendices.

SBOO MONITORING

The South Bay Ocean Outfall is located just north of the border between the United States and Mexico. It terminates approximately 5.6 km offshore at a depth of about 27 m. Unlike other southern California outfalls that are located on the surface of the seabed, the SBOO pipeline begins as a tunnel on land and then continues under the seabed to a distance of 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 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 designed to discharge and disperse effluent via a total of 165 diffuser risers. These include one riser located at the center of the outfall diffusers and 82 others spaced along each of the diffuser legs. However, low flow during the first several years of operation required closure of all ports along the northern outfall leg as well as many of those along the southern outfall leg. These closures are necessary to maintain sufficient back pressure within the drop shaft so that the outfall can operate in accordance with the theoretical model. Consequently, discharge during 2003 and previous years has been generally limited to the distal end of the southern outfall leg, with the exception of a few intermediate points at or near the center of the diffusers.

The regular SBOO sampling area extends from the tip of Point Loma southward to Playa Blanca, Mexico, and from the shoreline seaward to a depth of about 61 m. The offshore monitoring sites are arranged in a grid spanning the terminus of the outfall, and are 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. Additionally, analyses of fish tissues are performed semiannually to monitor levels of chemical constituents that may have ecological or human health implications.

RANDOM SAMPLE REGIONAL SURVEYS

The City of San Diego has conducted summer surveys of benthic sediment conditions and macrofaunal organisms throughout the San Diego region since 1994 in order to evaluate patterns and trends over a large geographic area. Such region-wide monitoring is designed not only to assess the quality and characteristics of sediments, but to provide additional information that may help to identify and distinguish reference areas from sites impacted by wastewater and stormwater discharge. These annual surveys are based on an array of stations randomly selected each year by the United States Environmental Protection Agency (USEPA) using the USEPA probability-based EMAP design. Surveys conducted in 1994, 1998, and 2003 involved other major southern California dischargers, were broad in scope, and included sampling sites representing the entire Southern California Bight (i.e., Cabo Colnett, Mexico to Point Conception, U.S.A.). Surveys limited to the San Diego region were conducted in 1995–1997 and 1999–2002 and have been previously reported (City of San Diego 1999, 2000b, 2001, 2002, 2003). Results of the 1994 and 1998 benthic surveys are available in Bergen et al. (1998, 2001), Noblet et al. (2002), and Ranasinghe et al. (2003). Results of the Bight'03 survey are not yet available.

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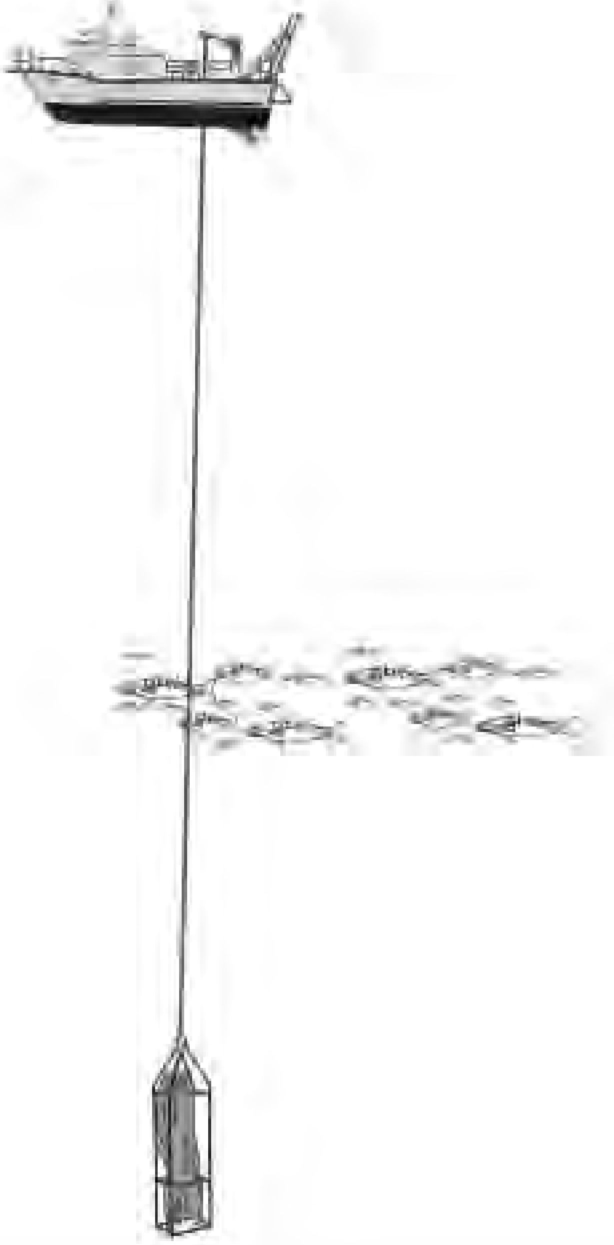
Oceanographic Conditions



Chapter 2
Oceanographic Conditions

INTRODUCTION

Measurements of physical and chemical parameters such as temperature, salinity, density, and dissolved oxygen are important components of a discharge monitoring program because many of these properties determine water column mixing potential. Analysis of temporal and spatial variability of these parameters can also elucidate water mass movement. Consequently, these measurements can help determine (1) deviations from expected patterns that may indicate influence of a wastewater plume, and (2) the extent to which water mass movement or mixing reflects the dispersion/dilution potential for discharged material. With a deep offshore discharge, the fate of treated municipal wastewater is strongly determined by horizontal mixing through diffusion and currents as well as vertical mixing through diffusion, upwelling, or storm events. For example, oceanographic properties of the water column, such as stratification, can influence the degree of vertical dispersion of the wastewater plume. Therefore, these measurements of physical parameters, together with bacterial concentrations (see Chapter 3), provide useful insight into the transport potential surrounding the South Bay Ocean Outfall (SBOO) throughout the year.

To assess possible impacts from the outfall discharge, the City of San Diego regularly monitors oceanographic conditions of the water column. Water quality in the South Bay region is naturally variable but is also subject to various anthropogenic and natural sources of contamination such as discharge from the SBOO, San Diego Bay and the Tijuana River. This chapter contributes to the investigation of SBOO impacts on the marine environment by analyzing the oceanographic conditions that occurred during 2003. Analysis and interpretation of water column conditions can then help to explain patterns of bacteriological occurrence (discussed in Chapter 3).

MATERIALS and METHODS

Field Sampling

Oceanographic measurements were collected by lowering a SeaBird conductivity, temperature and depth (CTD) instrument through the water column at fixed offshore sampling sites regularly throughout the year (**Figure 2.1**) Values for temperature, salinity, density, pH, transmissivity (water clarity), chlorophyll *a*, and dissolved oxygen were recorded at 40 stations at least once per month over a 3–5 day period. The stations form a grid encompassing an area of approximately 450 km^2 and were generally situated along 9, 18, 27, and 55-m depth contours. Thirty-seven stations are located in open-water from 3.4 km to14.6 km offshore. Three of these stations (I25, I26, and I39) are considered kelp bed stations subject to the COP water contact standards. These stations were sampled for bacterial analysis an additional four times each month in accordance with NPDES permit requirements. The three kelp stations were selected for their proximity to suitable substrates for the Imperial Beach kelp bed; however, this kelp bed has been historically transient and inconsistent in terms of size and density (North 1991, North et al. 1993). Thus, these three stations are only occasionally located within an area where kelp is actually found.

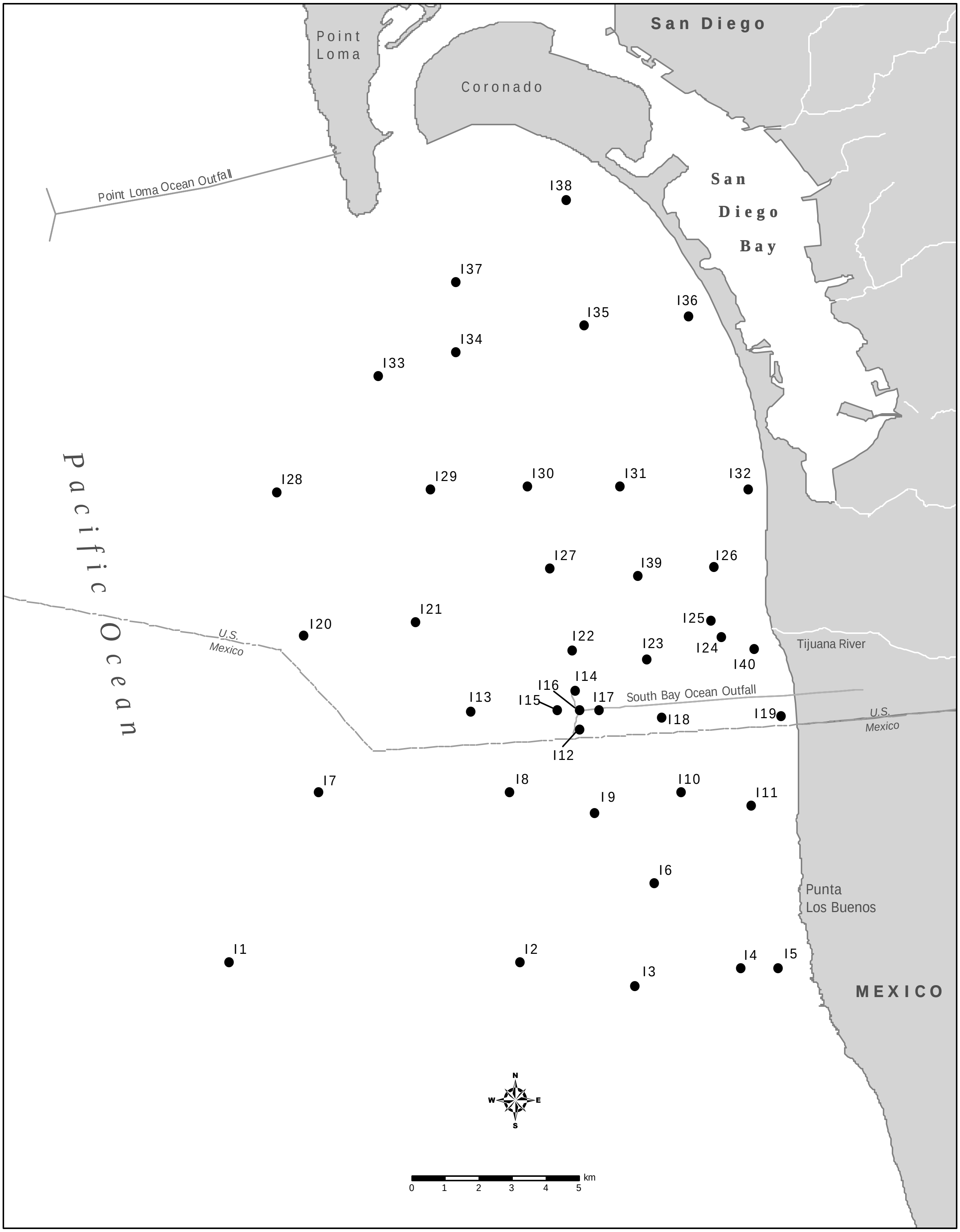


Figure 2.1

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

Profiles of each parameter were constructed for each station by averaging the values recorded over 1-m depth intervals during processing. This ensured that physical measurements used in subsequent data analyses corresponded with bacterial sampling depths. Further details regarding the CTD data processing are provided in the City's Quality Assurance Manual (City of San Diego 2004). To meet the California Ocean Plan sampling frequency requirements for kelp bed areas, CTD casts were conducted at the kelp stations an additional four times each month. Visual observations of weather and water conditions were recorded prior to each CTD sampling event.

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

RESULTS and DISCUSSION

Expected Seasonal Patterns of Physical and Chemical Parameters

Southern California weather can be classified into two basic "seasons", wet (winter) and dry (spring through fall), and certain patterns in oceanographic conditions track these "seasons." In the wet winters, water temperatures are cold and the water column is well-mixed resulting in similar properties in surface and deeper waters. In contrast, dry summer weather warms the surface waters and introduces thermally-sustained stratification. Despite a sampling schedule that limits oceanographers to snapshots in time spread out over several days during each month, analyses of oceanographic data collected from the South Bay region over the past nine years support this pattern.

Each year, typical winter conditions are present in January and February. A high degree of homogeneity within the water column is the normal winter signature for all physical parameters, although stormwater runoff may intermittently influence the density profile by causing a freshwater lens within nearshore surface waters. With little, if any, stratification of the water column, the chance that the wastewater plume may surface is highest during these winter months.

Winter conditions often extend into March, when a decrease in the frequency of winter storms brings about the transition of seasons. The increasing elevation of the sun and lengthening southern California days begin to warm the surface waters and cause the return of a seasonal thermocline and pycnocline to coastal and offshore waters. Once stratification is established by late spring, minimal mixing conditions tend to remain throughout the summer. In October or November, cooler weather, reduced solar input, and increased stormy weather cause the return of the well-mixed, homogeneous water column characteristic of winter months.

Observed Seasonal Patterns of Physical and Chemical Parameters

Temperature is the main contributor to stratification in southern California waters (Dailey et. al. 1993) and provides the best indication of discharge plume surfacing potential. During 2003, thermal stratification of the water column deviated from the expected seasonal pattern during the spring but followed normal trends during other months (**Figure 2.2**). Thermal stratification was minimal or absent from January through March with differences between average surface and bottom temperatures consistently less than 2°C. Accordingly, temperature values varied little during these winter months: surface waters (above 2m) ranged between 14.2 and 16.5°C, while the cooler bottom waters (below 27 m) ranged between 10.9 and 15.2°C. The absence of a stratified water column is the likely reason that plume-influenced waters were visually detected in surface waters during aerial overflights conducted from January though mid-March (Ocean Imaging 2003a, b).

Although gradual surface water warming began in March, surface water temperatures from March through June were 2–3°C lower than normal (NOAA/NWS 2004). Stratification during these spring months was mostly due to bottom water cooling and a halocline/pycnocline that developed following substantial freshwater input during February and April rains (**Figure 2.3**). Typical summer surface water temperatures and strong thermal stratification did not appear until July, when surface water temperatures, and therefore, water column stability peaked at an average 19.3°C. Bottom water temperatures remained fairly constant (between 10.4 and 10.5°C) throughout the spring, summer and fall months following a rapid cooling in March. Unlike the temperature stability seen in bottom waters, surface waters exhibited typical summer and fall variability.

In August, the average surface water temperature was 2°C lower than July's high (Figure 2.2). This late summer/early fall dip in surface water temperatures was likely due to a shift in the overall wind pattern. For most of the year, winds were south/southwesterly, but during August and September winds consistently blew west/northwesterly. This shift in wind direction may have influenced August surface temperatures by enhancing upwelling or by allowing a surface intrusion of arctic-influenced California Current waters.

Although slightly warmer surface temperatures returned during September, thermal stratification never reached the strength, coherence or shallowness of the 2002 thermocline (City of San Diego 2003). The depth of the thermocline from May through October averaged 5–15m. As mixing increased in the fall, the bottom waters warmed noticeably and thermal stratification began to break down. By December, bottom temperatures reached an average of 13.7°C and had returned to within 2°C of the surface water temperatures.

These temperature conditions are apparent in single-station profiles and all-station volumetric interpolations of data collected during January, July, and October (**Figures 2.4–2.6**). The density and dissolved oxygen plots corroborate the seasonal patterns of water column stratification and mixing that were apparent from temperature data. The thoroughly mixed and homogeneous water column present January through March is represented by the January plots (Figure 2.4). The transition to shallow, thermal-driven stratification began in June, and was at its strongest during July (Figure 2.5). By October, stratification had weakened from the mid-summer highs (Figure 2.6). Finally, in November and December, stratification disappeared and the water column returned to a thoroughly mixed state similar to that found the previous January.

Seasonal patterns of parameter changes are also apparent in differences between mean values for surface and bottom waters (**Table 2.1**). Average differences between surface and bottom waters for temperature and density values occured during the summer months (June–September). In contrast, differences in salinity values were greatest in spring (March–May). Extreme values for the remaining parameters (dissolved oxygen, pH,

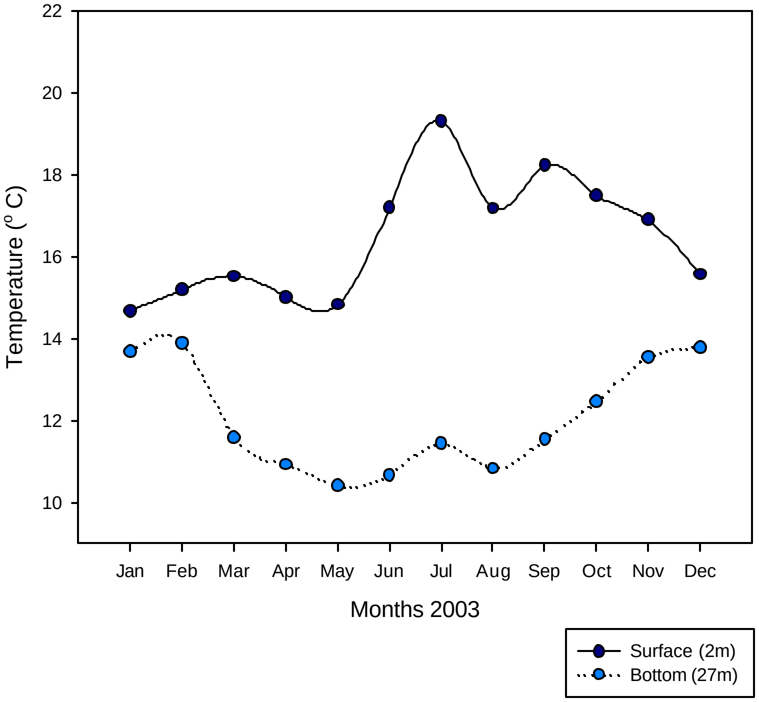


Figure 2.2

Monthly average temperatures for surface (≤2m) and bottom (≥27m) waters during 2003.

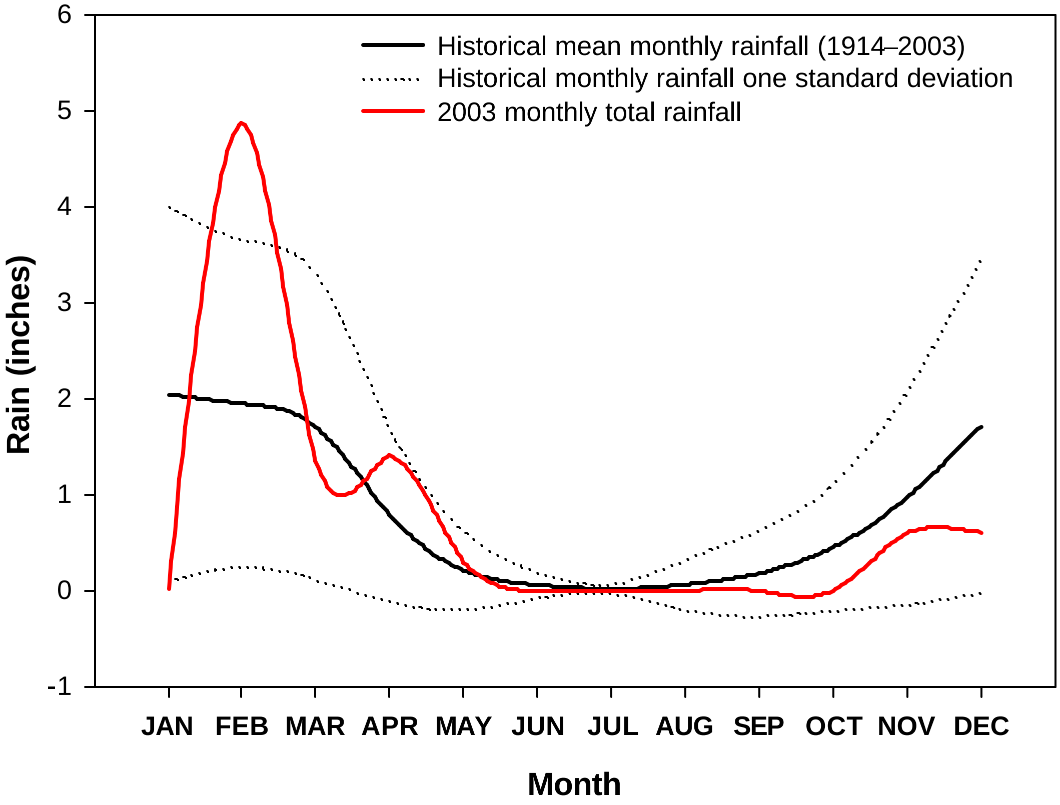


Figure 2.3

Total monthly rainfall at Lindbergh Field (San Diego, CA) for 2003 compared to monthly average rainfall for the historical period 1914 through 2003.

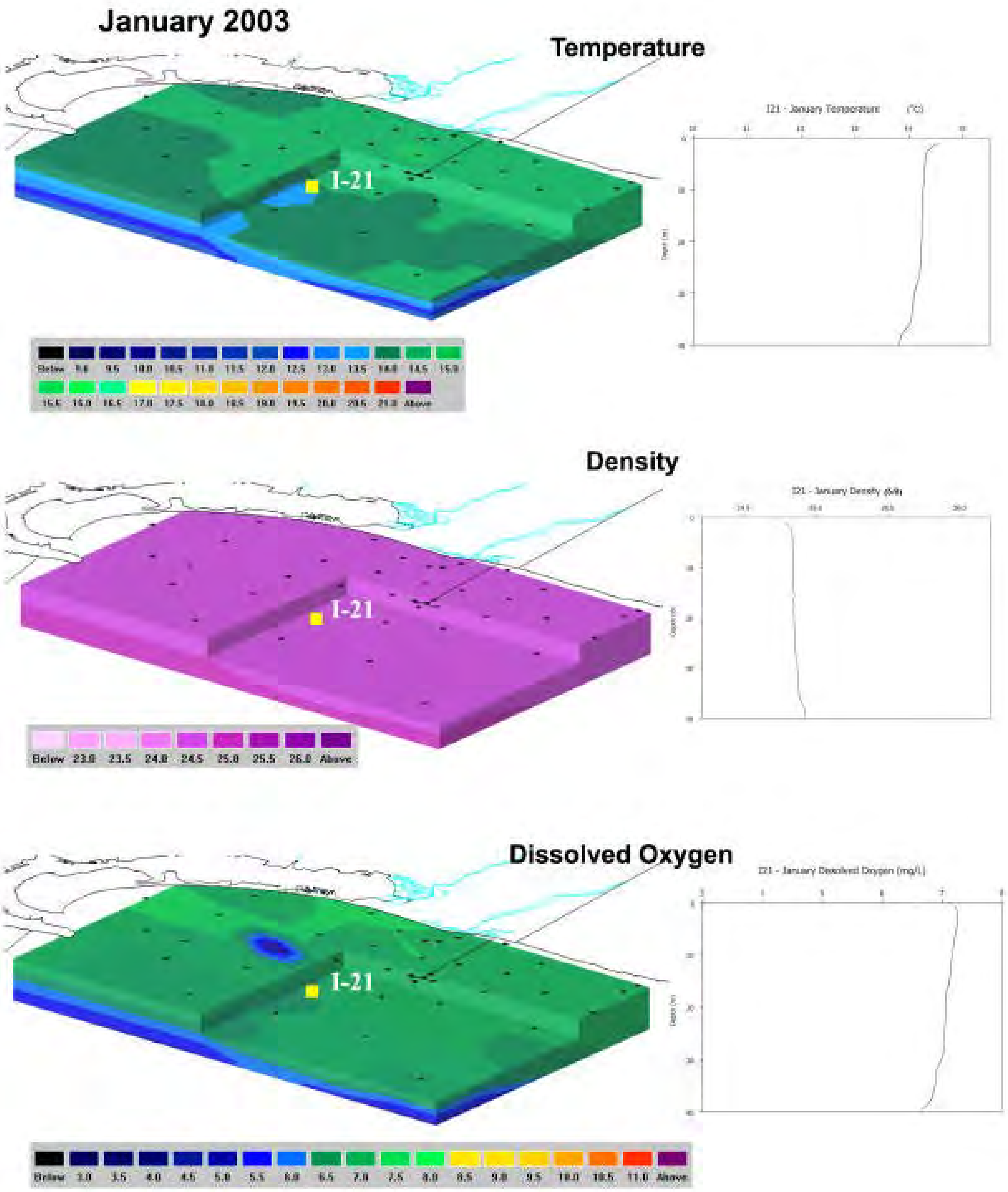


Figure 2.4

Interpolated volumetric (3D) plots of temperature, density (*/2), and dissolved oxygen at stations surrounding the SBOO on January 6, 7, and 8, 2003. Accompanying profiles illustrate these same parameters for offshore station I21 on January 8, 2003.

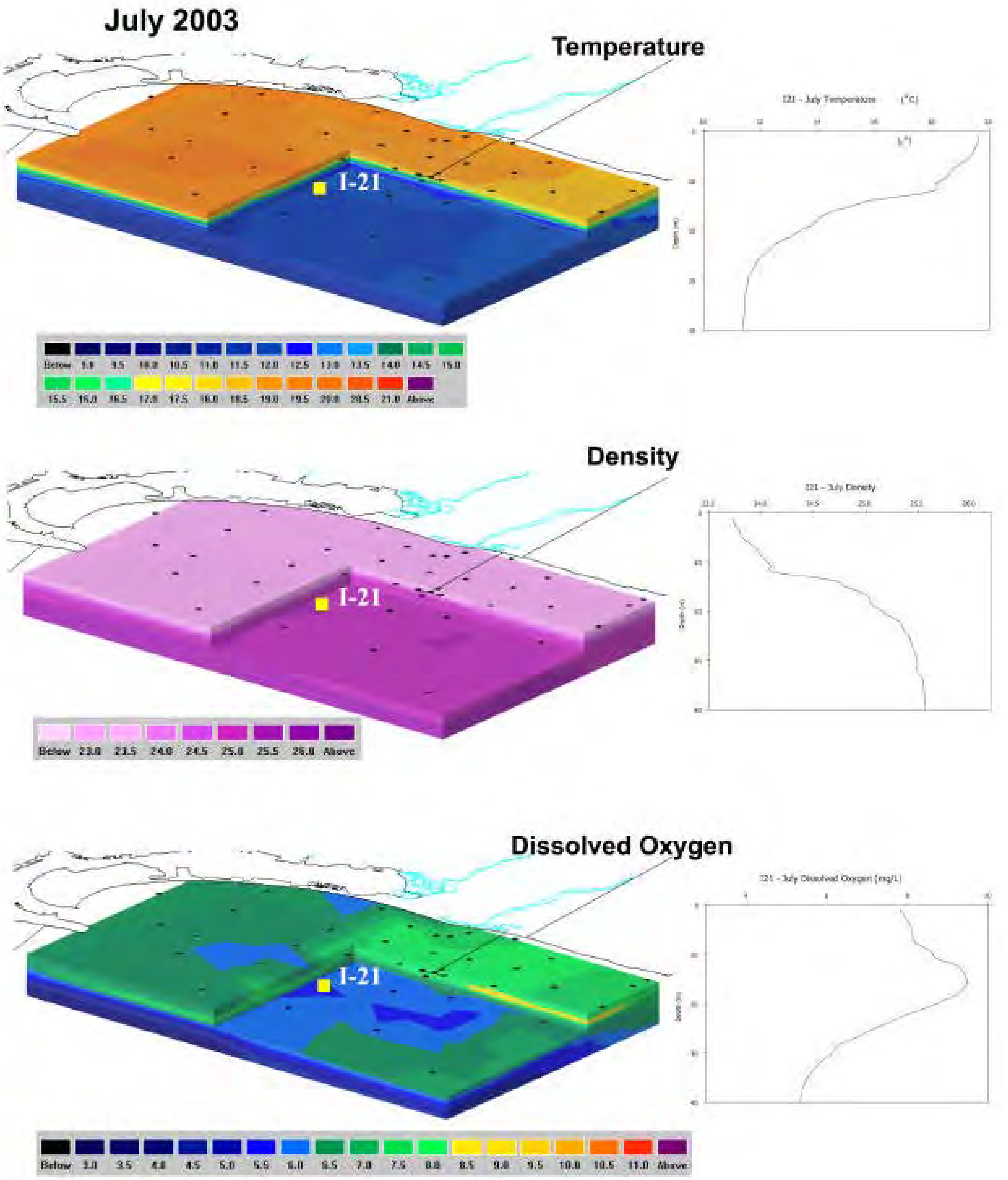


Figure 2.5

Interpolated volumetric (3D) plots of temperature, density (*/2), and dissolved oxygen at stations surrounding the SBOO on July 8, 9, and 10, 2003. Accompanying profiles illustrate these same parameters for offshore station I21 on July 10, 2003.

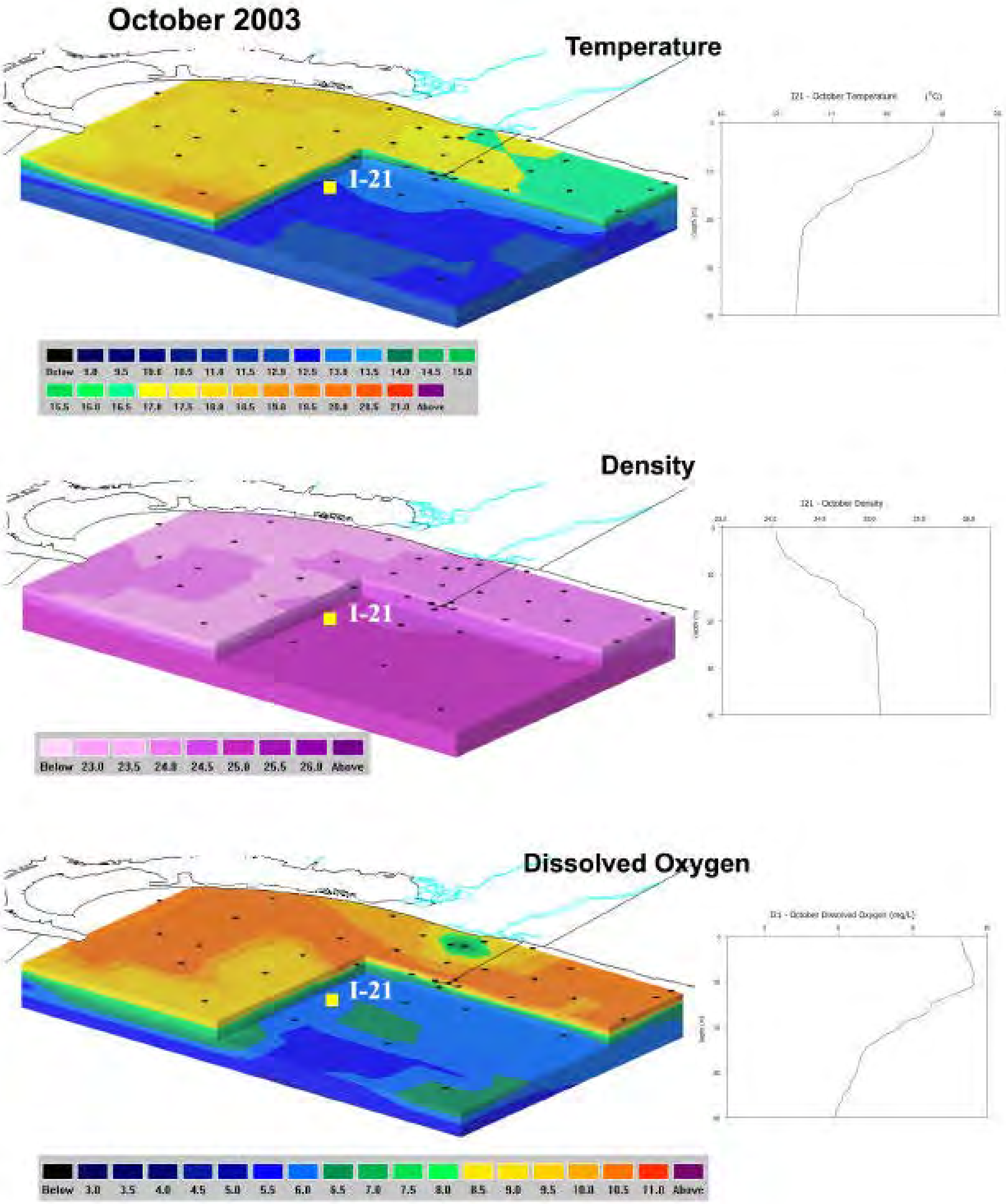


Figure 2.6

Interpolated volumetric (3D) plots of temperature, density (*/2), and dissolved oxygen at stations surrounding the SBOO on October 1, 2, and 3, 2003. Accompanying profiles illustrate these same parameters for offshore station I21 on October 3, 2003.

chlorophyll *a*, and transmissivity) occurred during the late summer and early fall months. These values correspond to the presence of an extensive and intense plankton bloom that dominated the offshore region of the San Diego coastline from mid-August through October. The highest average dissolved oxygen, pH, chlorophyll *a*, and the lowest average transmissivity values were recorded during the same time period.

Rainfall during 2003 followed historical patterns for most of the year, although rains were much lower than normal in January and much higher than normal during February (almost 3 inches above normal) and April (see Figure 2.3). As evident in satellite imagery, water clarity in the nearshore regions was clearly impacted by heavy rains during February, March, and April (Ocean Imaging 2003a,c). The timing of monthly sampling events did not closely follow the spring rain events; therefore, lower transmissivity values did not correspond well with rainfall.

Low nearshore transmissivity patterns for each month of the year were similar to or even more pronounced than the pattern seen in August data (**Figure 2.7**). This indicates that even during periods of limited or no rainfall, nearshore water clarity was still strongly influenced by terrestrial contributions. For instance, the consistent pattern of moderately to highly turbid waters near the mouth of San Diego Bay and directly offshore of the Tijuana River Estuary suggest that these sources had persistent negative impacts on nearshore water quality in

Table 2.1

Differences (Diff) between the top (≤2 m) and bottom (≥27 m) waters for mean values of temperature (˚C), salinity (ppt), density (*/2),dissolved oxygen (mg/L), pH, chlorophyll *a* (µg/L), and transmissivity (%) at all SBOO stations during 2003. The greatest differences between top and bottom values are highlighted and in bold type.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp	*Top*	14.7	15.2	15.5	15.0	14.8	17.2	19.3	17.2	18.2	17.5	16.9	15.6
	Bot	13.7	13.9	11.6	10.9	10.4	10.7	11.4	10.8	11.6	12.5	13.5	13.8
	Diff	1.0	1.3	3.9	4.1	4.4	**6.5**	**7.9**	6.4	**6.6**	5.0	3.4	1.8
Sal	*Top*	33.33	33.39	33.28	33.43	33.48	33.57	33.52	33.36	33.34	33.23	33.17	33.22
	Bot	33.35	33.39	33.62	33.68	33.70	33.64	33.52	33.52	33.39	33.27	33.11	33.14
	Diff	0.01	0.01	**0.34**	**0.25**	**0.23**	0.07	0.00	0.16	0.05	0.04	0.05	0.09
Dens	*Top*	24.8	24.7	24.5	24.8	24.8	24.4	23.8	24.2	23.9	24.0	24.1	24.5
	Bot	25.0	25.0	25.6	25.8	25.9	25.8	25.5	25.7	25.4	25.2	24.8	24.8
	Diff	0.2	0.3	1.1	1.0	1.0	**1.4**	**1.7**	**1.4**	**1.5**	1.1	0.7	0.3
Chl *a*	*Top*	2.7	2.2	3.8	5.9	7.0	3.5	3.6	3.3	10.4	28.5	2.2	3.0
	Bot	2.7	2.6	1.9	2.7	3.2	3.6	3.2	2.0	3.1	2.9	1.6	2.7
	Diff	0.0	0.4	1.9	3.1	**3.8**	0.1	0.4	1.3	**7.3**	**25.6**	0.6	0.4
DO	*Top*	7.3	7.9	8.1	8.4	8.4	8.0	7.6	9.5	9.4	10.1	8.0	8.1
	Bot	6.6	7.0	4.9	4.6	4.6	4.6	5.6	5.4	6.0	6.0	6.9	6.8
	Diff	0.7	0.9	3.2	3.8	**3.9**	3.4	2.0	**4.1**	3.5	**4.1**	1.1	1.3
pH	*Top*	8.05	8.09	8.08	8.15	8.11	8.15	8.18	8.19	8.23	8.35	8.12	8.15
	Bot	7.97	7.99	7.78	7.78	7.76	7.79	7.89	7.82	7.85	7.89	7.93	8.03
	Diff	0.07	0.10	0.30	**0.37**	0.35	0.36	0.29	**0.37**	**0.38**	**0.46**	0.19	0.12
XMS	*Top*	79	85	78	73	76	82	79	78	63	59	84	83
	Bot	77	88	91	88	89	88	89	91	90	90	90	86
	Diff	2	3	12	**15**	13	7	10	13	**27**	**31**	6	4

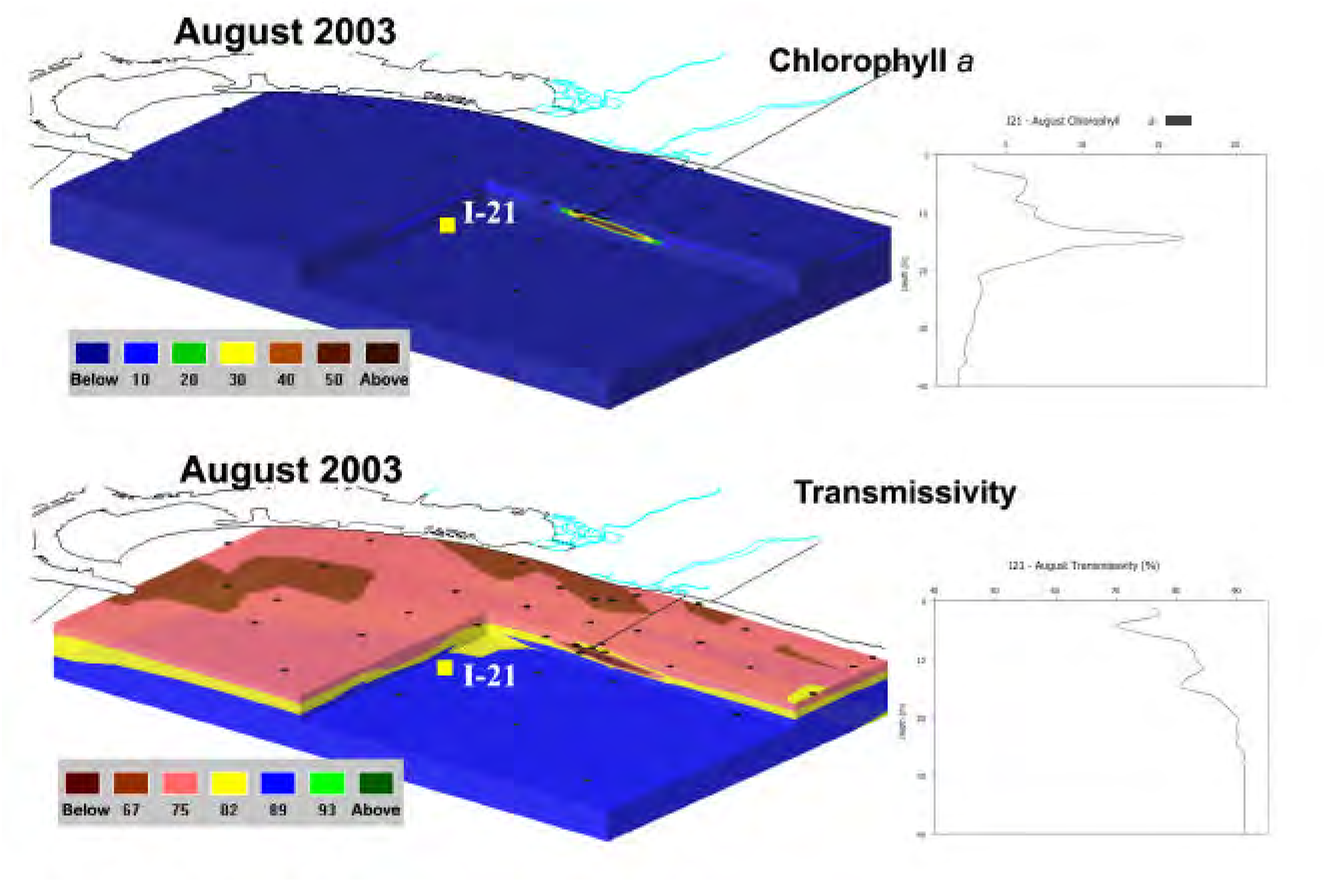


Figure 2.7

Interpolated volumetric (3D) plots of chlorophyll *a* and transmissivity at stations surrounding the SBOO during August 4–6, 2003. Accompanying profiles illustrate these same parameters for station I21 on August 6, 2003.

the South Bay region. It should be noted that most contributions from the Tijuana River Estuary are not from the river itself but rather correspond to tidal flushing of the estuary (Ocean Imaging 2003a). A similar dynamic, although not yet verified, is likely true for San Diego Bay.

During late summer and early fall, however, an extensive red tide significantly reduced water clarity and overshadowed any impact of the terrestrial contributions. Plankton blooms were a phenomenon throughout the Southern California Bight in 2003 as stronger than normal upwelling conditions along the coast returned following the moderate El Niño in 2002 (Venrick 2003). The red tide was so extensive that it depressed water clarity at almost every station during September and October (**Figures 2.7** and **2.8**). Although satellite and aerial overflight images clearly show a large plankton bloom in the surface waters off La Jolla and Pt. Loma during August (Ocean Imaging 2003d), the bloom did not reach surface waters in the South Bay region until September. Recorded chlorophyll concentrations during August did suggest a limited extent, subsurface plankton bloom at mid-depth near the outfall (Figure 2.7). The bloom expanded to encompass surface waters from the beginning of September through most of October (Figure 2.8). While transmissivity was not well correlated with chlorophyll during most months, the two were strongly correlated during September and October ($r^2 = 0.487$, $p < 0.01$, and $r^2 = 0.856$, $p < 0.001$, respectively) (**Figure 2.9**).

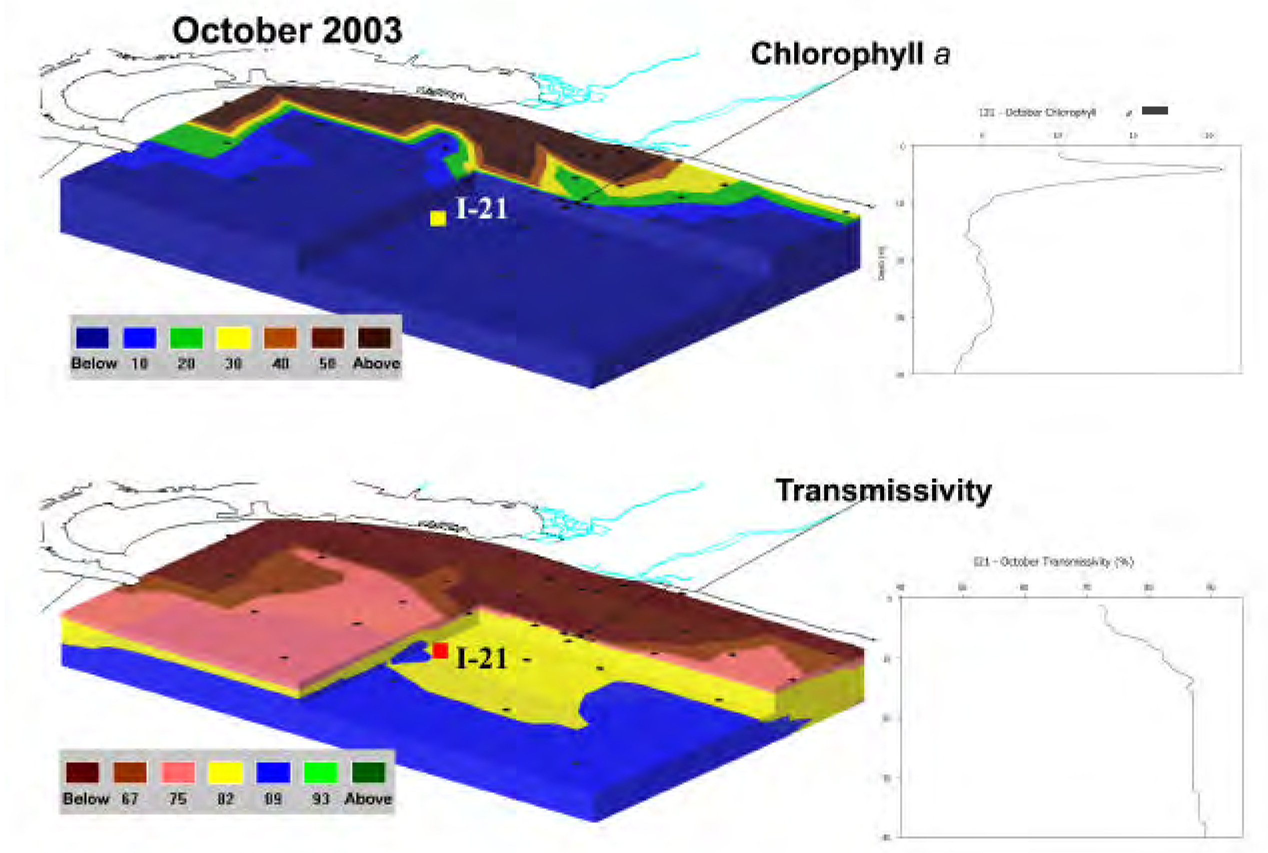


Figure 2.8

Interpolated volumetric (3D) plots of chlorophyll *a* and transmissivity at stations surrounding the SBOO during October 1–3, 2003. Accompanying profiles illustrate these same parameters for station I21 on October 3, 2003.

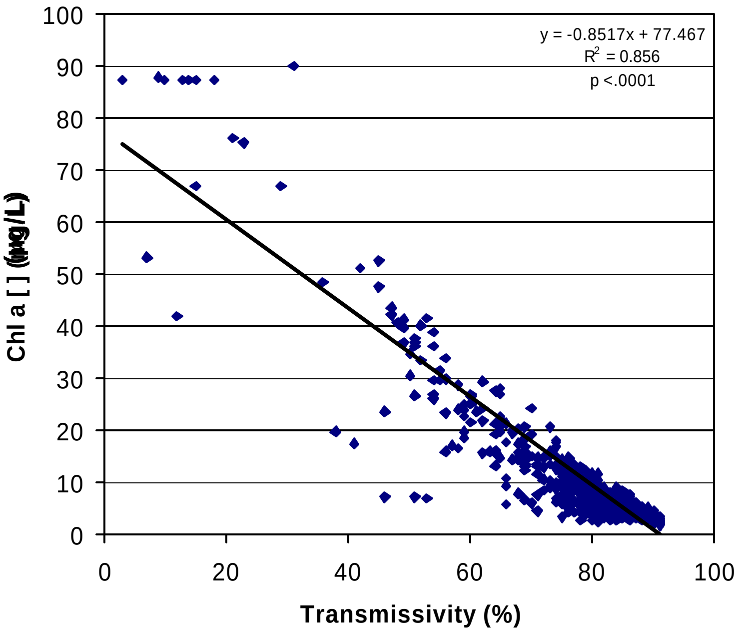


Figure 2.9

Correlation between transmissivity and chlorophyll *a* concentrations at all stations during October 2003.

SUMMARY and CONCLUSIONS

Oceanographic conditions during 2003 were generally within expected variability, although specific conditions (and the seasonal timing of those conditions) deviated somewhat from expected annual seasonal patterns. For the most part, rainfall fell within the range of long-term variability for each month, although the very heavy February rains were anomalous. The influx of freshwater during February, March and April was a likely contributor to density-dependent stratification in the early spring. This pycnocline provided some depth stratification prior to the development of thermal-driven stratification (the thermocline) that began in June and persisted through October.

Although upwelling conditions prevailed all along the West coast during 2003, interpretation of SBOO monthly sampling data did not provide clear evidence of upwelling. Other conditions that influenced temperature and density of surface waters in the South Bay region may have obscured the upwelling signal. These included heavy rains in February, storm conditions during March, April, and May, a slower than normal onset of surface water warming, and a major shift in the dominant wind direction during August and September. In addition to upwelled waters, it is likely that cooler, nutrient rich waters of the California Current may have been pushed inshore by changing wind patterns. This water mass may have further contributed to conditions conducive to the development of an extensive red tide event that dominated coastal waters off San Diego from August through October.

Reduced water clarity was closely associated with the increased chlorophyll concentrations of the red tide during September and October. During other months, chlorophyll concentrations were not well-correlated with turbidity. Contributions from runoff and sediment resuspension continued to compromise water clarity in nearshore waters from the mouth of San Diego Bay to the Tijuana River estuary.

Although spring and summer surface water warming occurred slower and was less intense than normal, stratification still appeared sufficient to prevent much mixing between surface and deeper waters from March through October. Considerable freshwater input from February and April rains likely contributed to an early development of the pycnocline and was likely bolstered by cooling of the bottom waters. The resultant stratification throughout most of the year ensured that the plume surfaced only during January and February. These oceanographic conditions contributed to the observed spatial patterns of bacterial concentrations discussed in the following chapter.

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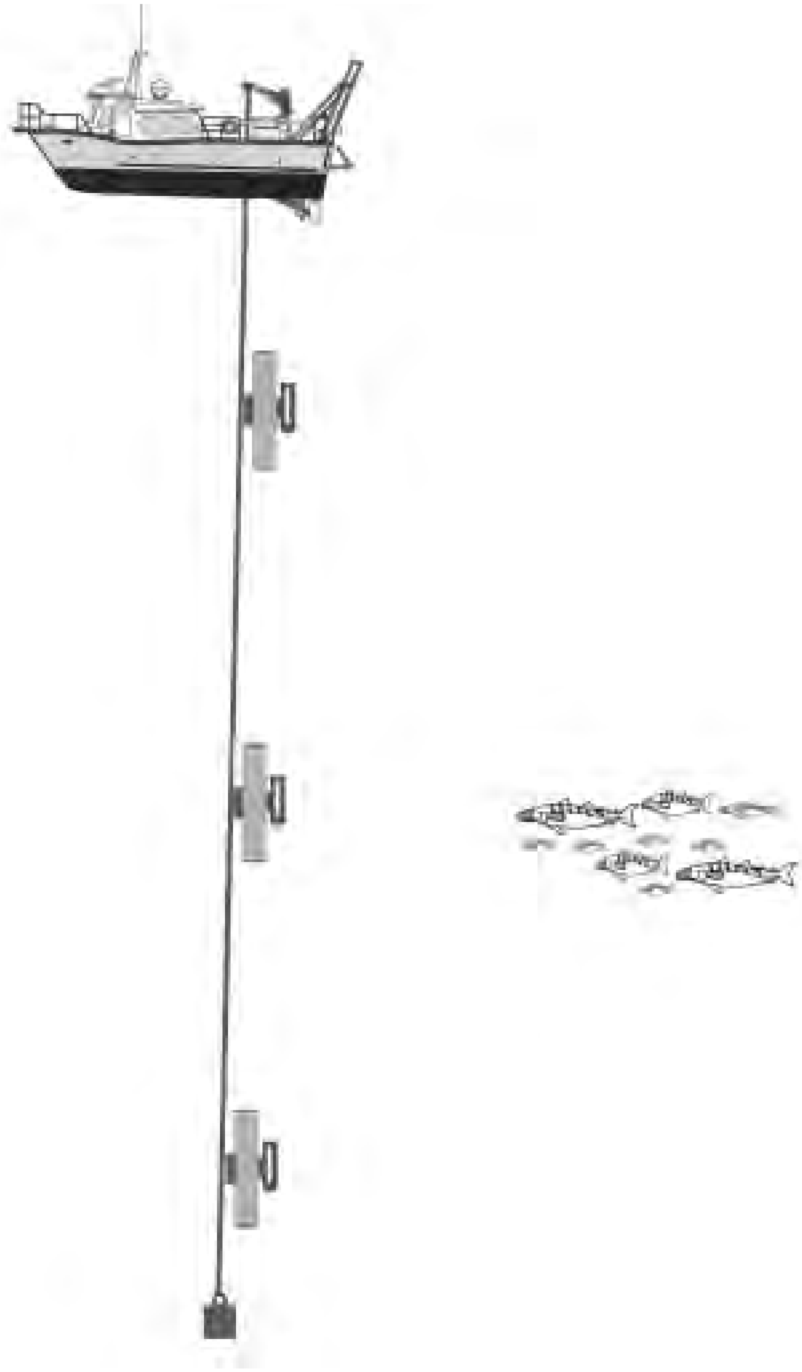
Microbiology



Chapter 3
Microbiology

INTRODUCTION

The City of San Diego performs shoreline and water column bacterial monitoring in the region surrounding the South Bay Ocean Outfall (SBOO). The presence, absence and abundance of bacteria, together with oceanographic data (see Chapter 2), can provide information about the movement and dispersion of wastewater discharged through the outfall. Analyses of these data may also implicate point or non-point sources other than the outfall as contributing to bacterial contamination events in the region. The SBOO monitoring program is designed to assess general water quality and demonstrate level of compliance with the California Ocean Plan (COP) as required by the NPDES discharge permit. Raw bacteriological values and individual station compliance data are submitted to the International Boundary and Water Commission and Regional Water Quality Control Board in the form of Monthly Receiving Waters Monitoring Reports. This chapter summarizes and interprets bacterial concentration data collected during 2003.

MATERIALS and METHODS

Field Sampling

Water samples for bacterial analysis were collected at fixed shore and offshore sampling sites throughout the year (**Figure 3.1**). Weekly sampling was performed at eleven shore stations to monitor bacteria levels along public beaches. Three stations (stations S0, S2, and S3) that are located south of the US/Mexico border are not subject to COP water contact standards. Eight other sites (stations S4–S6, S8–S12) are located within the United States and extend from the border northward to Coronado. These eight stations are subject to COP water contact standards. In addition, 28 offshore stations were sampled monthly at three discrete depths, usually over a 3-day period. These offshore sites are located in a grid pattern surrounding the outfall, along the 9, 18, 27, 37, and 55-m depth contours. Three of these stations (I25, I26, and I39) are considered kelp bed stations subject to the COP water contact standards. These stations were sampled for bacterial analysis an additional four times each month in accordance with NPDES permit requirements. The three kelp stations were selected for their proximity to suitable substrates for the Imperial Beach kelp bed; however, this kelp bed has been historically transient and inconsistent in terms of size and density (North 1991, North et al. 1993). Thus, these three stations are only occasionally located within an area where kelp is actually found.

Seawater samples from the 11 shore stations were collected from the surf zone in sterile 250-mL 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 seawater samples were then transported on ice to the City’s Marine Microbiology Laboratory and analyzed to determine concentrations of total coliform, fecal coliform, and enterococcus bacteria.

Offshore samples were analyzed for the same three bacterial parameters, as well as total suspended solids, and oil and grease. These water samples were collected using either a series of Van Dorn bottles or a rosette

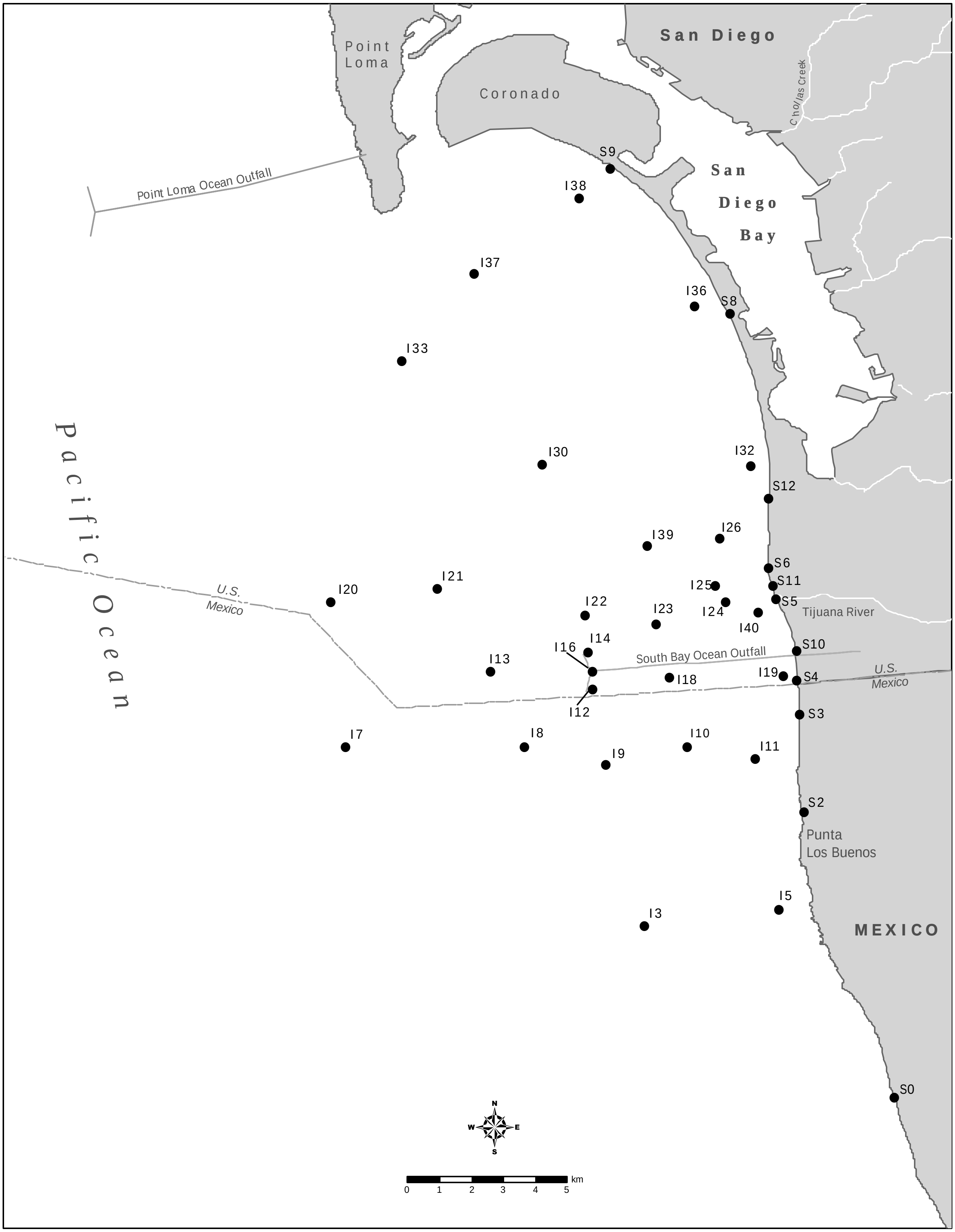


Figure 3.1

Water quality monitoring stations where bacterial samples are taken, South Bay Ocean Outfall Monitoring Program.

sampler fitted with Niskin bottles. Specific field sampling procedures are outlined in the City's Quality Assurance Manual (City of San Diego 2004). Aliquots for each analysis were drawn into appropriate sample containers. The samples were refrigerated on board ship and then transported to either the City's Marine Microbiology Laboratory for bacterial analysis or to the City's Wastewater Chemistry Laboratory for analysis of oil and grease, and suspended solids. Visual observations of weather and sea state were also recorded at the time of sampling.

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

Laboratory Analyses and Data Treatment

All bacterial analyses were performed within eight hours of sample collection and conformed to the membrane filtration techniques outlined in the City's Quality Assurance Manual (City of San Diego 2004). The Marine Microbiology Laboratory follows guidelines issued by the EPA Water Quality Office, Water Hygiene Division and the California State Department of Health Services (CS-DHS), Water Laboratory Approval Group with respect to sampling and analytical procedures (Bordner, et al. 1978; Greenberg, et al. 1992).

Colony counting, calculation of results, data verification and reporting all follow guidelines established by the EPA (see Bordner, et al. 1978). According to these guidelines, plates with bacterial counts above or below permissible counting limits were given ">", "<", or "e" (estimated) qualifiers. However, these qualifiers were ignored and the counts were treated as discrete values during the calculation of compliance with COP standards and various statistical analyses. Bacteriological benchmarks for receiving waters discussed in this report are >1,000 CFU/100 mL for total coliform values, >400 CFU/100 mL for fecal coliforms, and >104 CFU/100 mL for enterococcus bacteria. These benchmarks are used as reference points to distinguish elevated bacteriological values, and should not be construed as compliance limits or as indicators of health risk.

Monthly mean densities of total coliform, fecal coliform, and enterococcus bacteria were calculated for the eleven shore stations and three kelp bed stations. In order to detect spatio-temporal patterns in bacteriological contamination, these data were evaluated relative to monthly rainfall and climatological data collected at Lindbergh Field, San Diego, CA, as well as satellite and remote sensing data collected by OI. Shore and kelp bed station compliance with COP bacteriological standards were summarized according to the number of days that each station was out of compliance with the 30-day total coliform, 10,000 total coliform, 60-day fecal coliform, and geometric mean standards (see Box 3.1). Bacteriological data for offshore stations data is not subject to COP standards; however, these data were used to examine spatio-temporal patterns in the dispersion of waste field. Generally, contaminated waters can be identified when total coliform concentrations are >1,000 CFU/mL and the fecal:total (F:T) ratio is 0.1 or higher (see CS-DHS 2000). Offshore station water quality samples that met these criteria were used as indicators of the waste field. These data were used in conjunction with volumetric plots of bacteriological densities to identify dispersion of the waste field. Voxal Analyst, a volumetric modeling software package, was used to plot the data.

Quality assurance tests were performed routinely on water samples to insure that sampling variability did not exceed acceptable limits. Duplicate and split field samples were generally collected each month and processed by laboratory personnel to measure intra-sample and inter-analyst variability, respectively. Results of these procedures were reported in the Quality Assurance Manual (City of San Diego 2004).

RESULTS and DISCUSSION

Temporal Variability – Shore Stations

The annual mean concentrations of total and fecal coliform bacteria along the shoreline in 2003 were considerably higher than the previous year and approached or exceeded levels not seen since the 1998 El Niño (**Figure 3.2**). These higher values were due to increased rainfall in 2003 (i.e., from 4.2 inches in 2002 to 9.2 inches in 2003), and particularly to uncharacteristically heavy rainfall that occurred early in the year (see Chapter 2). For example, the highest densities of indicator bacteria occurred during February, March, and April when rainfall was the heaviest (i.e., >1.3 inches/month) (**Table 3.1**). Even the high coliform counts in May were limited to the first week of sampling that followed a 0.3 inch rainfall. In contrast, the subsequent warm and dry conditions that persisted through October reduced bacterial contamination in the region to sporadic events. There were only seven instances when total coliform concentrations exceeded 10,000 CFU/100 mL during these months, compared to 75 instances during the remainder of the year (i.e., January–May, November–December). Differences between the wet and dry seasons were also evident for total coliform concentrations at shore stations near the Tijuana River (i.e., S4, S5, S6, S10, and S11) where contaminants from upstream sources (e.g., sod farms) and the estuary (e.g., decaying plant material) are released during periods of increased flow from the river (**Figure 3.3**).

Temporal Variability - Kelp and Offshore stations

Generally, data from kelp and offshore monthly sampling stations indicate that the wastewater plume remained offshore at depths below 12 m for most of the year (**Figure 3.4**). For example, evidence of the plume reaching surface waters was limited to January and February when samples with total coliform densities above 16,000 CFU/100mL were collected in surface waters near the outfall (stations I12 and I16). In contrast, surface water total coliform densities were consistently below 1,000 CFU/mL from March through the end of the year. Mixing of the water column most likely allowed plume material to surface near the outfall early in the year, while a stratified water column that began in March restricted the plume to mid- and deep-water depths for the remainder of the year (see Chapter 2).

Similar seasonal patterns were also evident in surface (2 m) vs. bottom (27 m) waters (**Figure 3.5**). Bacterial densities of all three indicator bacteria were elevated in the surface waters in January and February and relatively low in the months that followed. Peak surface water bacterial densities occurred in February, while bottom waters densities were highest in May. In general, surface and bottom water bacterial densities were less variable this year than last (see City of San Diego 2003).

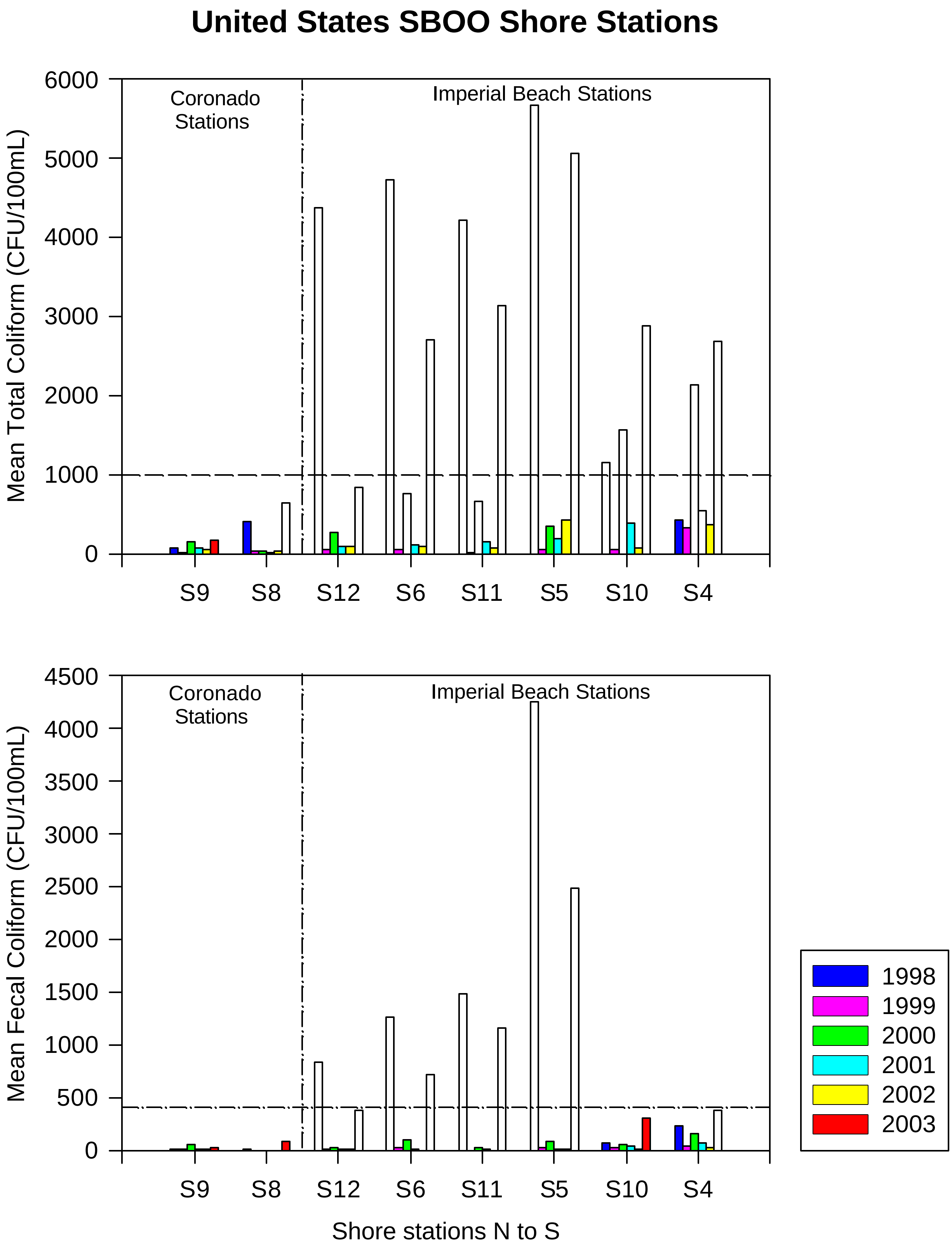


Figure 3.2

Average annual total and fecal coliform concentrations (CFU/100 mL) for each U.S.-based SBOO shore station from 1998–2003.

Table 3.1

Shore station bacterial densities and rainfall data for the SBOO region during 2003. Mean total coliform, fecal coliform and enterococcus bacterial densities are expressed as CFU/100 mL. Mean rainfall is expressed in inches as measured at Lindbergh Field, San Diego, CA.

Month	Stations	**S9**	**S8**	**S12**	**S6**	**S11**	**S5**	**S10**	**S4**	**S3**	**S2**	**S0**	**Monthly**
(Rainfall)	**n**	**52**	**53**	**53**	**58**	**58**	**61**	**59**	**57**	**51**	**51**	**51**	**means all**
	Bacteria												**stations**
Jan	Total	27	28	17	7	24	360	19	327	62	262	350	**134**
(0.02)	Fecal	4	15	7	3	4	30	6	188	13	104	32	**37**
	Entero	8	21	65	402	6	23	90	358	9	25	20	**93**
Feb	Total	912	6442	6800	11500	11172	11634	6240	9706	12001	4393	10125	**8646**
(4.88)	Fecal	19	884	3892	5401	5903	6459	250	1717	5251	2774	665	**3291**
	Entero	21	594	2212	4648	3715	4492	393	1504	5157	3420	754	**2577**
Mar	Total	89	4	793	8800	9720	14914	10432	9008	8082	4252	4678	**7409**
(1.36)	Fecal	11	2	23	482	1877	7171	397	186	592	384	291	**1285**
	Entero	40	2	33	56	162	4326	68	93	451	406	149	**658**
Apr	Total	81	8	20	154	165	9380	5688	4922	3245	3248	6821	**3420**
(1.41)	Fecal	72	2	6	13	5	6863	1905	1485	2411	1884	737	**1597**
	Entero	2	2	7	5	5	2806	934	842	2222	1486	448	**868**
May	Total	2	77	1214	3233	6530	7610	25	88	142	10	5406	**2441**
(0.30)	Fecal	2	5	17	1083	2887	2667	3	20	9	2	311	**737**
	Entero	2	2	3	10	22	2429	3	22	6	6	140	**277**
Jun	Total	250	20	34	56	115	202	351	809	2113	6426	11	**944**
(trace)	Fecal	89	2	26	3	9	24	9	36	54	305	2	**51**
	Entero	256	3	3	6	32	32	60	75	169	273	2	**82**
Jul	Total	125	51	75	70	100	150	80	90	138	162	5693	**621**
(trace)	Fecal	4	3	28	11	17	74	13	19	8	13	84	**25**
	Entero	10	4	13	13	10	26	8	29	60	6	41	**20**
Aug	Total	125	88	88	39	51	28	113	88	29	27	164	**76**
(0.0)	Fecal	5	2	4	5	7	24	6	27	5	2	3	**8**
	Entero	3	2	80	10	17	71	14	20	8	4	7	**21**
Sept	Total	193	98	196	345	688	417	1608	1388	1981	3844	16	**994**
(trace)	Fecal	13	13	40	9	8	12	18	39	22	265	2	**40**
	Entero	3	5	280	28	30	39	42	76	100	180	6	**72**
Oct	Total	165	67	42	81	151	40	480	100	20	682	16000	**1363**
(trace)	Fecal	25	3	4	2	6	3	5	16	6	30	880	**73**
	Entero	12	27	14	7	18	19	18	33	21	15	520	**55**
Nov	Total	17	43	100	10	12	48	6	18	50	4006	338	**422**
(0.60)	Fecal	9	3	13	9	3	4	3	12	7	456	8	**48**
	Entero	5	34	23	11	6	4	11	23	20	62	8	**19**
Dec	Total	118	12	37	726	2751	4333	666	134	158	158	7402	**1571**
(0.61)	Fecal	6	9	15	31	271	135	16	8	13	10	151	**65**
	Entero	10	9	33	19	74	302	14	6	57	26	36	**58**
Annual	**Total**	**172**	**648**	**845**	**2702**	**3140**	**5073**	**2885**	**2691**	**2305**	**2286**	**4548**	
Means	**Fecal**	**22**	**88**	**382**	**721**	**1156**	**2490**	**307**	**379**	**706**	**531**	**250**	
	Entero	**29**	**65**	**257**	**532**	**481**	**1504**	**172**	**292**	**697**	**496**	**167**	

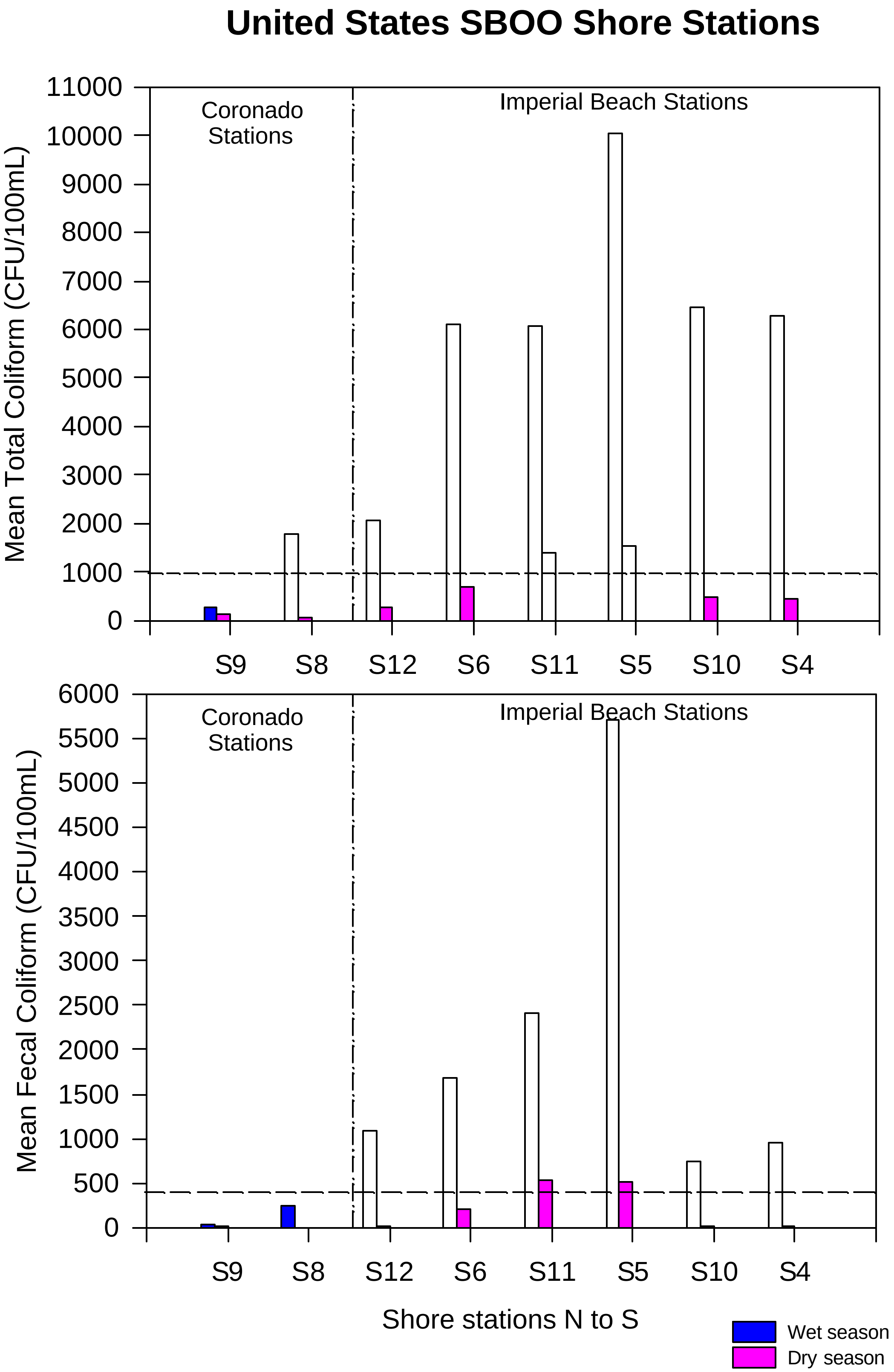


Figure 3.3

Mean fecal coliform concentrations (CFU/100 mL) for SBOO shore stations during wet months (January–April) versus dry months (May–October) for 2003. Shore stations are listed left to right from north to south.

Spatial Variability - Shore, Kelp and Offshore stations

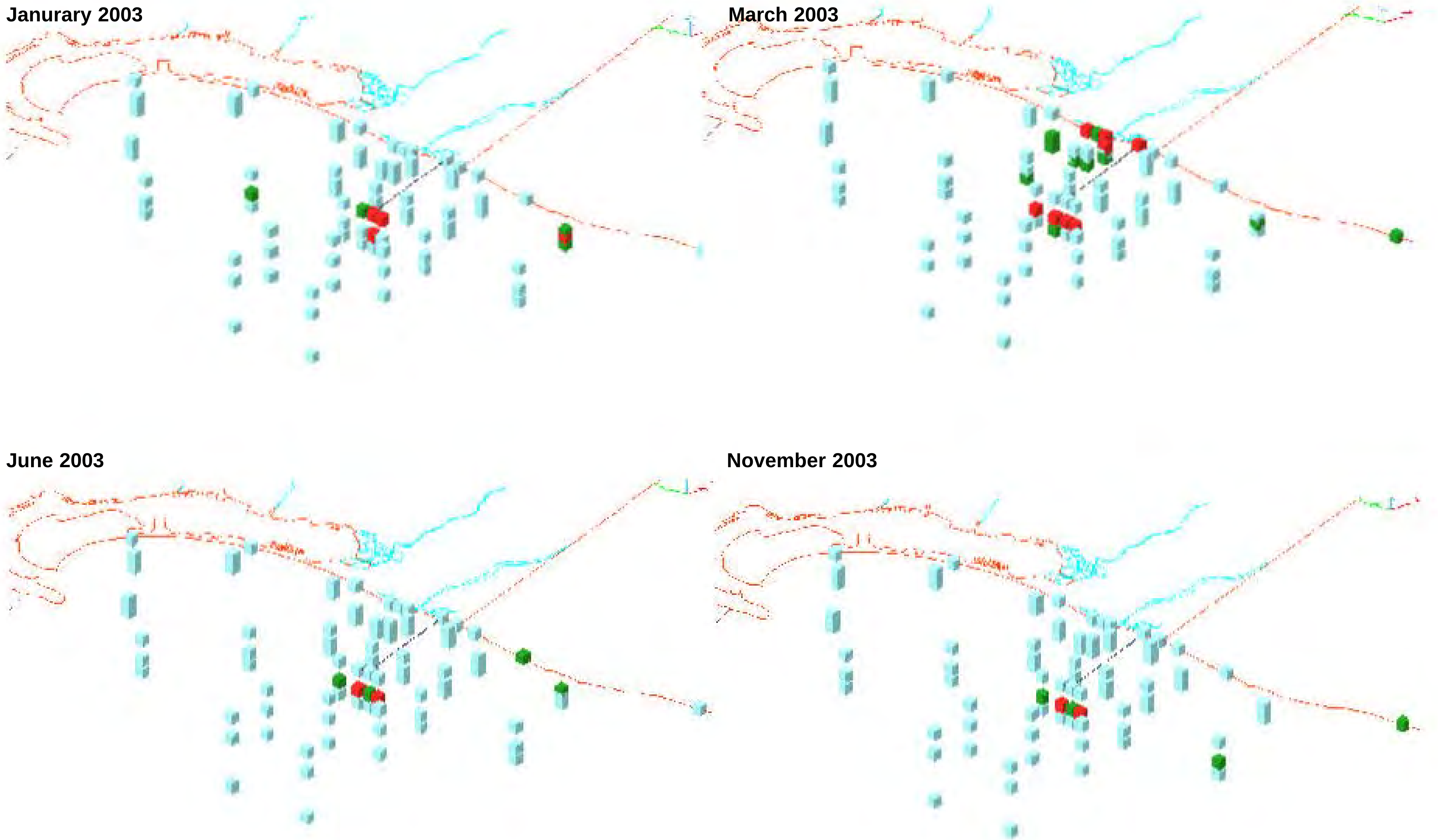
Overall, there was no direct evidence from samples taken at the shore, nearshore kelp bed, or offshore stations that the wastewater plume reached the shoreline in 2003. Bacterial densities indicative of the wastewater plume were detected most frequently in water samples collected near the discharge site (**Table 3.2**). Twenty samples with fecal: total (F:T) ratios >0.1 were collected at the three outfall stations (I12, I14, I16), while six were collected north of the SBOO and only three were collected southward. Five such samples were detected at several near shore stations, but most of these instances (i.e., March) appear to be affected by Tijuana River discharge (see Ocean Imaging 2003b). The relatively infrequent detection of the elevated bacterial densities distant from the discharge site may result from the dilution of the effluent.

High bacterial densities along the shoreline and in shallow, near shore waters may be related to sources other than the SBOO. Transport of Tijuana River water affected bacterial counts along the shoreline and at some near shore stations (see above). For example, river discharge in early May was likely responsible for elevated total coliform concentrations in samples from shore stations surrounding the river mouth (S5, S6, and S11) and nearshore stations I24 (11 m), I25 and I40 (all depths). These samples followed the only rainfall event of the month. Low F:T ratios (<0.5) indicate that these samples were probably not representative of the SBOO discharge. Elevated bacterial counts at stations south of the Tijuana River (i.e., S2, S3, S4, S5, and S10) are likely due to the predominantly southward flow of surfaces waters in the region that carry discharge from the River southward. Similarly, discharge from Los Buenos Creek affects station S0, the only station south of its outlet (see Ocean Imaging 2003c).

Bacterial Patterns and Remote Sensing Surveys

Satellite and aerial remote sensing performed by Ocean Imaging Corporation show that the SBOO plume was discernible in surface waters to 15 m in January through early April 2003 (Ocean Imaging 2003a, b). It was observed again in November and remained visible through the rest of the year (Ocean Imaging 2003d, e). Generally, plume patterns obtained from aerial and high resolution satellite images showed close spatial agreement with bacteriological field sampling results collected on the same day. When the plume was visible near-surface (e.g., January, February), sampling stations located within its footprint revealed elevated bacterial concentrations. As expected, bacterial counts tended to be highest within the most concentrated, core portions of the plume signature (usually I12 and I16), and decreased with distance away from the core as the intensity of the imaged plume also decreased. For example, on February 3, during very calm weather and current conditions, the plume's turbidity signature in DMSC imagery was discernible up to about 4 km northeast from the outfall. Although near-surface sampling at stations I12 and I16 showed elevated counts, station I23 (also within the imaged plume) showed only background bacteria levels – possibly due to dilution of the effluent with distance or time-dependent mortality.

The aerial and satellite imaging data never showed the plume to reach the shore. Instead, aerial images revealed generally good agreement between shoreline bacteriological sampling results and the runoff plume extents of the Tijuana River. Remote sensing imagery has revealed that the Tijuana River plume has different spectral characteristics when it is caused by simple tidal flushing of the marsh versus when it contains runoff effluent from further upstream (i.e., after major rain events). During times of year when the imaged River plume exhibited only tidal flushing characteristics (e.g., January), sampling near the River mouth generally revealed low or moderate bacterial concentrations (Ocean Imaging 2003a). When the plume's spectral signature indicated



Janurary 2003

March 2003

June 2003

November 2003

Figure 3.4

Volumetric plots illustrating total coliform concentrations (CFU/100 mL) for seasonally-representative monthly offshore and corresponding weekly shore samples at SBOO stations for 2003. Increasingly separated stacked blocks represent the three sample depths for each offshore station. Total coliform concentrations <1,000 are color-coded blue; >1,000 but <10,000 are green; and >10,000 are red.

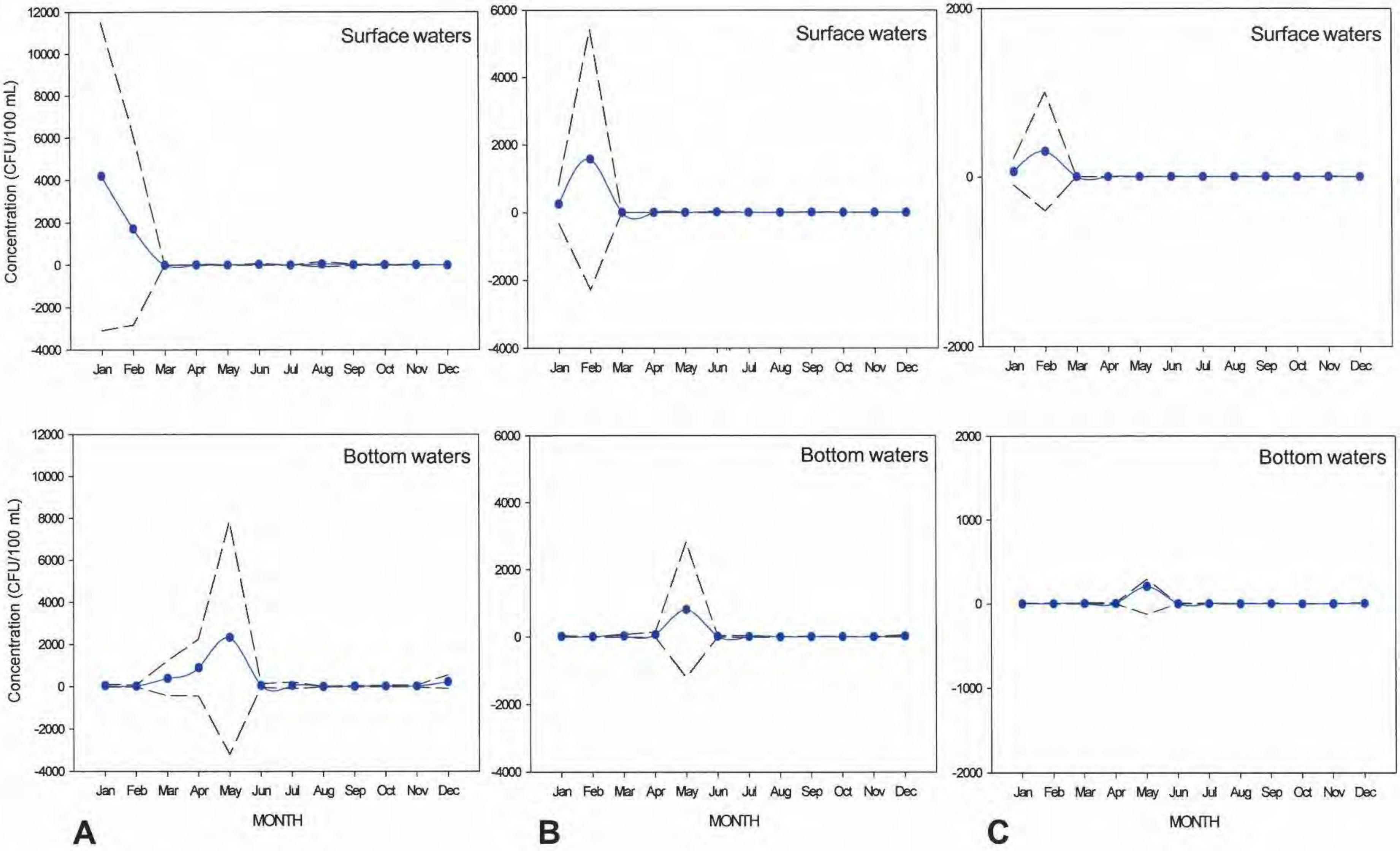


Figure 3.5

Mean concentrations and standard deviations (as an indication of variability) at SBOO stations along the 27-m contour for surface waters and bottom waters during 2003: (A) total coliform, (B) fecal coliform, and (C) enterococcus.

Table 3.2

Offshore water quality samples sampled during 2003 where total coliform densities were >1,000 CFU/100 mL and fecal:total (F:T) coliform ratios ≥0.1. Depth in meters.

Station	Month	Depth	Fecal	Total	Enterococcus	Ratio (F:T)
North						
I30	January	18	750	4000	68	0.19
I22	March	18	4200	12000	400	0.35
I30	April	27	200	1200	8	0.17
I22	"	18	1200	8800	400	0.14
I22	June	18	1500	8800	300	0.17
I21	December	18	560	2100	28	0.27
Outfall						
I12	January	2	1600	16000	450	0.10
I16	February	2	1600	12000	400	0.13
I12	"	18	2400	18000	300	0.13
I16	March	18	11000	16000	250	0.69
I14	"	18	8600	16000	500	0.54
I12	"	18	12000	16000	150	0.75
I16	April	18	200	1800	52	0.11
I14	"	18	650	5800	120	0.11
I12	May	18	12000	16000	1800	0.75
I12	"	27	5800	16000	600	0.36
I16	June	18	3000	9000	250	0.33
I14	"	18	12000	16000	11000	0.75
I12	"	18	12000	16000	2	0.75
I12	July	18	12000	16000	9400	0.75
I12	August	18	1000	6200	400	0.16
I16	September	18	1400	5000	250	0.28
I12	"	18	12000	16000	12000	0.75
I16	November	18	720	3200	120	0.23
I14	"	18	12000	16000	6000	0.75
I12	"	18	11000	16000	1200	0.69
South						
I3	May	18	4800	16000	250	0.30
I9	August	18	300	2800	150	0.11
Inshore						
I40	March	2	12000	16000	800	0.75
I39	"	18	400	1500	30	0.27
I26	"	9	450	1700	32	0.26
I10	April	12	3800	16000	350	0.24
I18	May	18	850	2100	150	0.40

runoff from upstream (e.g., February, March), corresponding bacterial concentrations tended to be characteristically high along the shoreline affected by the runoff plume (Ocean Imaging 2003b).

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

Compliance with California Ocean Plan (COP) bacterial standards (**Box 3.1**) for U.S. shore and kelp bed stations is summarized in **Tables 3.3** and **3.4**. Rainfall affected overall compliance with COP standards in 2003, with most incidences of non-compliance corresponding to periods of relatively heavy rainfall. For example, bacterial concentrations at most stations exceeded at least one COP standard in March, following one of the wettest Februarys of record. In addition, several stations (e.g., S4, S5, S6, S10, I25, and I26) were out of compliance with various standards in January 2003 despite having bacteriological densities below benchmark values (i.e., 1,000 CFU/100 mL for total coliform and 400 CFU/100 mL for fecal coliform). These exceedences were a result of high bacterial densities collected in late December 2002 following a series of winter storms. As in previous years, stations located near the Tijuana River mouth exceeded the water quality standards more frequently than those further northward or further offshore (e.g., City of San Diego 2003).

The four northernmost shore stations (S6, S8, S9, and S12) were compliant with COP standards over 70% of the time. In contrast, percent compliance at several southern stations (i.e., S4, S5, S10, and S11) was less than 70% for at least two standards (e.g., 30-day total and 60-day fecal). The proximity of these four stations to the Tijuana River mouth may explain the frequency with which they were out of compliance. The predominantly southward flow of surfaces waters in the region is most likely responsible for the decreased compliance at stations south of the Tijuana River (i.e., S4, S5, and S10) relative to those stations further to the north.

All three kelp stations showed a similar pattern of increased incidence of non-compliance during periods of heavy rainfall (see Tables 3.1 and 3.3). As with the shore stations, incidences of non-compliance in January were due to high bacterial counts from samples collected after the December 2002 rains. Overall, the two shallow stations (I25 and I26) were compliant with the 30-day coliform standard approximately 72 and 78%, respectively, much lower than over 98% compliance recorded for the 18-m station (I39). Compliance

Box 3.1

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

(1) *30-day total coliform standard* — no more than 20% of the samples at a given station in any 30-day period may exceed a concentration of 1,000 CFU/100 mL.

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

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

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

Table 3.3

Summary of compliance with 2001 California Ocean Plan water contact standards for SBOO shore and kelp bed stations during 2003. Values reflect the number of days that each station exceeded the 30-day and 10,000 total coliform standards (see Box 3.1). Shore stations are listed left to right from north to south.

30-Day Total Coliform Standard

	# of possible	Shore Stations								Kelp Stations		
Month	**sampling days**	**S9**	**S8**	**S12**	**S6**	**S11**	**S5**	**S10**	**S4**	**I-25**	**I-26**	**I-39**
January	31	0	0	0	15	0	29	29	29	20	20	8
February	28	2	3	9	17	17	16	17	17	0	0	0
March	31	18	26	31	31	31	31	31	31	31	31	0
April	30	0	0	10	21	21	30	30	30	18	13	0
May	31	0	0	18	0	25	31	15	15	29	17	0
June	30	0	0	2	0	4	9	0	19	4	0	0
July	31	0	0	0	0	0	0	0	14	0	0	0
August	31	0	0	0	0	0	0	0	0	0	0	0
September	30	0	0	0	21	21	21	21	21	0	0	0
October	31	0	0	0	0	0	0	2	0	0	0	0
November	30	0	0	0	0	0	0	19	0	0	0	0
December	31	0	0	0	1	0	1	1	0	0	0	0
Compliance (%)		95%	92%	81%	71%	67%	54%	55%	52%	72%	78%	98%

10,000 Total Coliform Standard

	# of possible	Shore Stations								Kelp Stations		
Month	**sampling days**	**S9**	**S8**	**S12**	**S6**	**S11**	**S5**	**S10**	**S4**	**I-25**	**I-26**	**I-39**
January	31	0	0	0	0	0	0	0	0	0	0	0
February	28	0	1	1	2	2	2	0	1	0	0	0
March	31	0	0	0	1	1	3	1	1	1	0	0
April	30	0	0	0	0	0	2	0	0	0	0	0
May	31	0	0	0	0	1	1	0	0	1	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

Table 3.4

Summary of compliance with 2001 California Ocean Plan water contact standards for SBOO shore and kelp bed stations during 2003. Values reflect the number of days that each station exceeded the 60-day fecal coliform and geometric mean standards (see Box 3.1). Shore stations are listed left to right from north to south.

60-Day Fecal Coliform Standard

	# of possible	Shore Stations								Kelp Stations		
Month	**sampling days**	**S9**	**S8**	**S12**	**S6**	**S11**	**S5**	**S10**	**S4**	**I-25**	**I-26**	**I-39**
January	31	0	0	0	0	0	31	31	31	0	0	0
February	28	0	4	4	18	17	28	28	28	0	0	0
March	31	0	31	31	31	31	31	31	31	0	0	0
April	30	0	26	26	30	30	30	30	28	24	0	0
May	31	0	0	0	18	29	31	31	31	31	0	0
June	30	0	0	0	14	30	30	15	15	16	0	0
July	31	0	0	0	0	5	5	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	1	1	0	0	0	0	0
Compliance (%)		100%	83%	83%	70%	61%	49%	55%	55%	81%	100%	100%

Geometric Mean

	# of possible	Shore Stations								Kelp Stations		
Month	**sampling days**	**S9**	**S8**	**S12**	**S6**	**S11**	**S5**	**S10**	**S4**	**I-25**	**I-26**	**I-39**
January	31	0	0	0	0	0	23	16	22	0	0	0
February	28	0	0	0	3	4	9	0	16	0	0	0
March	31	0	0	0	27	31	31	0	10	9	0	0
April	30	0	0	0	0	0	30	0	0	0	0	0
May	31	0	0	0	0	0	22	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
Compliance (%)		100%	100%	100%	92%	90%	68%	96%	87%	98%	100%	100%

Table 3.5

Mean monthly means for total suspended solids (TSS) and oil and grease (O&G) from 2 m samples for each SBOO offshore station during 2003.

	Monthly Means	
Month	TSS	O&G
January	3.3	< 0.2
February	2.6	< 0.2
March	4.8	< 0.2
April	6.2	0.4
May	4.8	0.3
June	3.7	0.4
July	4.4	< 0.2
August	4.4	0.8
September	10.4	0.5
October	13.8	0.8
November	5.9	0.3
December	3.0	0.3

at these shallow stations was most likely influenced by Tijuana River discharge. The relatively low fecal coliform levels at these stations suggest that the elevated total coliform values may not have been related to wastewater discharge.

Bacterial Patterns Compared to Other Wastewater Indicators

Oil and grease measurements were generally low and of limited use as indicators of sewage contamination according to 2003 data. Monthly means of oil and grease concentrations were consistently <1.0 mg/L (**Table 3.5**). The highest oil and grease concentrations (2.7–4.8 mg/L) were recorded on August 5 at station I14 near the discharge site and at three nearshore stations (I19, I25, and I26). However, bacterial concentrations in the 2 m subsurface samples on August 5 were very low (i.e., <2 CFU/100 mL), and the only elevated bacterial densities were directly above the outfall diffusers at station I12 (18 m). Visual observations from that day indicated ocean conditions were calm and the waters clear with no indication of the wastewater plume.

Concentrations of total suspended solids (TSS) were variable and did not correspond to bacterial concentrations. During 2003, elevated TSS values corresponded primarily to a large and expansive red tide that took place from August through October (see Chapter 2). The highest TSS concentrations occurred in October at nearshore stations (e.g., maximum concentration = 52.6 mg/L at station I25). Bacteriological indicators from the same sample ranged from <2 to 160 CFU/100 mL. In contrast, the sample with the highest bacteriological density (total coliforms = 7,200 CFU/100 mL) corresponded to a TSS sample with a low concentration of suspended materials (3.4 mg/L). Taken together, these results suggest a limited utility of high suspended solids or oil and grease concentrations for detection of the waste field.

SUMMARY and CONCLUSIONS

Bacteriological data for the South Bay region indicate that the waste water plume from the South Bay Ocean Outfall (SBOO) was confined below a stratified water column for most of the year and dispersed rapidly whenever transported laterally. Elevated bacterial counts were evident near the surface only during January and February when the water column was well-mixed. Data from remote sensing suggests a predominantly southward flow of the surface waters to 15 m and a southwesterly detection of the waste water plume. Concentrations of bacterial indicators from monthly sampling events detected the wastewater plume at depths of 18 m and below, and predominantly offshore and northward of the discharge site. Together, these data suggest that even though elevated bacterial densities were detected at the shore and nearshore stations at various times during the year there was no evidence that they resulted from shoreward transport of the SBOO waste field.

Water quality conditions for the South Bay region were strongly influenced by relatively heavy rainfall in 2003. For the most part, values exceeding compliance levels along the shore and at kelp bed stations appear to have been caused by contamination from non-outfall sources released during and after storm events. Patterns of bacterial concentration and visible satellite imagery data indicate that contributions from the Tijuana River, San Diego Bay, and non-point source stormwater runoff are all more likely than the SBOO to have a critical impact on the water quality at shore and nearshore stations.

Overall, even with the presence of major storm activity in March, April, and May, and the delayed onset of the seasonal thermocline (see Chapter 2), the bacterial data demonstrated minimal, if any, impact to nearshore water quality from the SBOO discharge during 2003.

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Sediment Characteristics

Chapter 4
Sediment Characteristics

INTRODUCTION

Sediment conditions can influence the distribution of benthic invertebrates by affecting the ability of various species to burrow, build tubes or feed (Gray 1981, Snelgrove and Butman 1994). In addition, many demersal fishes are associated with specific sediment types that reflect the habitats of their preferred prey (Cross and Allen, 1993). Both natural and anthropogenic factors affect the distribution, stability and composition of sediments. Ocean outfalls are one of many anthropogenic factors that can directly influence the composition and distribution of ocean sediments. Wastewater outfalls discharge and subsequently deposit a wide variety of organic and inorganic compounds. Among the commonly detected compounds discharged via outfalls are trace metals, pesticides and various organic compounds (e.g., organic carbon, nitrogen and sulfide compounds) (Anderson et al. 1993). Moreover, the presence of the large concrete pipe or associated structures can alter the hydrodynamic regime in the immediate area.

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

The chemical composition of sediments can be similarly affected by the geological history of an area. Sediment erosion from bays, cliffs, shores, rivers and streams, contribute to the composition of metals within the area. In addition, the organic content of sediments is greatly affected by nearshore primary productivity. This includes marine plankton production as well as terrestrial plant debris from bays, estuaries and river runoff (Mann 1982, Parsons et al. 1990). Concentrations of these materials within ocean sediments generally increase with increasing amounts of fine sediment particles chiefly as a result of adsorption (Emery 1960).

This chapter presents summaries and analyses of sediment grain size and chemistry data collected during 2003 in the vicinity of the South Bay Ocean Outfall (SBOO). The major goals of the study were: (1) to assess the impact of the discharged wastewater on the benthic environment by analyzing the spatial and temporal variability of the various sediment parameters, and (2) to determine the presence or absence of sedimentary and chemical footprints near the discharge site.

MATERIALS and METHODS

Field Sampling

Sediment samples were collected during January and July of 2003 at 27 stations surrounding the South Bay Ocean Outfall (**Figure 4.1**). These stations are located along the 19, 28, 38, and 55-m depth contours and

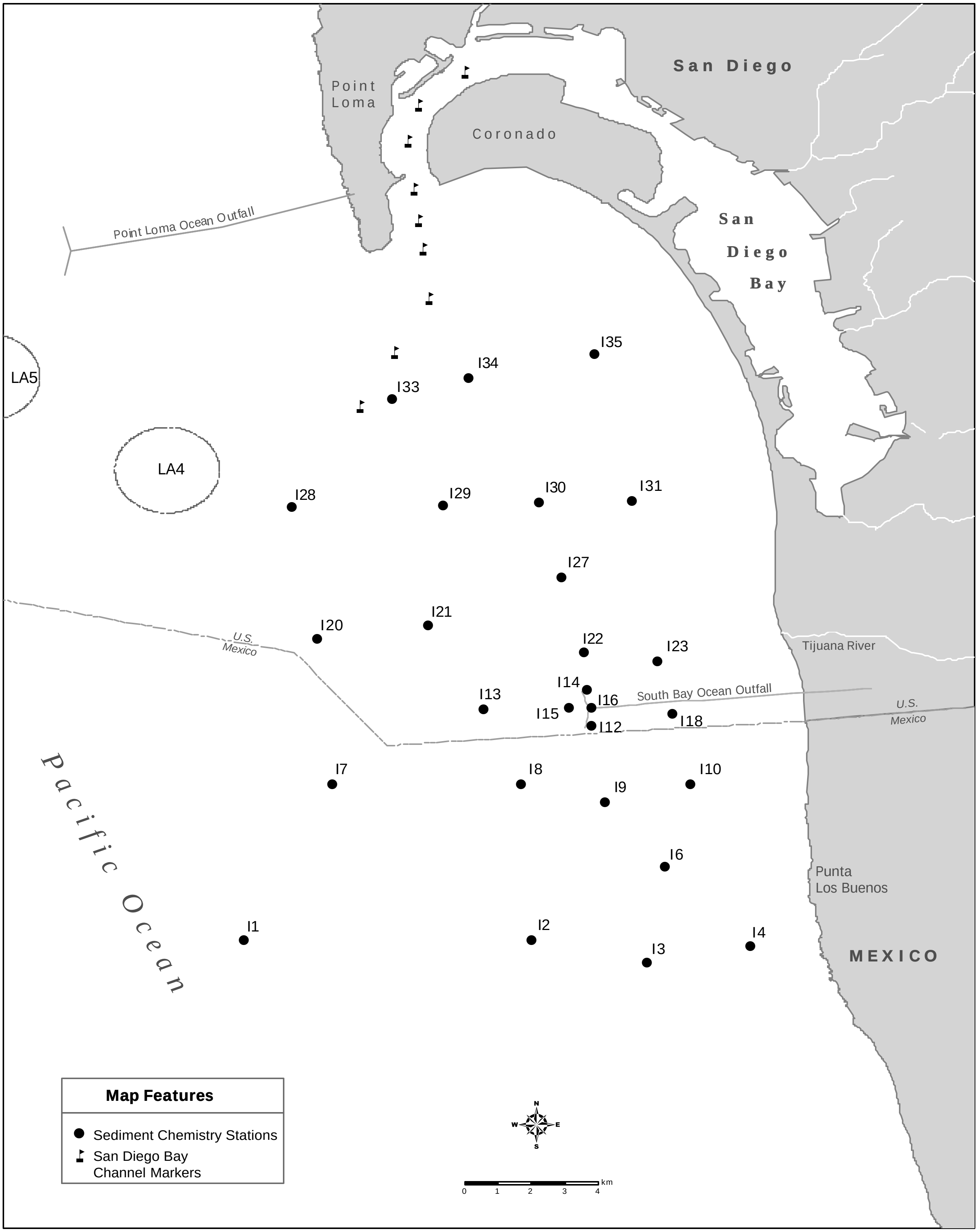

Figure 4.1
Sediment chemistry station locations, South Bay Outfall Monitoring Program.

form a grid surrounding the terminus of the outfall. A chain-rigged 0.1 m^2 Van Veen grab was used to collect each sample. 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 grain size analyses were performed at the City of San Diego's Wastewater Chemistry Laboratory. Particle size analysis was performed using a Horiba LA-920 laser scattering particle analyzer, which measures particles ranging in size from -1 to 11 phi (i.e., sand, silt and clay fractions). Coarser sediments (e.g., very coarse sand, gravel, shell hash) were removed from samples prior to analysis by screening the samples through a 2.0 mm mesh sieve. These data were expressed as the percent "Coarse" of the total sample sieved (see **Appendix A.2**).

A disparity in trace metal detection rates occurred between the January and July surveys as a result of a change in instrumentation. A more sensitive Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) technique for analysis of metals was introduced mid-year of 2003. An IRIS axial ICP-AES system replaced the Atomscan radial ICP-AES. The superior abilities of the IRIS axial ICP-AES lowered the method detection limits approximately an order of magnitude. Consequently, low concentrations of metals that would not have been detected in the January samples were detected during the July survey. These lower MDL values are presented in this report (see **Table 4.3**).

Data Analyses

The data output from the Horiba particle size analyzer were categorized as follows: sand was defined as particles ranging in size from >-1 to 4.0 phi, silt as particles from >4.0 to 8.0 phi, and clay as particles >8.0 phi (see Wentworth Scale, **Table 4.1**). These data were standardized and incorporated with a sieved coarse

Table 4.1

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

Wentworth Scale				Sorting Coefficient	
Phi Size	Microns	Millimeters	Description	Standard Deviation	Sorting
-2	4000	4	Pebble	Under 0.35 phi	very well sorted
-1	2000	2	Granule	0.35–0.49 phi	well sorted
0	1000	1	Very coarse sand	0.50–0.70 phi	moderately well sorted
1	500	0.5	Coarse sand	0.71–1.00 phi	moderately sorted
2	250	0.25	Medium sand	1.01–2.00 phi	poorly sorted
3	125	0.125	Fine sand	2.01–4.00 phi	very poorly sorted
4	62.5	0.0625	Very fine sand	Over 4.00 phi	extremely poorly sorted
5	31	0.031	Coarse silt		

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

Conversions for Diameter in Millimeters to Phi: D (phi) = -3.3219 log10 D (mm) fraction containing particles >2.0 mm in diameter to obtain a distribution of coarse, sand, silt, and clay totaling 100%. The coarse fraction was included with the phi -1 fraction in the calculation of various particle size parameters, which were calculated using a normal probability scale (see Folk 1968). The parameters included mean and median phi size, standard deviation of phi size (sorting coefficient), skewness, kurtosis and percent sediment type (i.e., coarse, sand, silt, clay).

Chemical parameters analyzed were total organic carbon (TOC), total nitrogen, total sulfides, trace metals, chlorinated pesticides, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyl compounds (PCBs). Generally, values below method detections limits are treated as "not detected" (i.e., Null). However, some parameters were determined to be present in a sample with high confidence (i.e., peaks are confirmed by mass-spectrometry) at levels below the MDL. These values were included in the data as estimated values. Null ("not detected") values were treated as zero values when performing statistics or estimating the overall means for the survey area.

Concentrations of the various sediment constituents that were detected in 2003 were compared to the average results from previous years, including pre-discharge (1995–1998) and post-discharge (1999–2003) periods. In addition, values for metals, TOC, TN and pesticides (i.e., DDE) were compared to median values for the Southern California Bight that were based on the cumulative distribution function (CDF) for each parameter (see Schiff and Gossett 1998). These CDFs were established for the Southern California Bight using data from a region wide survey in 1994, and are presented as the 50% CDF in the tables included herein. Levels of contamination were further evaluated by comparing the results of this study to the Effects Range Low (ERL) sediment quality guideline of Long et al. (1995). The ERL was originally calculated to provide a means for interpreting monitoring data by the National Status and Trends Program of the National Oceanic and Atmospheric Administration. The ERL represents chemical concentrations below which adverse biological effects were rarely observed.

RESULTS and DISCUSSION

Particle Size Distribution

With few exceptions, fine to medium sands comprised the overall composition of sediments surrounding the South Bay Ocean Outfall in 2003 (**Table 4.2**, **Figure 4.2**). Generally, stations located farther offshore and southward of the SBOO had coarser sediments than those located inshore and to the north of the outfall. Most stations offshore and southward of the SBOO had sediments consisting of relatively coarse particles (≤2.0 phi or ≥0.2 mm). The remaining stations located along the shallower 19 and 28-m contours and towards the mouth of San Diego Bay had finer sediments (>2.0 phi or <0.2 mm). The higher silt content at these latter stations is probably due to sediment deposition from the Tijuana River and to a lesser extent from San Diego Bay (see City of San Diego 1988). This pattern was evident even though the sediments at many sites varied in the proportion of shell hash, red relict sand, coarse sand and silt.

Sorting coefficients (standard deviation) in the area surrounding the SBOO were typically less than 1.0 phi (Table 4.2, Figure 4.2). Generally, such low values are indicative of moderately sorted to well sorted sediments (i.e., sediments composed of similarly sized particles) and are suggestive of strong wave and current activity within an area (see Gray 1981). In contrast, sorting coefficients above 1.0 phi indicate poorly sorted sediments (i.e., particles of varied sizes) and low wave and current activity. Stations I16 and I28 had sorting coefficients

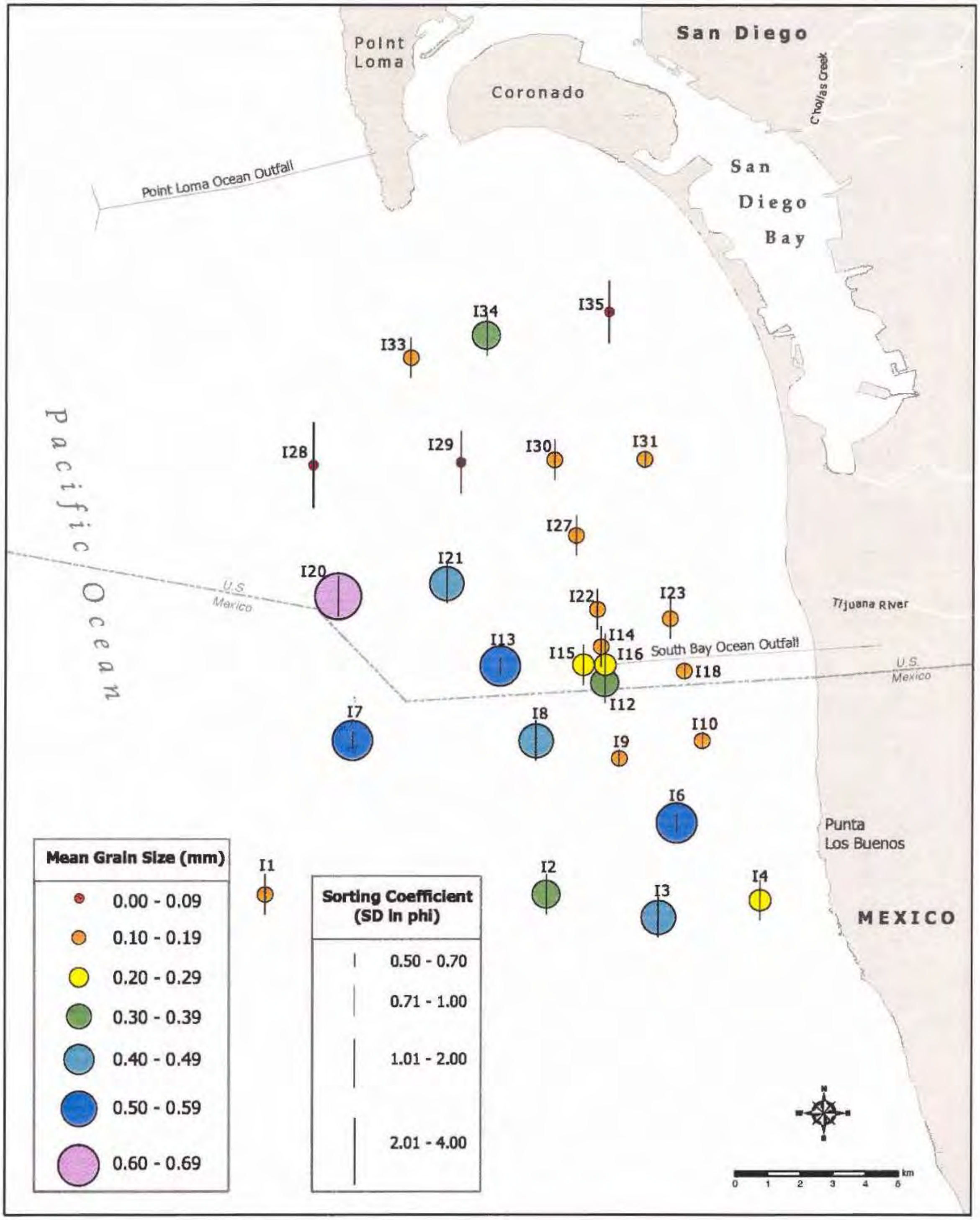

Figure 4.2

Particle size distribution for January and July surveys of sediment chemistry stations sampled during 2003. Mean particle size is based on diameter in millimeters, and sorting coefficient (standard deviation) is in phi units.

January 2003

July 2003

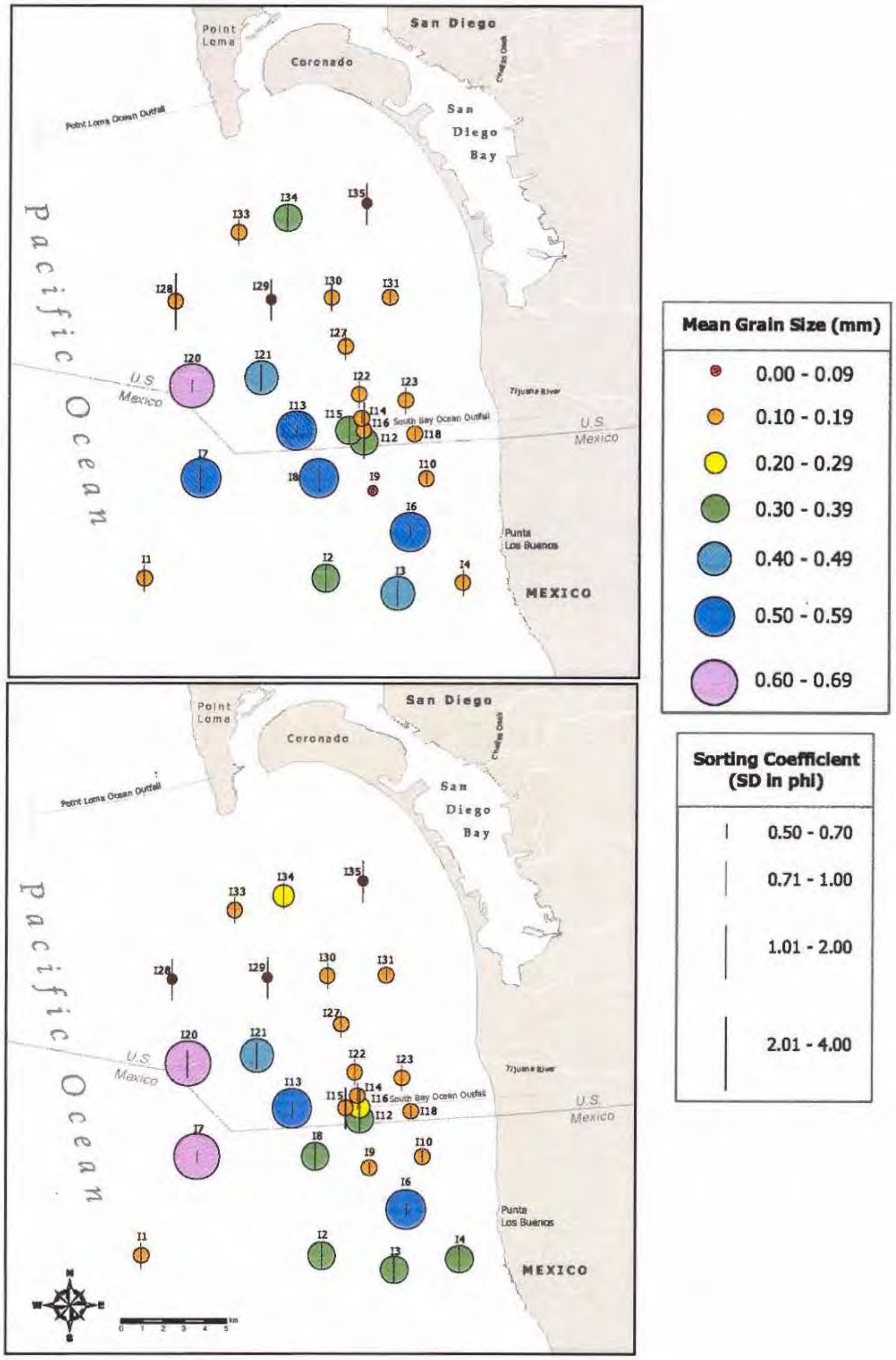

Figure 4.3

Comparison of January and July surveys for differences in sediment particle size distribution for SBOO sediment chemistry stations sampled during 2003. Mean particle size is based on diameter in millimeters, and sorting coefficient (standard deviation) is in phi units.

Table 4.2

Summary of particle size parameters and organic loading indicators at SBOO stations during 2003. Data are expressed as annual means. CDF = cumulative distribution functions (see text); NA = not available. MDL = method detection limit. Area Mean = area mean for 2003. Pre = pre-discharge mean values (1995–1998). Post = post discharge mean values (1999–2003). Sediment Observations are from combined infauna and chemistry grab observations.

	Mean Phi	SD Phi	Mean mm	Coarse %	Sand %	Fines %	Sulfides ppm	TN WT%	TOC WT%	Sediment Observations
CDF							NA	0.051	0.748	
MDL							0.14	0.005	0.01	
19 m stations										
I35	3.8	1.2	0.07	0.0	59.8	40.1	4.69	0.039	0.340	fine sand, silt, organic tubes
I34	1.7	0.8	0.31	3.1	96.9	0.0	3.91	0.005	0.047	sand, shell hash
I31	3.1	0.6	0.12	0.1	92.9	6.8	4.83	0.013	0.111	silt, sandy silt, chem w/ oil
I23	3.0	0.8	0.13	0.1	91.7	7.9	2.46	0.015	0.110	coarse sand, silt, shell hash
I18	3.1	0.7	0.12	0.1	91.0	8.7	2.03	0.013	0.098	silt, silty sand
I10	3.1	0.7	0.12	0.2	91.7	8.0	0.24	0.016	0.122	silt
I4	2.2	1.0	0.22	3.0	92.4	4.6	0.26	0.013	0.083	sand, silt, red relict sand, shell hash
28 m stations										
I33	3.0	1.0	0.13	0.1	88.7	11.0	5.12	0.027	0.214	silty sand, medium sand, shell hash, algae
I30	3.2	0.8	0.11	0.1	85.4	14.5	7.67	0.022	0.193	fine sand, sandy silt
I27	3.2	0.8	0.11	0.1	87.3	12.6	4.22	0.018	0.155	fine sand
I22	3.1	0.8	0.12	0.0	88.8	10.0	4.07	0.017	0.141	silt, fine silty sand, chem w/ organics&oil
I14	3.1	0.8	0.12	0.0	88.7	11.3	2.54	0.017	0.130	fine sand
I15	2.1	1.0	0.23	2.4	91.4	6.2	2.25	0.014	0.099	fine sand
I16	2.2	2.0	0.22	3.8	84.4	9.2	2.49	0.010	0.062	coarse & fine sand, silt, clay, shell hash
I12	1.5	0.9	0.35	4.8	94.7	0.5	1.56	0.005	0.043	fine sand, coarse black sand, shell hash
I9	3.3	0.7	0.10	0.0	85.8	14.1	4.16	0.020	0.158	silt
I6	0.9	0.7	0.54	8.9	91.1	0.1	0.31	0.008	0.045	sandy silt, red relict sand, shell hash
I2	1.6	0.8	0.33	4.2	95.7	0.0	0.00	0.009	0.052	fine sand
I3	1.3	0.8	0.41	5.1	94.9	0.0	0.00	0.005	0.048	fine sand, red relict sand
38 m stations										
I29	3.4	1.2	0.09	0.0	76.8	23.2	7.92	0.026	0.233	silty sand, red relict sand, shell hash
I21	1.1	0.8	0.47	6.2	93.5	0.2	0.88	0.006	0.060	fine red relict sand, shell hash
I13	0.9	0.7	0.54	8.7	91.2	0.1	1.43	0.008	0.048	red relict & coarse sand, shell hash, rocks
I8	1.2	0.9	0.44	7.2	91.0	1.8	0.03	0.011	0.072	fine sand
55 m stations										
I28	3.6	2.1	0.08	4.4	60.6	35.0	6.78	0.036	0.337	coarse sand & black sand, silt, shell hash
I20	0.6	0.8	0.66	15.3	82.6	2.2	0.82	0.010	0.071	coarse red relict sand, shell hash
I7	0.8	0.7	0.57	12.4	86.8	0.8	0.03	0.009	0.048	red relict sand
I1	2.8	0.9	0.14	0.0	91.4	8.4	0.04	0.021	0.096	silt, fine sand
Area Means										
2003	2.3	0.9	0.20	3.3	87.7	8.8	2.62	0.015	0.119	
Post	2.4	0.8	0.19	1.8	89.2	8.9	2.22	0.017	0.133	
Pre-	2.6	1.1	0.16	1.4	87.7	10.2	4.59	0.019	0.143	

of approximately 2.0 phi for both surveys indicating poorly sorted sediments. However, these higher values are probably more indicative of the anthropogenic activities that have occurred in areas near these sites: i.e., dredged sediment disposal around station I28 and outfall construction at station I16 (see City of San Diego 2003).

Overall, there appears to have been little change in mean phi size for the region since 1995. For example, particle sizes averaged 2.3 phi (0.20 mm) in 2003, 2.4 phi (0.19 mm) for all post-discharge years, and 2.6 phi (0.16 mm) over the pre-discharge period (1995–1998). There were also few differences in particle size distribution between the January and July 2003 surveys (**Figure 4.3**). The greatest change in sediment particles occurred at stations I4 and I15, which exhibited changes in mean particle size >1.0 phi between January and July (**Appendix A.2**).

Indicators of Organic Loading

The average concentrations of total organic carbon and total nitrogen for the SBOO area in 2003 were similar to those of previous surveys (**Figure 4.4**). Concentrations of both parameters were below the median values for the Southern California Bight (Table 4.2). The highest average values for these indicators were found at stations I28, I29, I33, and I35 and correspond to high percent fines concentrations at these sites. This is not unexpected, since particle size is known to be a factor affecting concentrations of organic parameters (Emery 1960, Eganhouse and Venkatesan 1993).

Although average sulfide concentrations were only slightly higher than the MDL, they also appeared to correspond to concentrations of percent fines. The average sulfide values for the 2003 survey was slightly higher than the post-discharge mean, but considerably lower than the pre-discharge mean. Overall, there was no pattern in the concentrations of indicators of organic loading relative to the SBOO discharge.

Trace Metals

Trace metal concentrations in the SBOO sediments were generally low compared to the median values for southern California, and all were below the ERL sediment quality thresholds (**Table 4.3**). Many of the trace metals were detected at concentrations near or below their MDLs. These include antimony, beryllium, cadmium, copper, lead, mercury and tin. Selenium and silver were not detected at any station. The highest concentrations of metals occurred at stations I35 and I9, and may be related to the finer particles at these two stations. In contrast, the highest concentrations of arsenic occurred where the sediments consisted of very coarse red relict sand (i.e., stations I21, I7, and I13). Generally, there was no pattern in trace metal contamination related to proximity to the SBOO.

Pesticides

A single chlorinated pesticide was detected in three sediment samples collected during 2003. The DDT derivative, p,p-DDE, was detected in the January survey at stations I28 (300 ppt) and I29 (370 ppt), and the July survey at station I29 (480 ppt). These values were lower than the median CDF value of 1,250 ppt for this pesticide, and significantly lower than the ERL of 3,890 ppt. Station I28 has had elevated pesticide levels in the past which have been periodically associated with dredge disposal materials (see City of San Diego 2001, 2002a, b).

PCBs and PAHs

PCBs were not detected at any station during 2003. Additionally, low levels of eleven PAH compounds were detected at only two stations. Station I12 had a total PAH concentration of 75 ppt in January, while station I1 had a total PAH concentration 417 ppt in July (see **Appendix A.3**). These values were well below the ERL of

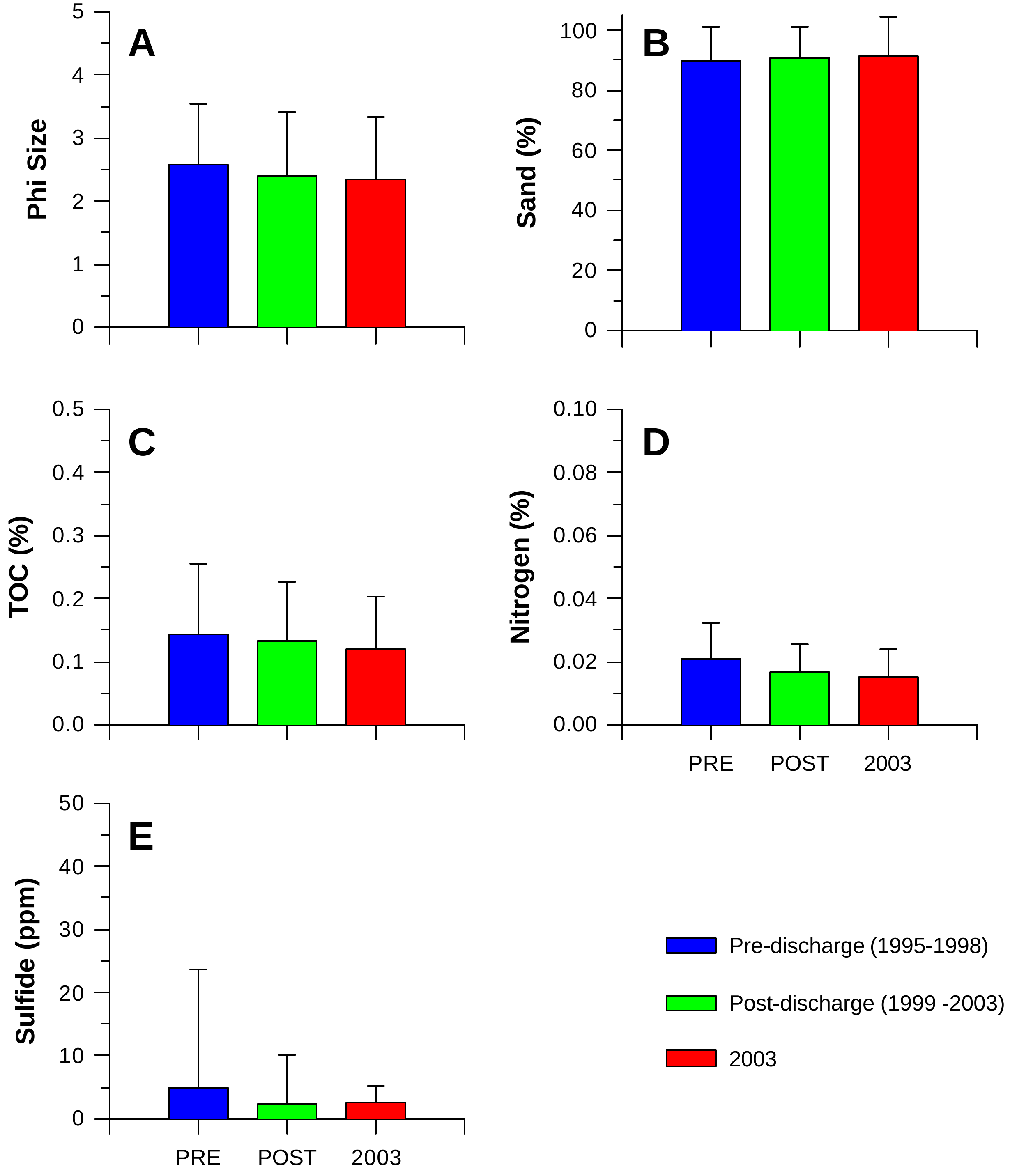

Figure 4.4

Comparison of values for several sediment quality parameters surrounding the SBOO in 2003 with values during all post-discharge monitoring (1999–2003) and the pre-discharge period (1995–1998): (A) mean phi size; (B) percent sand; (C) percent total organic carbon; (D) percent total nitrogen; (E) sulfides (ppm). Data are expressed as area wide means for each survey period. Error bars represent one standard deviation.

Table 4.3

Concentrations of trace metals (parts per million) detected at each station during 2003. CDF = cumulative distribution function (see text). MDL = method detection limit. ERL TV = Effects Range Low Threshold Value. NA = not available. Area Mean = area mean for 2003. Pre = pre-discharge mean values (1995–1998). Post = post discharge mean values (1999–2003). Values that exceed the median CDF are indicated in bold type. See **Appendix A.1** for metal names represented by the periodic table symbols.

	Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Tl	Sn	Zn
MDL	1.15	0.13	0.33	0.002	0.001	0.01	0.016	0.028	0.75	0.142	0.004	0.003	0.036	0.022	0.059	0.052
CDF	9400	0.2	4.80	NA	0.26	0.29	34.0	12.0	16800	10.2	NA	0.04	16.3	NA	NA	56.0
ERL	NA	NA	8.2	NA	NA	1.2	81	34	NA	46.7	NA	0.15	20.9	NA	NA	150
19 m stations																
I35	8810	nd	2.70	46.50	**0.87**	0.05	11.5	7.5	11055	2.10	113.0	0.020	4.4	nd	0.3	29.1
I34	1990	nd	1.22	10.40	0.02	nd	6.2	1.3	4195	nd	57.0	0.005	2.5	nd	0.2	5.7
I31	4115	0.1	1.05	16.90	0.03	0.02	8.1	1.7	4020	0.60	52.8	0.003	0.9	0.1	0.2	8.9
I23	5250	nd	1.33	26.70	0.04	0.01	9.1	3.1	5445	nd	69.5	0.009	1.4	nd	0.1	10.8
I18	5420	nd	1.43	34.30	**0.64**	0.02	11.3	2.9	6705	0.80	75.3	0.001	1.2	nd	0.1	12.0
I10	6925	nd	1.47	42.50	0.05	0.02	10.5	5.4	7490	1.00	79.8	0.008	3.4	nd	0.1	18.4
I4	3055	nd	1.46	2.83	0.01	0.01	6.6	0.8	3285	0.40	35.8	0.003	0.4	nd	0.2	5.9
28 m stations																
I33	4755	nd	1.79	20.60	**0.41**	0.01	7.2	8.0	6420	1.90	76.5	0.022	1.6	nd	0.2	16.6
I30	6545	0.1	1.61	31.60	**0.60**	0.02	12.9	3.7	6675	1.00	66.0	0.006	3.2	nd	0.2	16.5
I27	6630	nd	1.42	35.80	**0.53**	0.02	9.7	4.1	6575	1.10	71.9	0.008	3.4	nd	0.1	16.3
I22	5020	nd	1.61	24.70	**0.40**	0.03	9.9	4.1	5125	1.00	56.2	0.004	1.6	nd	0.1	12.0
I14	6655	nd	1.71	43.00	**0.56**	0.03	11.3	4.9	7225	1.00	76.3	0.005	3.1	nd	0.1	17.5
I15	2930	0.1	2.39	22.10	0.04	0.01	9.4	1.8	5250	1.00	35.5	0.005	1.0	nd	0.2	10.7
I16	3145	nd	1.82	10.10	0.03	0.01	5.3	1.4	4040	nd	40.5	0.005	0.8	nd	0.2	8.7
I12	2170	0.1	1.66	8.47	0.02	0.01	8.5	0.8	3480	0.50	31.6	0.002	2.5	nd	0.2	6.9
I9	8590	nd	2.15	46.80	0.06	0.03	17.4	5.4	8610	1.00	91.3	0.004	7.6	nd	0.1	20.9
I6	1011	0.1	4.25	1.50	0.02	0.01	7.3	0.7	3630	0.70	11.7	0.005	0.4	nd	0.3	1.4
I2	1200	0.1	0.62	1.67	0.15	0.02	8.1	0.6	1195	0.40	10.7	0.003	0.3	0.1	0.3	0.9
I3	904	0.1	0.84	1.50	0.01	0.01	7.8	0.8	1260	0.50	8.1	0.004	0.4	0.1	0.3	1.0
38 m stations																
I29	5485	nd	2.39	28.10	0.06	0.01	25.1	4.1	8125	1.30	65.6	0.014	10.8	nd	0.2	16.5
I21	1360	0.1	**6.93**	2.57	0.03	0.02	12.4	1.2	7425	1.40	15.6	0.002	1.2	9.0	0.3	6.4
I13	1070	0.1	**5.84**	2.48	0.02	0.01	10.6	5.6	5445	1.20	16.4	0.008	0.3	nd	0.3	5.1
I8	1815	0.1	3.06	6.94	0.03	nd	8.1	1.0	4870	0.80	21.0	nd	0.5	nd	0.3	7.3
55 m stations																
I28	5445	nd	2.16	15.70	0.04	0.02	8.7	4.4	6795	nd	55.4	0.024	5.1	nd	0.3	15.1
I20	1185	nd	3.37	2.13	0.02	0.01	4.2	0.6	4905	0.80	18.3	0.005	0.2	nd	0.3	5.5
I7	1190	0.1	**5.76**	2.02	0.02	nd	12.8	0.7	6480	1.20	18.5	0.002	2.8	nd	0.3	5.8
I1	2795	nd	1.08	7.39	0.03	0.02	5.9	1.5	3510	nd	39.1	0.005	1.3	nd	0.2	6.5
Area Means																
2003	3906	0.1	2.34	18.34	0.18	0.02	9.8	2.9	5527	0.99	48.5	0.007	2.3	2.3	0.2	10.7
Post	4589	0.1	2.44	18.36	0.16	0.06	9.1	4.1	5869	0.27	53.1	0.003	1.4	0.5	0.0	12.6
Pre-	5164	0.1	2.47	na	0.12	0.00	10.2	2.6	6568	0.09	47.4	0.003	1.9	0.2	0.0	12.5

1,684 ppt, and near or below their respective MDL levels. Station I1 (55 m) is located in Mexican waters, while station I12 (28 m) is near the south outfall diffuser.

SUMMARY and CONCLUSIONS

Overall, sediment conditions surrounding the South Bay Ocean Outfall (SBOO) in 2003 were similar to previous years (see City of San Diego 2003). Moreover, there was no indication of contaminant footprints surrounding the South Bay outfall based on analyses of particle size or sediment chemistry data.

During 2003, sediments within the SBOO sampling grid consisted primarily of fine to medium sands with an average particle size of 2.3 phi (0.20 mm). The spatial patterns in sediment composition may be partially attributed to the multiple geological origins of red relict sands, shell hash, coarse sands, and other detrital sediments (Emery 1960). Stations located offshore and southward of the SBOO consisted of very coarse sediments. In contrast, stations located in shallower water and north of the outfall towards the mouth of San Diego Bay had finer sediments. Sediment deposition from the Tijuana River and to a lesser extent from San Diego Bay probably contributes to the higher content of silt at these stations (see City of San Diego 1988). Generally, the low sediment sorting coefficients suggest that relatively strong currents in the region may affect sediment composition at the SBOO sample sites.

Concentrations of organic indicators and metals were relatively low in South Bay sediments compared to the entire southern California continental shelf (see Schiff and Gossett 1998). Higher concentrations of organic compounds and most trace metals were generally associated with finer sediments. This pattern is consistent with that found in other studies, in which the accumulation of fine sediments has been shown to greatly influence the organic and metal content of sediments (e.g., Eganhouse and Venkatesan 1993). Most metals were detected at all or nearly all stations as a result of the use of a more sensitive metals detection instrument during the July survey. Only silver and selenium were undetected, while antimony and thallium were rarely detected. Stations I35 and I9 had the highest concentrations metals overall, and both had higher percentages of fine sediments in comparison to other stations. In contrast, the highest concentrations of arsenic were found where sediments consisted of very coarse red relict sand. Other sediment contaminants were rarely detected in the region during 2003. For example, PCBs were not detected at any stations, and only one derivative of the chlorinated pesticide DDT was detected at two stations. PAHs were found at only two stations; one station during January and another during July.

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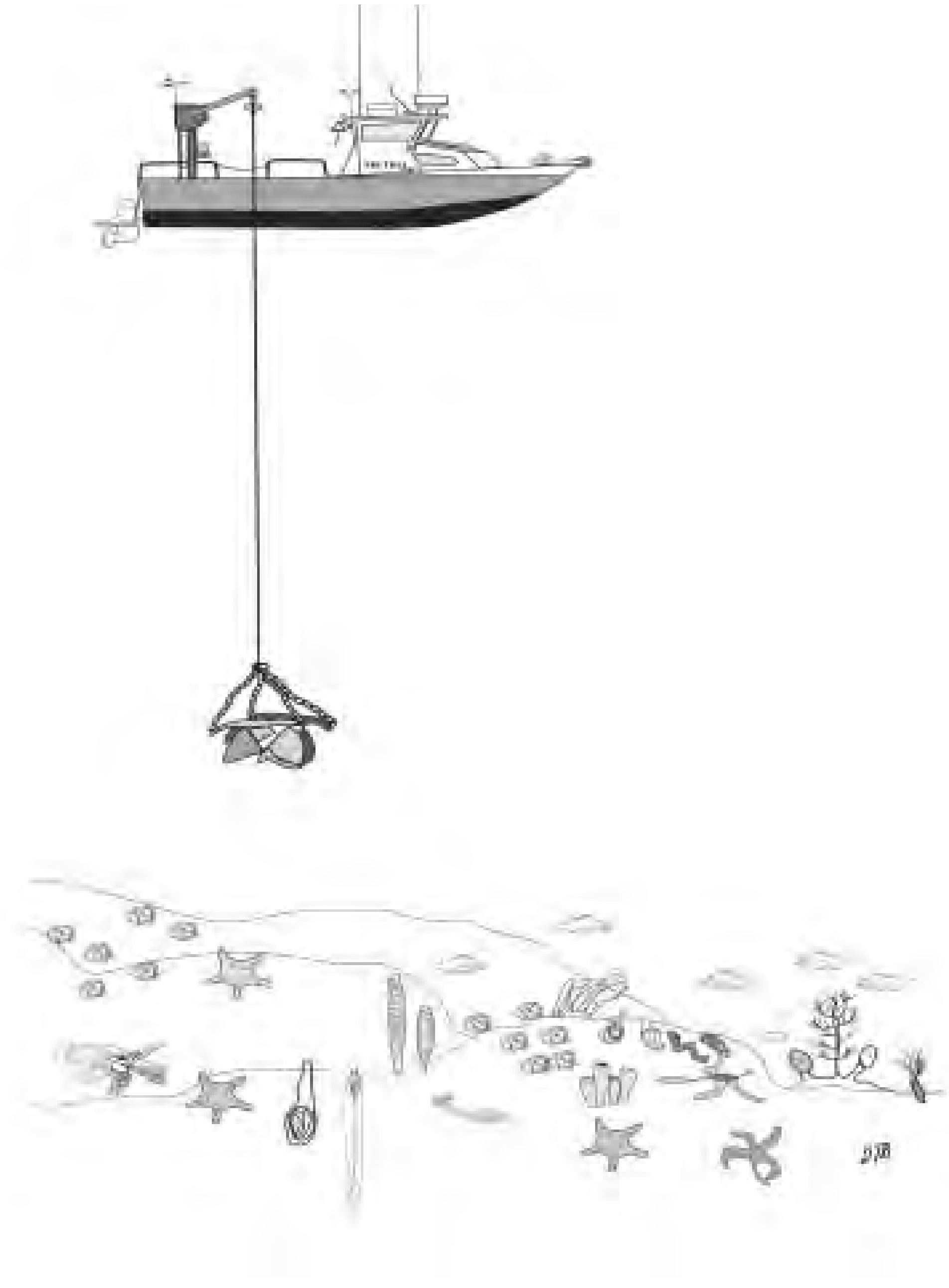
Macrobenthic Communities



Chapter 5
Macrobenthic Communities

INTRODUCTION

Along the coastal shelf of southern California, benthic macroinvertebrates that live within or on the surface of the sediments (i.e., infauna and epifauna, respectively), represent a diverse faunal community (Fauchald and Jones 1979, Thompson et al. 1993a, Bergen et al. 2001). These animals are important members of the marine ecosystem, serving vital functions in wide ranging capacities. Some species decompose organic material as a crucial step in nutrient cycling; others filter suspended particles from the water column, contributing to water clarity. Benthic macrofauna are also an essential food source for fish and other organisms.

Human activities that impact the benthos can sometimes result in toxic contamination, low levels of oxygen, or other forms of environmental degradation. Certain macrofaunal species are highly sensitive and rarely occur in such impacted areas. Others are opportunistic and thrive under altered conditions. Since various species respond differently to environmental stress, macrobenthic assemblages have become valuable indicators of anthropogenic impact (Pearson and Rosenberg 1978, Warwick 1993, Smith et al. 2001). Consequently, the assessment of benthic community structure is a major component of many marine monitoring programs, which document both existing conditions and trends over time.

The structure of benthic communities is influenced by many factors including sediment conditions (e.g., particle size and sediment chemistry), water conditions (e.g., temperature, salinity, dissolved oxygen, and current velocity) and biological factors (e.g., food availability, competition, and predation). For example, benthic assemblages on the coastal shelf off San Diego typically vary along gradients in particle size and depth. Nevertheless, both human activities and natural processes can influence the structure of invertebrate communities in marine sediments. Therefore, in order to determine whether changes in community structure are related to human impacts, it is necessary to have documentation of background or reference conditions for an area. Such information is available for the SBOO discharge area and the San Diego region in general (e.g., City of San Diego 1999, 2000).

This chapter presents analyses and interpretations of the macrofaunal data collected at fixed stations surrounding the SBOO during 2003. Included are descriptions and comparisons of soft-bottom macrofaunal assemblages in the area, and analysis of benthic community structure.

MATERIALS & METHODS

Collection and Processing of Samples

Benthic samples were collected during January and July, 2003 at 27 stations surrounding the SBOO pipe (**Figure 5.1**). These stations range in depth from 18 to 60 m and are distributed along the following main depth contours: the 19, 28, 38, and 55-m contours.

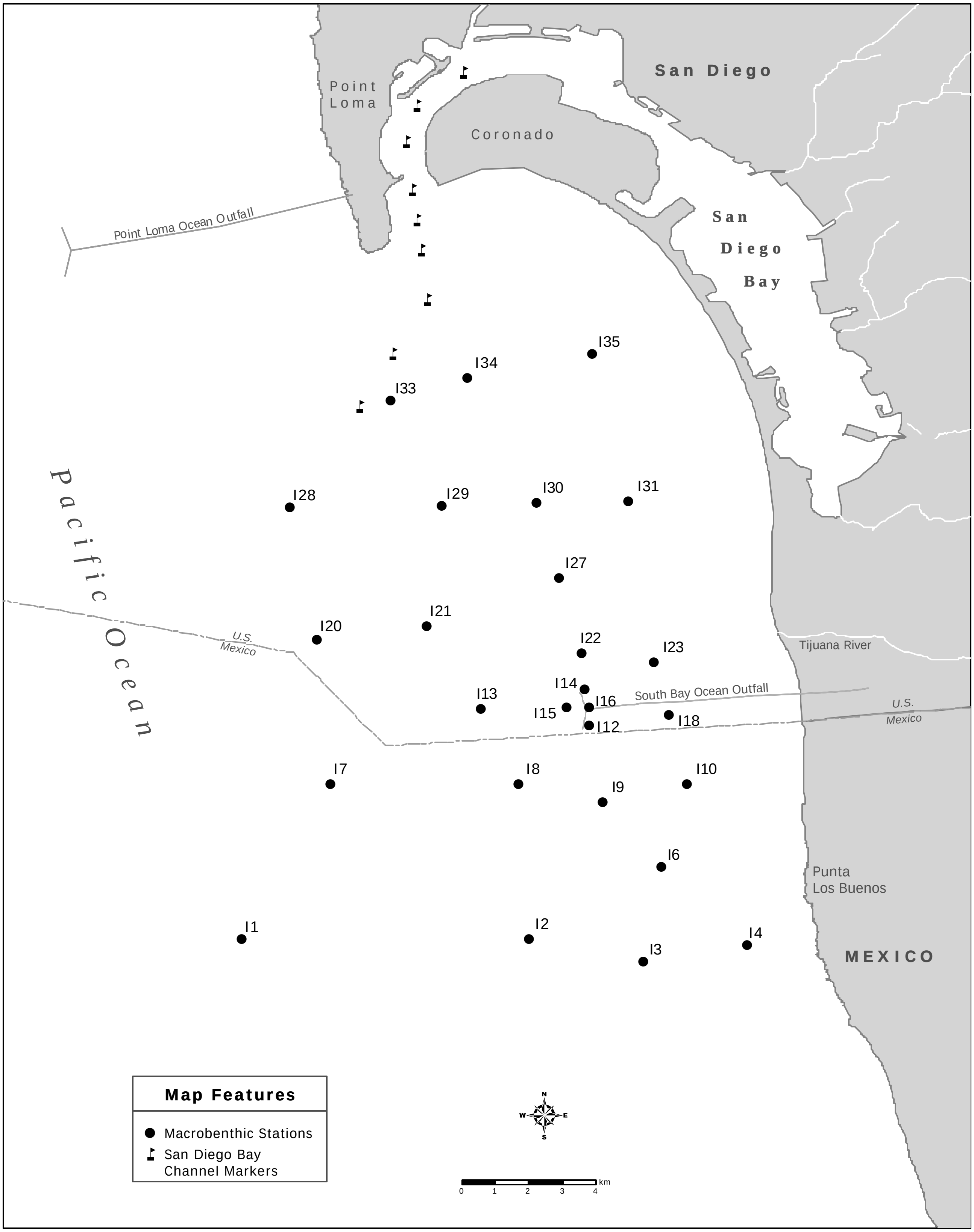


Figure 5.1
Macrobenthic station locations, South Bay Ocean Outfall Monitoring Program.

Samples for benthic community analysis were collected from two replicate 0.1-m^2 van Veen grabs per station during each survey. A third grab was collected at each station for physico-chemical analyses of the sediments (see chapter 4). The criteria established by the United States Environmental Protection Agency (USEPA) to ensure consistency of grab samples were followed with regard to sample disturbance and depth of penetration (USEPA 1987). All samples were sieved aboard ship through a 1.0-mm mesh screen. Organisms retained on the screen were relaxed for 30 minutes in a magnesium sulfate solution and then fixed in buffered formalin (see City of San Diego 2004). After a minimum of 72 hours, each sample was rinsed with fresh water and transferred to 70% ethanol. All organisms were sorted from the debris into major taxonomic groups by a subcontractor. Biomass was measured as the wet weight in grams per sample for each of the following taxonomic categories: Annelida (mostly polychaetes), Arthropoda (mostly crustaceans), Mollusca, Ophiuroidea, non-ophiuroid Echinodermata, and all other phyla combined (e.g., Chordata, Cnidaria, Nemertea, Platyhelminthes, Phoronida, Sipuncula). Values for ophiuroids and all other echinoderms were later combined to give a total echinoderm biomass. After biomassing, all animals were 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: species richness (number of species per 0.1-m^2 grab); total number of species per station for the year; abundance (number of individuals per grab); biomass (grams per grab, wet weight); Shannon diversity index (H' per grab); Pielou's evenness index (J' per grab); Swartz dominance (minimum number of species accounting for 75% of the total abundance in each grab); Infaunal Trophic Index (ITI per grab) (see Word 1980); and Benthic Response Index (BRI per grab) (see Smith et al. 2001).

Multivariate analyses were performed using PRIMER v5 (Plymouth Routines in Multivariate Ecological Research) software to examine spatio-temporal patterns in the overall similarity of benthic assemblages in the region (see Clarke 1993, Warwick 1993). These analyses included classification (cluster analysis) by hierarchical agglomerative clustering with group-average linking, and ordination by non-metric multidimensional scaling (MDS). The macrofaunal abundance data were fourth-root transformed and the Bray-Curtis measure of similarity was used as the basis for both classification and ordination. Analyses were run on individual grab samples and on the mean of the two replicate grabs per station/survey. Differences in results were considered negligible; thus for clarity and simplicity, results presented herein are for mean abundances of replicate grabs per station/survey. 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 (see Field et al. 1982).

RESULTS & DISCUSSION

Community Parameters

Number of Species

In total, 683 macrobenthic taxa were identified during 2003. Of these, 22% represented rare or unidentifiable taxa that were recorded only once. The average number per 0.1 m^2 grab ranged from 27 to 137, and the cumulative number of taxa per station ranged from 65 to 275 (**Table 5.1**). This wide variation in species richness is consistent with previous years, and can probably be attributed to different habitat types (see City of

Table 5.1

Benthic community parameters at SBOO stations sampled during 2003. Data are expressed as annual means for: species richness, no. species/0.1 m^2(SR); total no. species for the year (Tot Spp); abundance/0.1 m^2 (Abun); biomass, g/0.1 m^2; diversity (H'); evenness (J'); Swartz dominance, no. species comprising 75% of a community by abundance (Dom); benthic response index (BRI); infaunal trophic index (ITI).

	SR	Tot spp	Abun	Biomass	H'	J'	Dom	BRI	ITI
19 m stations									
I-35	79	164	205	5.9	3.9	0.90	32	25	79
I-34	27	70	144	3.0	2.2	0.72	6	1	74
I-31	48	102	401	1.8	2.1	0.55	7	13	71
I-23	64	166	484	5.7	2.9	0.71	12	14	68
I-18	44	107	200	3.3	2.4	0.63	9	12	72
I-10	48	106	130	2.0	3.3	0.86	20	17	77
I-4	31	74	111	6.0	2.9	0.85	11	-1	74
28 m stations									
I-33	95	201	343	2.4	3.8	0.84	30	24	75
I-30	56	128	198	2.0	3.2	0.79	18	21	73
I-27	35	81	130	1.0	2.6	0.72	11	21	73
I-22	53	114	202	4.1	2.9	0.72	14	20	76
I-14	45	109	148	1.0	2.9	0.78	15	18	74
I-16	43	114	135	2.6	3.2	0.85	15	18	84
I-15	30	73	73	6.0	3.0	0.89	14	15	73
I-12	39	105	99	2.2	3.1	0.87	17	14	77
I-9	57	129	165	1.3	3.3	0.82	21	22	76
I-6	41	98	155	3.5	2.6	0.70	11	12	75
I-2	32	65	102	1.0	2.9	0.83	11	10	75
I-3	32	74	211	6.9	2.4	0.70	8	6	80
38 m stations									
I-29	61	162	211	2.3	3.3	0.79	21	12	82
I-21	35	78	145	5.2	2.5	0.71	11	4	94
I-13	30	76	71	1.4	2.8	0.87	14	6	87
I-8	40	91	125	6.0	2.9	0.78	13	13	75
55 m stations									
I-28	137	275	350	26.7	4.6	0.93	62	9	84
I-20	37	86	103	1.8	3.0	0.86	14	3	91
I-7	39	92	87	10.6	3.2	0.90	18	-1	88
I-1	42	94	102	1.5	3.3	0.88	19	15	76
All stations									
Mean	49	112	179	4.3	3.0	0.79	17	13	78
Min	27	65	71	1.0	2.1	0.55	6	-1	68
Max	137	275	484	26.7	4.6	0.93	62	25	94

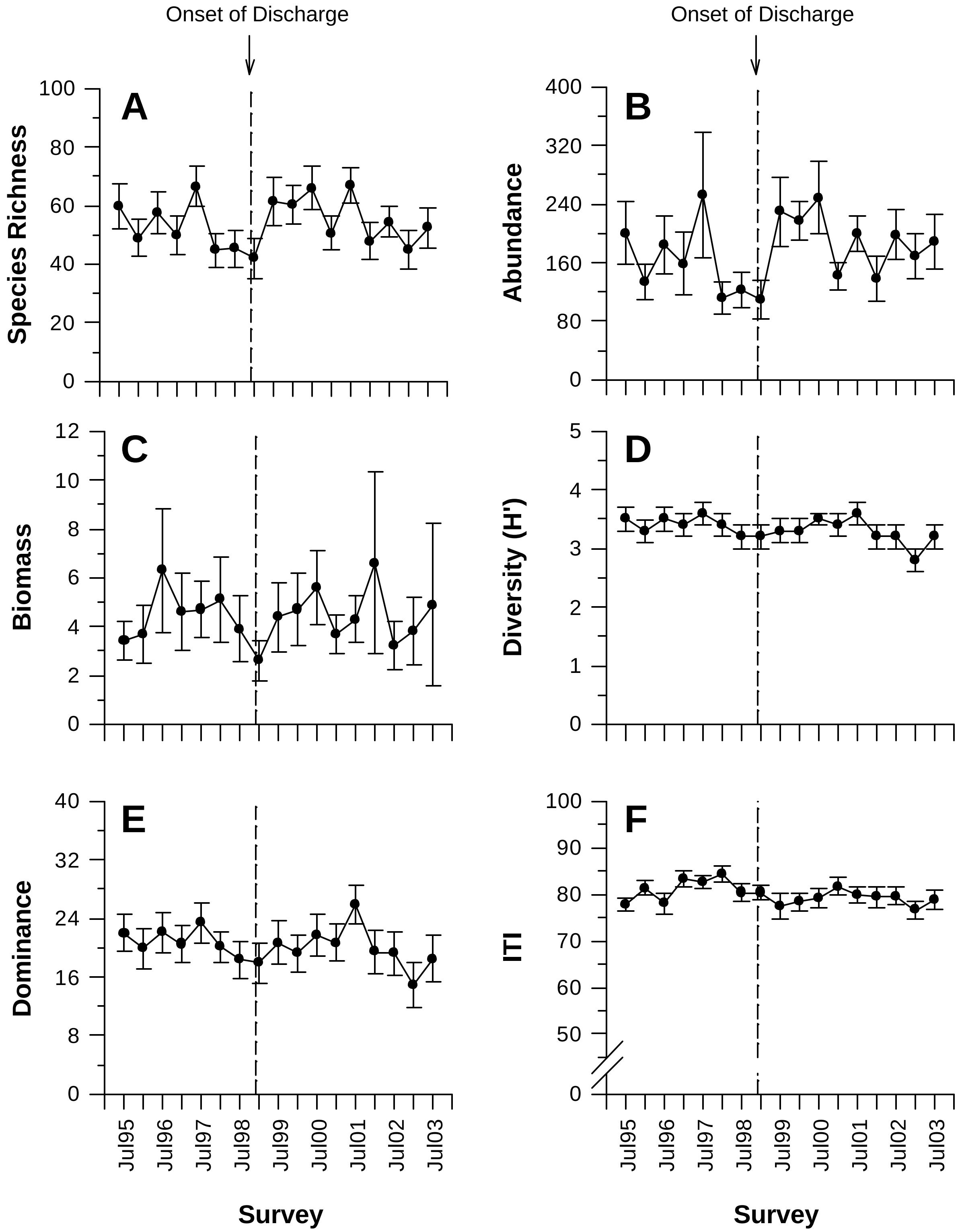


Figure 5.2

Summary of benthic community structure parameters surrounding the South Bay Ocean Outfall (1995–2003). (A) Species Richness = number of species; (B) Abundance = number of individuals; (C) Biomass = grams, wet weight; (D) Diversity = Shannon diversity index (H'); (E) Dominance = Swartz dominance index; (F) ITI = infaunal trophic index. Data are expressed as means per $0.1m^2$ grab pooled over all stations for each survey (n = 54). Error bars represent 95% confidence limits.

San Diego 2003). Higher numbers of species, for example, are common at stations such as I28, I35, and I29 where the sediments contain more fine particles than most SBOO sites (see Chapter 4). In addition, species richness varied seasonally, averaging about 16% higher in July than in January (see **Figure 5.2**A). Although species richness varied both spatially and temporally, there were no apparent patterns relative to distance from the outfall.

Polychaete worms made up the greatest proportion of species, accounting for 32–54% of the taxa at various sites during 2003. Crustaceans composed 14–35% of the species, molluscs 11–26%, echinoderms 2–11%, and all other taxa combined about 4–16%. These percentages are generally similar to those observed during previous years, including prior to discharge (e.g., see City of San Diego 2000, 2003).

Macrofaunal Abundance

Macrofaunal abundance ranged from a mean of 71 to 484 animals per grab in 2003 (Table 5.1). The greatest number of animals occurred at stations I23, I31, I28, and I33, which were the only sites that averaged over 300 individuals per sample. Stations I28 and I33 are typically characterized by high abundance, with a variety of different taxa accounting for the high numbers (see City of San Diego 2003). In contrast, high abundances at I23 and I31 were primarily due to large numbers of individuals representing dominant taxa such as the spionid polychaetes *Spiophanes bombyx* and *S. duplex*, and the sabellid polychaete *Euchone arenae*. Mean abundance varied slightly between the January and July surveys, reflecting a seasonal pattern similar to that described for species richness (see Figure 5.2B). Overall, abundance values were well within the range of historical variation, and there were no clear spatial patterns relative to the outfall.

Similar to past years, polychaetes were the most abundant animals in the region, accounting for 35–86% of the different assemblages during 2003. Crustaceans averaged 7–33% of the animals at a station, molluscs 4– 20%, echinoderms >1–16%, and all remaining taxa about 1–21% combined.

Biomass

Total biomass averaged from 1.0 to 26.7 grams per 0.1 m^2 (Table 5.1). High biomass values are often due to the collection of large motile organisms such as sand dollars, sea stars, crabs, and snails. For example, during 2003 a single specimen of the gastropod mollusc *Crossata californica* weighed 90 grams, accounting for over 84% of the annual biomass at station I28, and over 34% of the biomass for all stations during the July survey (see Figure 5.2C). Another large gastropod, *Neverita reclusiana* (33.8 g), had a similar impact on the biomass at station I7. In addition, large specimens (>10 g) of the echinoderms *Dendraster terminalis* and *Lovenia cordiformis* skewed the biomass at stations I3, I4, I8, and I15. Although these megabenthic invertebrates introduced considerable variability, biomass at the SBOO stations during 2003 was similar to historical values (Figure 5.2C).

Overall, polychaetes accounted for 4–66% of the biomass at a station, crustaceans 1–76%, molluscs 2–86%, echinoderms 1–85%, and all other taxa combined 2–43%. In the absence of large individual molluscs or echinoderms, polychaetes dominated most stations in terms of biomass.

Species Diversity and Dominance

Species diversity (H') varied widely during 2003, ranging from 2.1 at station I31 to 4.6 at I28 (Table 5.1). The H' values from the January survey represent some of the lowest reported to date at the SBOO stations (Figure 5.2D). These low values can largely be explained by high abundances of the polychaetes *Spiophanes bombyx*, *Spiophanes duplex*, and *Euchone arenae*. Although average diversity in the region was lower than typical, spatial patterns were generally consistent with previous years (see City of San Diego 2003), and no patterns relative to distance from the outfall were apparent. The relatively wide range of evenness values (0.55–0.93) also reflects the dominance of a few species at some of the SBOO stations. Most sites with evenness values below the mean (0.8) were dominated by the polychaetes mentioned above. The spatial patterns in evenness were similar to those described for diversity.

Species dominance was measured as the minimum number of species accounting for 75% of a community by abundance (see Swartz 1978). Consequently, dominance as discussed herein is inversely proportional to numerical dominance, such that low values indicate communities dominated by few species. Values at individual stations varied widely, averaging from 6 to 62 species per station during the year (Table 5.1). The relatively low dominance throughout the region during January (see Figure 5.2E), reflects high numbers of a few dominant polychaetes discussed above. No clear patterns relative to the outfall were evident in dominance values.

Environmental Disturbance Indices

The benthic response index (BRI) during 2003 averaged from -1 to 25 at the various SBOO stations (Table 5.1). Index values below 25 (on a scale of 100) suggest undisturbed communities or "reference conditions," and those in the range of 25–33 only represent "a minor deviation from reference condition" which may or may not

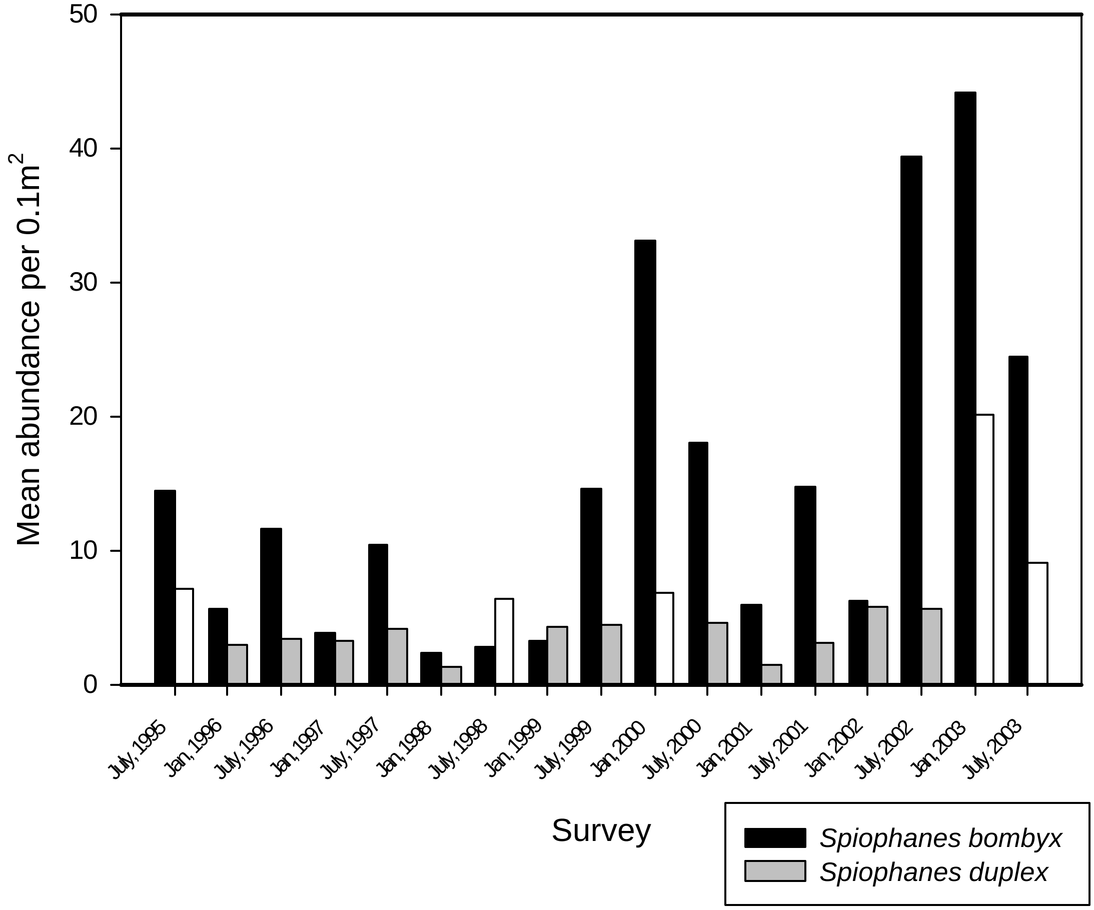


Figure 5.3

Mean abundance per 0.1 m^2 grab of the common polychaetes *Spiophanes bombyx* and *Spiophanes duplex*, for each survey at the SBOO benthic stations from July 1995 to July 2003.

Table 5.2

Dominant macroinvertebrates at the SBOO benthic stations sampled during 2003. Included are the 10 most abundant species overall, the 10 most abundant per occurrence, and the 10 most frequently collected (or widely distributed) species. Abundance values are expressed as mean number of individuals per 0.1 m^2 grab sample. MAS = mean abundance per sample; MAO = mean abundance per occurrence; PA = percent of total abundance; FO = frequency of occurrence (%).

	Species	Higher taxa	MAS	MAO	PA	FO
Most Abundant						
1.	*Spiophanes bombyx*	Polychaeta: Spionidae	34.3	34.9	19.2	98
2.	*Spiophanes duplex*	Polychaeta: Spionidae	14.6	20.7	8.1	70
3.	*Euchone arenae*	Polychaeta: Sabellidae	7.0	18.8	3.9	37
4.	*Tellina modesta*	Mollusca: Bivalvia	3.9	6.6	2.2	59
5.	Nematoda	Nematoda	3.7	10.5	2.1	35
6.	*Dendraster terminalis*	Echinodermata: Echinoidea	2.3	7.3	1.3	31
7.	*Ampelisca cristata cristata*	Crustacea: Amphipoda	2.0	2.7	1.1	74
8.	*Monticellina siblina*	Polychaeta: Cirratulidae	2.0	3.7	1.1	54
9.	*Hesionura coineaui difficilis*	Polychaeta: Phyllodocidae	1.9	12.9	1.1	15
10.	*Hemilamprops californicus*	Crustacea: Cumacea	1.7	2.9	1.0	59
Most Abundant per Occurrence						
1.	*Pareurythoe californica*	Polychaeta: Amphinomidae	1.2	63.5	0.7	2
2.	*Polycirrus* sp SD 3	Polychaeta: Terebellidae	0.7	39.0	0.4	2
3.	*Spiophanes bombyx*	Polychaeta: Spionidae	34.3	34.9	19.2	98
4.	*Spiophanes duplex*	Polychaeta: Spionidae	14.6	20.7	8.1	70
5.	*Euchone arenae*	Polychaeta: Sabellidae	7.0	18.8	3.9	37
6.	*Hesionura coineaui difficilis*	Polychaeta: Phyllodocidae	1.9	12.9	1.1	15
7.	*Micropodarke dubia*	Polychaeta: Hesionidae	0.2	12.0	0.1	2
8.	Nematoda	Nematoda	3.7	10.5	2.1	35
9.	*Saccocirrus* sp	Polychaeta: Saccocirridae	0.5	9.7	0.3	6
10.	*Cirriformia* sp SD 2	Polychaeta: Cirratulidae	0.4	9.5	0.2	4
Most Frequently Collected						
1.	*Spiophanes bombyx*	Polychaeta: Spionidae	34.3	34.9	19.2	98
2.	*Sigalion spinosus*	Polychaeta: Sigalionidae	1.7	2.1	0.9	80
3.	Maldanidae †	Polychaeta: Maldanidae	1.6	2.0	0.9	80
4.	*Ampelisca cristata cristata*	Crustacea: Amphipoda	2.0	2.7	1.1	74
5.	*Spiophanes duplex*	Polychaeta: Spionidae	14.6	20.7	8.1	70
6.	*Onuphis* sp SD 1	Polychaeta: Onuphidae	1.2	1.7	0.7	69
7.	*Foxiphalus obtusidens*	Crustacea: Amphipoda	1.5	2.2	0.8	67
8.	*Carinoma mutabilis*	Nemertea: Anopla	1.7	2.7	1.0	65
9.	Lineidae †	Nemertea: Anopla	0.6	0.9	0.3	63
10.	*Euphilomedes carcharodonta*	Crustacea: Ostracoda	1.6	2.7	0.9	61

† = unidentified juveniles and/or damaged specimens

reflect anthropogenic impact (Smith et al. 2001). Station I35 had the highest BRI, and was the only station above the upper limit for reference conditions. There were no patterns in BRI relative to distance from the outfall, and index values at sites nearest the discharge did not suggest significant environmental disturbance.

The infaunal trophic index (ITI) averaged from 68 to 94 at the various sites in 2003 (Table 5.1). There were no patterns with respect to the outfall, and all values at sites near the discharge were characteristic of undisturbed sediments (i.e., ITI > 60, Word 1980). In addition, average ITI over all sites has changed little since monitoring began (see Figure 5.2F).

Dominant Species

Most assemblages in the SBOO region were dominated by polychaete worms. For example, the list of dominant fauna in **Table 5.2** includes 13 polychaetes, four crustaceans, two nemerteans, one mollusc, one echinoderm, and nematodes (not identified beyond phylum).

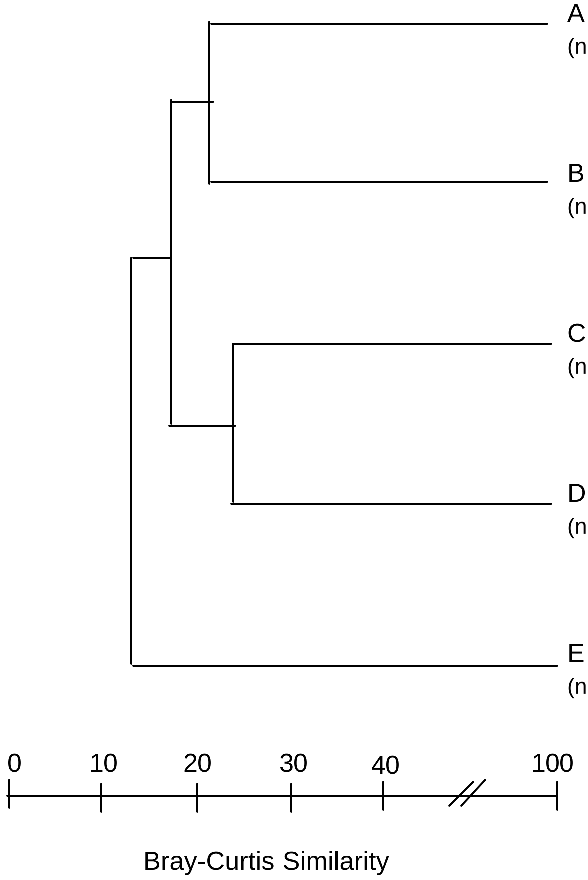
The spionid polychaete *Spiophanes bombyx* was the most numerous and the most ubiquitous species, averaging about 34 worms per grab and occurring in 98% of the samples. A closely related species, *S. duplex*, was second in total abundance. Together, these two species accounted for over 27% of all individuals collected during 2003. Both were found in higher than usual numbers, especially during the January survey (see **Figure 5.3**). Other abundant taxa included the sabellid polychaete *Euchone arenae*, the bivalve mollusc *Tellina modesta*, and nematode worms.

Polychaetes comprised nine of the ten most abundant species per occurrence. Several of these species were found in high numbers at only a few stations (e.g., *Pareurythoe californica*, *Polycirrus* sp SD 3, *Micropodarke dubia*). Few macrobenthic species were widely distributed, and among these only *S. bombyx* occurred in more than 80% of the samples. Three of the most frequently collected species were also among the top ten taxa in terms of abundance (i.e., *S. bombyx*, *S. duplex*, and *Ampelisca cristata cristata*).

Multivariate Analyses

Classification analysis discriminated between five habitat-related benthic assemblages (cluster groups A–E) during 2003 (see **Figures 5.4** and **5.5**). These assemblages differed in terms of their species composition, including the specific taxa present and their relative abundances. The dominant species composing each group are listed in **Table 5.3**. An MDS ordination of the station/survey entities confirmed the validity of cluster groups A–E (see **Figure 5.6**). When physico-chemical sediment data were superimposed on the MDS plot, sediment grain size (i.e., fine vs. coarse sediments) and depth appeared to be the most likely factors affecting macrofaunal distribution in the region (see **Figure 5.7**). These analyses did not identify any clear patterns regarding proximity to the discharge.

Cluster group A comprised two stations located along the 55-m depth contour. Sediments at these sites contained a relatively high percentage of fine particles (see Figure 5.7a). The group A assemblage was characterized by high species richness and abundance, averaging 89 taxa and 226 individuals per grab (see Figure 5.4). The most abundant species were the amphinomid polychaete *Chloeia pinnata*, the ophiuroid *Amphiodia urtica*, and the polychaete *Spiophanes bombyx*. The following polychaetes were also characteristic



CG	Stations	SR	ABUN	Top Three Taxa
A (n=4)	I1, I28	89 (32–147)	226 (68–407)	*Chloeia pinnata* *Amphiodia urtica* *Spiophanes bombyx*
B (n=26)	I9, I10, I14, I16, I18, I22, I27, I29, I30, I31, I33, I35, I12b, I23a	55 (26–114)	205 (70–621)	*Spiophanes bombyx* *Spiophanes duplex* *Tellina modesta*
C (n=19)	I2, I3, I4, I6, I8, I13, I15, I21, I34, I12a	33 (12–51)	124 (17–475)	*Spiophanes bombyx* *Euchone arenae* *Dendraster terminalis*
D (n=4)	I20, I7	38 (21–56)	95 (41–158)	*Mooreonuphis* sp SD 1 *Mooreonuphis* sp *Spio maculata*
E (n=1)	I23b	75 (67–82)	683 (547–819)	*Hesionura coineaui difficilis* Nematoda *Pareurythoe californica*

Figure 5.4

Cluster results of the macrofaunal abundance data for the SBOO benthic stations sampled during January and July, 2003. Station designations: a=January survey, b=July survey, no letter designation=both surveys. Data are expressed as mean values per 0.1 m^2 grab over all stations in each group. CG=cluster group; SR=number of species; ABUN=number of individuals. Ranges in parentheses are for individual grab samples.

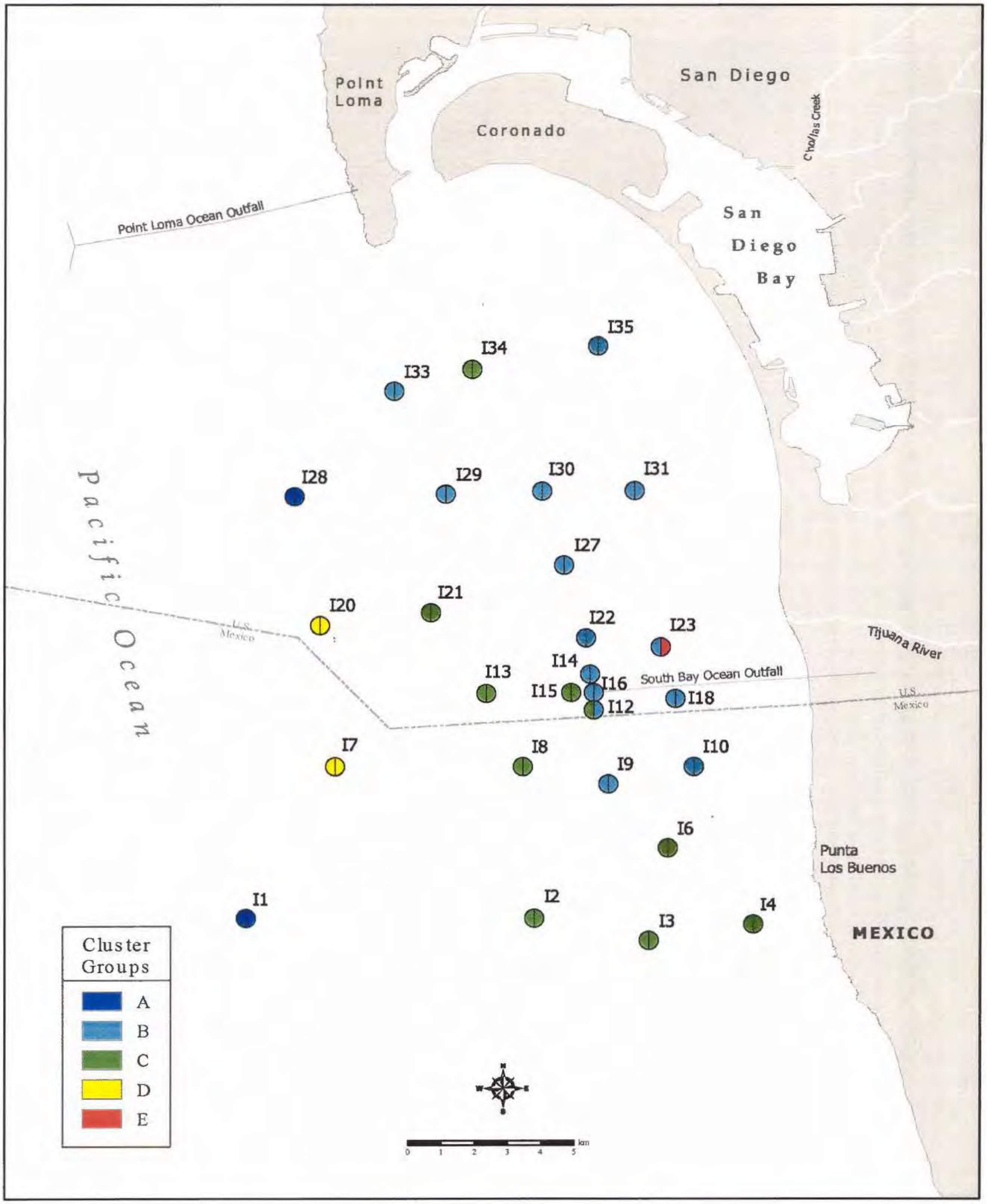


Figure 5.5

SBOO benthic stations sampled during January and July, 2003, color-coded to represent affiliation with benthic cluster groups. Left half of circle represents cluster group affiliation for the January survey, right half represents the July survey.

Table 5.3

Summary of the most abundant taxa composing cluster groups A–E from the 2003 survey of SBOO benthic stations. Data are expressed as mean abundance per sample (no./0.1m^2) and represent the ten most abundant taxa in each group. Values for the three most abundant species (bolded) in each cluster group are underlined. n=number of station/survey entities per cluster group

		Cluster Group				
Species/Taxa	**Higher Taxa Code***	**A** (n=4)	**B** (n=26)	**C** (n=19)	**D** (n=4)	**E** (n=1)
Ampelisca agassizi	C	4.3	0.2	0.1	.	.
Ampelisca cristata cristata	C	1.0	2.7	1.3	2.5	.
Amphiodia urtica	E	6.4	0.1	0.3	.	.
Anchicolurus occidentalis	C	.	0.1	1.9	.	0.5
Apionsoma misakianum	S	3.9	0.3	0.1	3.3	5.0
Aricidea (Acmira) simplex	P	5.5	.	.	0.3	.
Caecum crebricinctum	M	.	0.1	4.1	2.1	1.0
Chloeia pinnata	P	10.0	.	<0.1	0.8	.
Cirriformia sp SD 2	P	.	<0.1	.	.	18.5
Dendraster terminalis	E	.	.	6.5	.	1.0
Euchone arenae	P	1.3	3.0	13.7	4.0	16.5
Euclymeninae sp A	P	1.4	2.5	0.1	0.5	.
Euphilomedes carcharodonta	C	3.9	1.1	2.3	.	.
Hemilamprops californicus	C	0.6	2.7	1.1	.	0.5
Hesionura coineaui difficilis	P	.	0.1	0.3	1.5	90.0
Monticellina siblina	P	0.5	4.0	0.1	.	.
Mooreonuphis **sp**	P	.	0.1	0.4	10.4	.
Mooreonuphis **sp SD 1**	P	.	0.1	0.9	14.0	.
Myriochele gracilis	P	5.9	.	.	.	.
Nematoda	N	1.9	3.3	0.8	0.9	87.5
Nuculana taphria	M	0.9	3.3	<0.1	.	.
Onuphidae	P	0.3	0.2	0.5	2.3	0.5
Ophelia pulchella	P	.	<0.1	4.2	0.6	.
Ophiuroconis bispinosa	E	0.9	<0.1	0.1	2.3	.
Pareurythoe californica	P	.	.	.	.	63.5
Photis macinerneyi	C	.	0.1	1.9	.	.
Polycirrus sp	P	0.3	0.2	0.3	2.5	18.0
Polycirrus sp SD 3	P	.	.	.	.	39.0
Protodorvillea gracilis	P	.	0.1	1.6	0.8	45.0
Rhepoxynius heterocuspidatus	C	.	0.3	3.3	0.4	.
Saccocirrus sp	P	.	<0.1	<0.1	.	28.0
Solamen columbianum	M	1.5	<0.1	1.8	0.4	.
Spio maculata	P	.	0.4	0.6	5.9	0.5
Spiophanes bombyx	P	6.3	50.5	26.6	1.3	1.0
Spiophanes duplex	P	4.1	29.1	0.7	0.1	.
Sthenelanella uniformis	P	4.8	0.3	.	.	.
Syllis (Typosyllis) sp SD 1	P	.	.	0.2	0.3	50.5
Tellina modesta	M	0.4	7.5	0.8	.	.
Thysanocardia nigra	S	0.3	<0.1	0.2	2.3	.

* P = Polychaeta (Annelida), C = Crustacea (Arthropoda), M = Mollusca, E = Echinodermata, N = Nematoda, S = Sipuncula.

of this assemblage, but relatively uncommon in other groups: the oweniid *Myriochele gracilis*, the paraonid *Aricidea (Acmira) simplex*, and the sigalionid *Sthenelanella uniformis* (Table 5.3).

Cluster group B included sites that were primarily located along the 19 and 28-m depth contours, and where the sediments contained relatively high amounts of fine particles. This assemblage averaged 55 taxa and 205 individuals per 0.1 m^2. The dominant species in this group were *Spiophanes bombyx*, *S. duplex*, and *Tellina modesta*. Other characteristic taxa included the cirratulid polychaete *Monticellina siblina* and the bivalve mollusc *Nuculana taphria*.

Cluster group C comprised sites that were located along the 19, 28, and 38-m depth contours. These sites averaged a low percentage of fines, with some stations containing relict red sands. The group C assemblage averaged 33 taxa and 124 individuals per grab. *Spiophanes bombyx* was numerically dominant in this group, followed by *Euchone arenae*, and the echinoderm *Dendraster terminalis*. The opheliid polychaete *Ophelia pulchella*, the gastropod *Caecum crebricinctum*, and the amphipod *Rhepoxynius heterocuspidatus* were also characteristic of this assemblage.

Cluster group D comprised two stations characterized by coarse relict red sand that were located along the 55-m depth contour. In contrast to the other deepwater assemblage described above (group A), this group had fewer taxa and less individual organisms per grab. Polychaetes in the onuphid genus *Mooreonuphis* dominated this group, followed by the spionid polychaete *Spio maculata*.

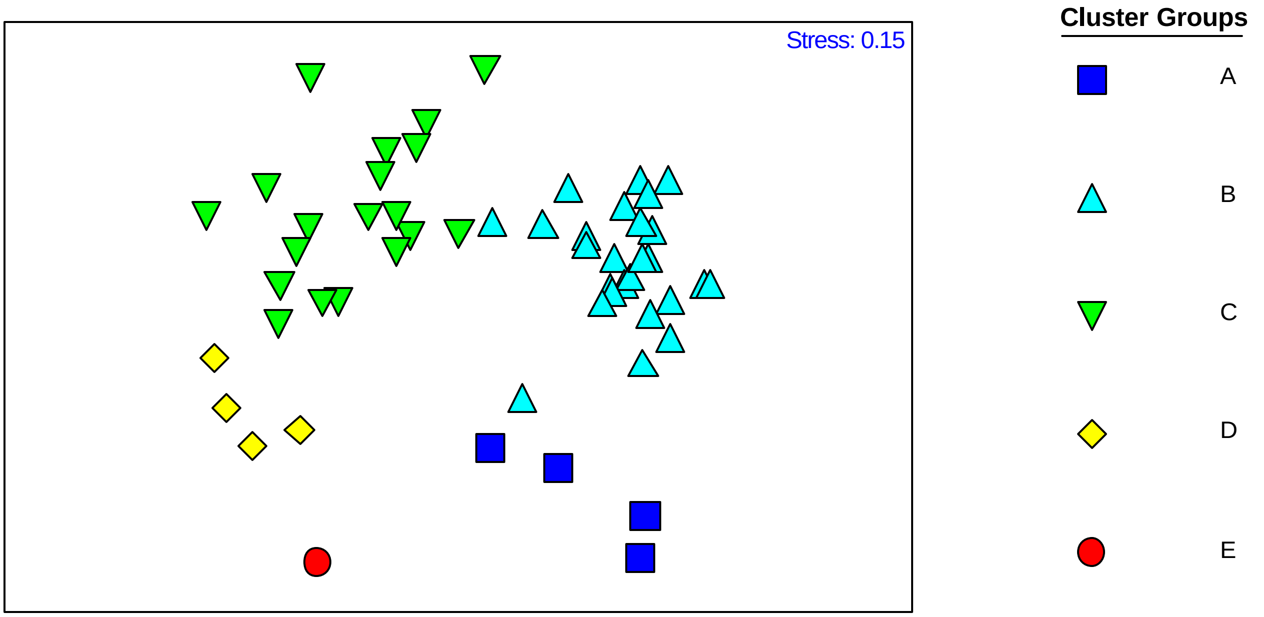
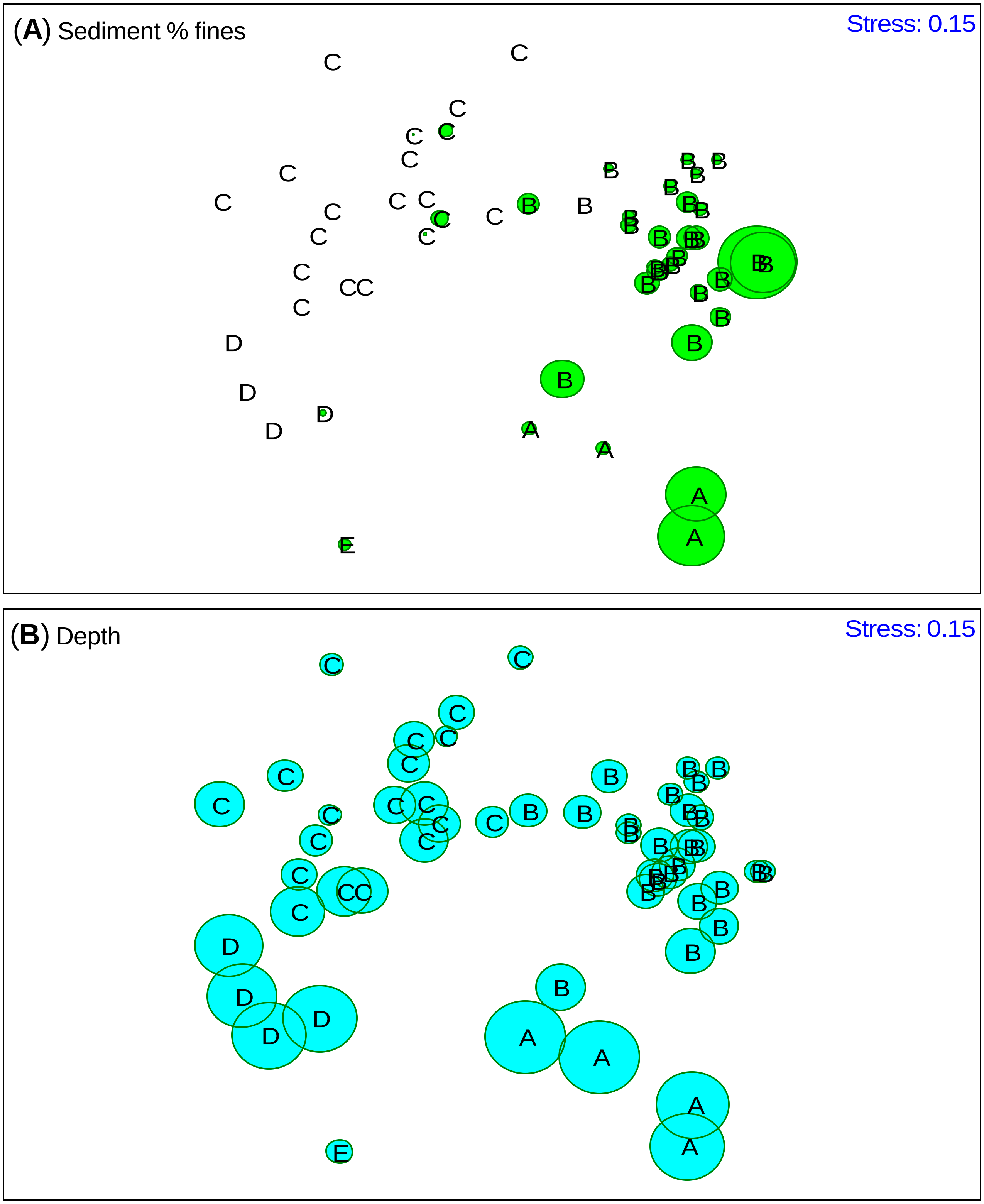


Figure 5.6

MDS ordination of SBOO benthic stations sampled during January and July, 2003. Plot based on fourth-root transformed macrofaunal abundance data for each station/survey entity. Cluster groups superimposed on station/surveys illustrate a clear distinction between faunal assemblages.



(A) Sediment % fines

(B) Depth

Figure 5.7

MDS ordination of SBOO benthic stations sampled during January and July, 2003. Cluster groups A–E are superimposed on station/surveys. Percentage of fine particles (silt + clay) in the sediments (A) and station depth (B) 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 depth.

Cluster group E represented the July survey from a single station (I23) located on the 19-m depth contour. Sediments at this site were characterized by a relatively low percentage of fine particles. The group E assemblage was somewhat anomalous for the region; it was dominated by nematode worms and some relatively uncommon polychaete species. Many of the dominant polychaetes from this group were absent from, or occurred in much lower numbers at the other SBOO stations (e.g., *Hesionura coineaui difficilis*, *Pareurythoe californica*, *Syllis (Typosyllis)* sp SD 1).

SUMMARY and CONCLUSIONS

Benthic macrofaunal assemblages surrounding the South Bay Ocean Outfall were similar in 2003 to those that occurred during previous years (City of San Diego 2000, 2003). In addition, these assemblages were generally typical of those occurring in other sandy, shallow water habitats throughout the Southern California Bight (SCB) (e.g., Thompson et al. 1987, 1993b, City of San Diego 1999, Bergen et al. 2001). For example, the two assemblages found at the majority of stations (e.g., groups B and C) contained high numbers of the spionid polychaete *Spiophanes bombyx*, a species characteristic of shallow-water environments in the SCB (see Bergen et al. 2001). These two groups represented sub-assemblages of the shallow SCB benthos that differed in the relative abundances of dominant and co-dominant species. Such differences probably reflect variation in microhabitat structure, such as the presence of a fine sediment component (i.e., group B), or coarse, relict red sands (i.e., group C). In contrast, the group A assemblage occurs in slightly deeper water 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). This assemblage was characterized by such species as the ophiuroid *Amphiodia urtica*, and the polychaetes *Chloeia pinnata*, *Myriochele gracilis*, *Aricidea (Acmira) simplex*, and *Sthenelanella uniformis*, which were not common at the shallower stations. A second deep water assemblage (group D) occurred where relict red sands were present. Onuphid polychaetes dominated this group, followed by the spionid polychaete *Spio maculata*. Finally, the group E assemblage collected at station I23 during the July survey was quite dissimilar from assemblages found at any other station. Nematode worms and the various polychaete species that were abundant in these samples were not common elsewhere in the region. Nevertheless, most of these taxa have been collected in similar numbers during previous surveys. Analysis of the sediment chemistry data provided no evidence to explain the occurrence of this assemblage, and the presence of these animals may reflect particular components of the sediments such as types and amounts of shell hash or algal detritus.

Multivariate analyses revealed no clear spatial patterns relative to the 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 sediment type and depth. During the January 2003 survey, overall averages for diversity (H') and dominance were low in comparison to previous years. These values can largely be explained by relatively high numbers of the spionid polychaetes *Spiophanes bombyx* and *S. duplex*. However, the temporal fluctuations in the populations of these taxa are similar in magnitude to those that have occurred elsewhere in the region and often correspond to large-scale oceanographic conditions (see Zmarzly et al. 1994). Overall, temporal patterns suggest that the benthic community has not been significantly impacted by the SBOO. For example, the range of values for species richness and abundance during 2003 was similar to that seen in previous years (see City of San Diego 2000, 2003). In addition, environmental disturbance indices such as the BRI and the ITI were generally characteristic of assemblages from undisturbed sediments.

Anthropogenic impacts 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 could not be identified during 2003. 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 likely occurred near the SBOO, 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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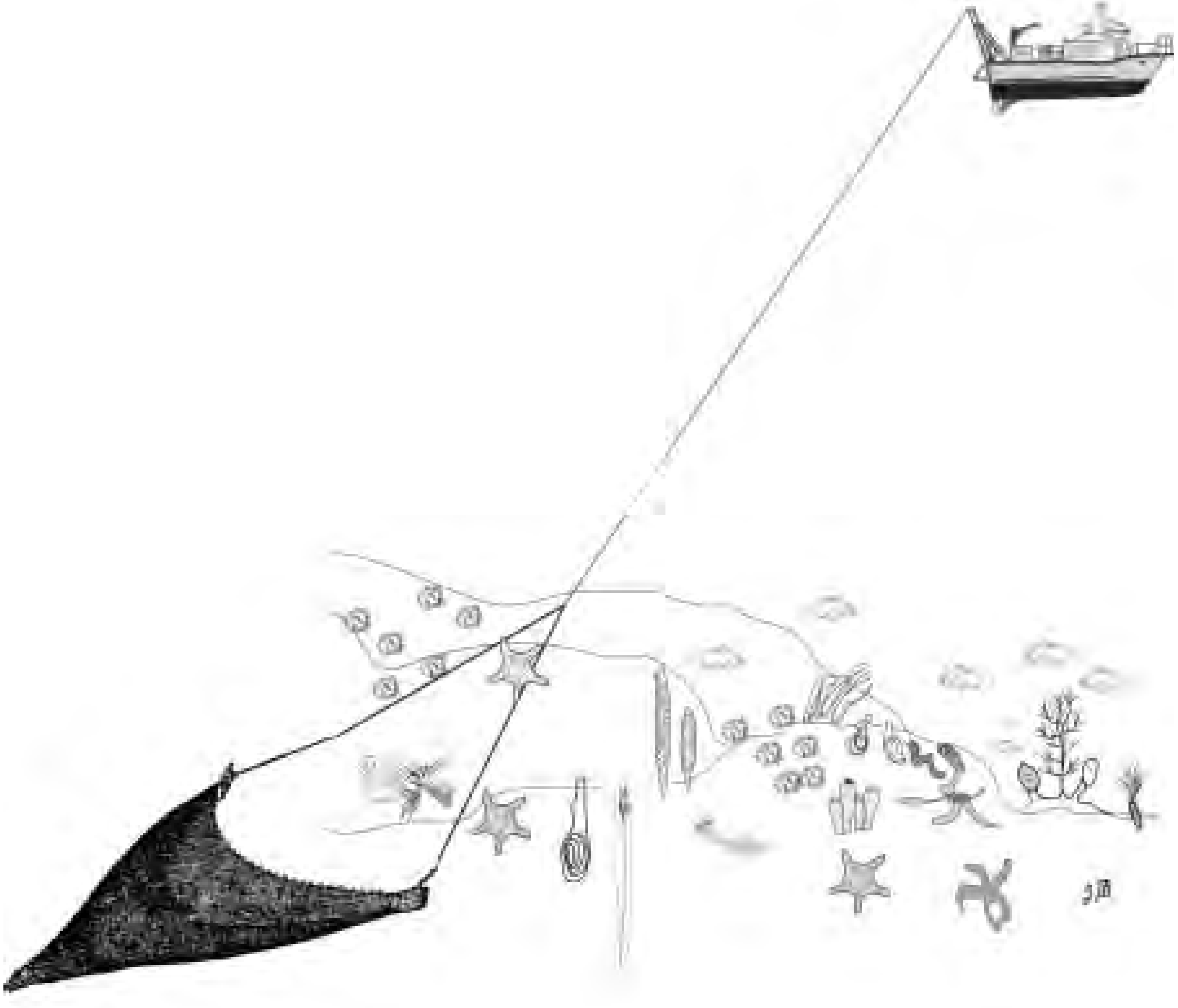
Demersal Fishes and Megabenthic Invertebrates



Chapter 6
Demersal Fishes and Megabenthic Invertebrates

INTRODUCTION

Demersal fish and megabenthic invertebrate communities have become an important focus of ocean monitoring programs throughout the world because of their proximity to potentially altered sediments. Fish and invertebrate assemblages of the Southern California Bight (SCB) mainland shelf have been sampled extensively for at least 30 years, primarily by programs associated with municipal wastewater and power plant discharges (Cross and Allen 1993). More than 100 species of fish inhabit the SCB, while the megabenthic invertebrate fauna consists of more than 200 species (Allen 1982, Allen et al. 1998). For the region surrounding the South Bay Ocean Outfall, the most common trawl-caught fishes include speckled sanddab, longfin sanddab, hornyhead turbot, California halibut, California lizardfish and occasionally white croaker. The common trawl-caught invertebrates include relatively large species such as sea urchins and sand dollars.

The City of San Diego has been conducting trawl surveys in the area surrounding the South Bay Ocean Outfall (SBOO) since 1995. These surveys were designed to monitor the effects of wastewater discharge on the local marine biota by assessing the structure and stability of the demersal fish and megabenthic invertebrate communities. This chapter presents analyses and interpretations of data collected during the 2003 trawl surveys.

MATERIALS and METHODS

Field Sampling

Trawl surveys were conducted in January, April, July, and October 2003 at seven fixed sites around the SBOO (**Figure 6.1**). These stations, SD15–SD21, are located along the 27-m isobath, and encompass an area south of Point Loma, California, USA to 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. Detailed methods for locating the stations and conducting trawls are described in the City of San Diego Quality Assurance Manual (City of San Diego 2004).

Trawl catches were brought on board for sorting and inspection. All organisms were identified to species or to the lowest taxon possible. If an animal could not be identified in the field, it was returned to the laboratory for further identification. The total number of individuals and the total biomass (wet weight, kg) were recorded for each species of fish. Additionally, each fish was inspected for external parasites or physical anomalies (e.g., tumors, fin erosion, discoloration) and measured to the nearest centimeter in length according to standard protocols (see City of San Diego 2004). The total number of individuals was also recorded for each invertebrate species. Due to the small size of most organisms, invertebrate biomass was measured primarily as a composite wet weight (kg) of all species combined; however, large or exceptionally abundant species were weighed separately. When the white sea urchin *Lytechinus pictus* was collected in large numbers, its abundance was estimated by multiplying the total number of individuals comprising a 1.0 kg subsample by the total urchin biomass.

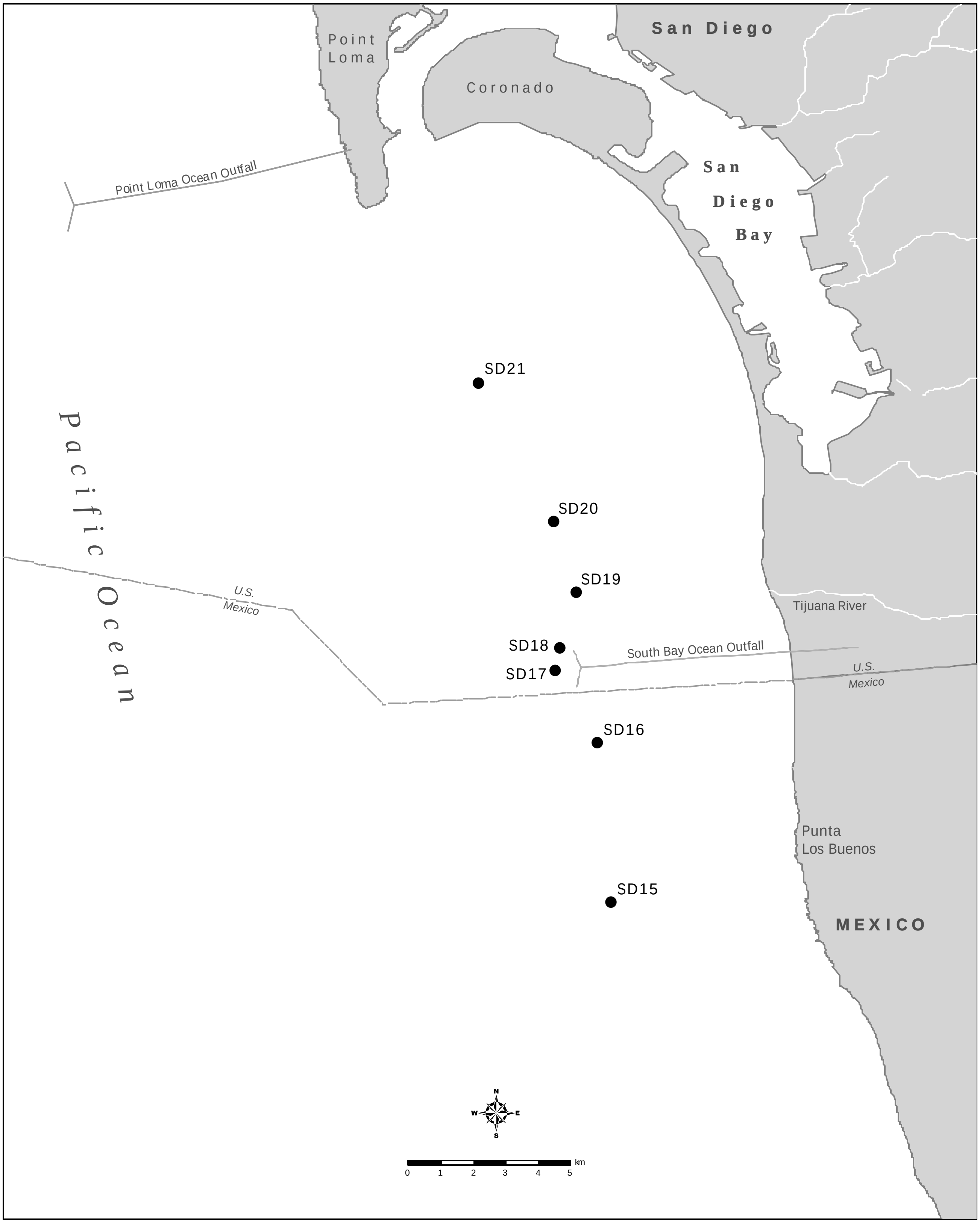


Figure 6.1
Otter trawl station locations, South Bay Ocean Outfall Monitoring Program.

Data Analyses

Populations of each fish and invertebrate species were summarized by: (1) frequency of occurrence (number of occurrences/total number of trawls x 100); (2) percent abundance (number of individuals/total of all individuals caught x 100); (3) mean abundance per haul (number of individuals/total number of trawls); (4) mean abundance per occurrence (number of individuals/number of occurrences). In addition, the following parameters were calculated for both the fish and invertebrate assemblages at each station: (1) species richness (number of species); (2) total abundance; (3) Shannon diversity index (H'); (4) total biomass.

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

RESULTS and DISCUSSION

Fish Community

Thirty-four species of fish were collected in the area surrounding the SBOO during 2003 (**Table 6.1**). The total catch for the year was 5,210 individuals, representing an average of about 186 fish per trawl. The speckled sanddab comprised 84% of the total catch, and was the only species present in every haul. Other frequently occurring fishes were California lizardfish, roughback sculpin, hornyhead turbot, English sole and California halibut. The California halibut had an average length of 32 cm, while the rest of these common species tended to be relatively small (<17 cm in length on average, **Appendix B.1**). With the exception of the halibut, species greater than 25 cm in length were collected infrequently. These larger species included the California skate, thornback, round stingray, shovelnose guitarfish, speckledfin midshipman, and barred sand bass.

Fish abundance and biomass were highly variable during 2003. Abundance ranged from 42 to 667 fish per haul (**Table 6.2**). This large variation was partly due to uncharacteristically large catches of speckled sanddab that increased steadily over the year (e.g., 457 in January, 949 in April, 1,223 in July, and 1,749 in October). Over 4,300 speckled sanddabs were collected in 2003, up from 2,200 in 2002 and just over 500 in 2001. The wide range in biomass values (0.9 to 15.0 kg per station) was generally attributable to larger hauls or the presence of a few large individuals. For example, the heaviest catches occurred at station SD21 in January and October, due to relatively large catches of white croaker and speckled sanddabs, respectively.

In contrast to abundance and biomass, species richness and diversity (H') varied little and were relatively low in 2003 (Table 6.2). The highest number of species per haul was 14 at station SD21 in October, while the lowest was 3 at SD15 in July. About 70% of the hauls had between 6–10 species. Diversity values were less than 2 at all stations, and generally lower than the previous year. These relatively low values are likely the result of the increasingly high catches of speckled sanddabs over the course of the year.

Table 6.1

Demersal fish species collected in 28 trawls in the SBOO region during 2003. Data for each species are expressed as: (1) percent abundance (PA); (2) frequency of occurrence (FO); (3) mean abundance per haul (MAH); and (4) mean abundance per occurrence (MAO).

Species	PA	FO	MAH	MAO
Speckled sanddab	84	100	156	156
California lizardfish	4	79	8	10
Roughback sculpin	2	61	4	6
Hornyhead turbot	1	82	3	3
Longfin sanddab	1	46	2	5
English sole	1	54	2	3
Yellowchin sculpin	1	25	2	7
California scorpionfish	1	39	1	3
Plainfin midshipman	1	36	1	4
White croaker	1	7	1	18
California halibut	1	50	1	2
Spotted turbot	<1	39	1	2
Pacific sanddab	<1	32	1	2
California tonguefish	<1	29	1	2
Fantail sole	<1	21	<1	1
California skate	<1	18	<1	1
Giant kelpfish	<1	14	<1	1
Longspine combfish	<1	11	<1	2
Thornback	<1	11	<1	1
Kelp pipefish	<1	7	<1	1
Lingcod	<1	7	<1	6
Pink seaperch	<1	7	<1	1
Round stingray	<1	7	<1	1
Shiner perch	<1	7	<1	4
Shovelnose guitarfish	<1	7	<1	1
Barred sand bass	<1	4	<1	1
Bay goby	<1	4	<1	1
Bigmouth sole	<1	4	<1	3
Curlfin sole	<1	4	<1	1
Diamond turbot	<1	4	<1	1
Flatfish unidentified	<1	4	<1	2
Pygmy poacher	<1	4	<1	1
Queenfish	<1	4	<1	9
Slimy snailfish	<1	4	<1	1
Specklefin midshipman	<1	4	<1	1

Fish community structure has varied in this region since 1996 (**Figure 6.2**). Although species richness has remained within a small range (between 5 and 14 species per station per year), abundances have fluctuated substantially over the years (between 28 and 275 individuals per station). Annual abundance values generally reflect differences in the populations of the dominant species, especially speckled sanddabs (e.g., during 2003). This inter-annual variability also reflects large hauls of schooling species that occur infrequently. For example, large hauls of white croaker were responsible for the high abundance at SD21 in 1996, while a large haul of northern anchovy caused the high abundance at SD16 in 2001. Overall, none of the observed changes appear to be associated with the initiation of discharge from the South Bay outfall.

Table 6.2

Summary of demersal fish community parameters for SBOO stations sampled during 2003. Data are expressed as means and standard deviations (SD) for species richness, abundance, diversity (H'), and biomass (BM) (kg, wet weight); n = 4.

Parameter	Station	Jan	Apr	Jul	Oct	Mean	SD
Species Richness	SD15	8	6	3	7	6	2
	SD16	4	6	7	9	7	2
	SD17	6	9	5	10	8	2
	SD18	10	13	9	10	11	2
	SD19	6	8	8	10	8	2
	SD20	4	12	13	9	10	4
	SD21	10	11	6	14	10	3
	Survey Mean	7	9	7	10		
	Survey SD	3	3	3	2		
Abundance	SD15	42	204	187	174	152	74
	SD16	79	164	224	296	191	92
	SD17	100	165	124	209	150	48
	SD18	95	145	270	243	188	82
	SD19	95	182	216	159	163	51
	SD20	54	151	219	314	185	110
	SD21	102	127	203	667	275	265
	Survey Mean	81	163	206	295		
	Survey SD	24	25	44	174		
Diversity (H')	SD15	0.9	0.4	0.1	0.4	0.4	0.3
	SD16	0.2	0.5	0.5	0.6	0.4	0.2
	SD17	0.4	0.9	0.5	1.0	0.7	0.3
	SD18	0.7	0.9	0.7	0.8	0.8	0.1
	SD19	0.3	0.7	0.8	0.7	0.6	0.2
	SD20	0.3	0.9	0.9	0.5	0.7	0.3
	SD21	1.7	1.1	1.0	0.1	1.0	0.7
	Survery Mean	0.6	0.8	0.6	0.6		
	Survey SD	0.5	0.3	0.3	0.3		
Biomass	SD15	2.1	2.5	1.4	3.6	2.4	0.9
	SD16	1.3	3.2	3.3	4.2	3.0	1.2
	SD17	2.1	4.8	1.7	6.8	3.9	2.4
	SD18	3.8	5.2	3.4	4.7	4.3	0.8
	SD19	2.1	3.8	3.5	3.1	3.1	0.7
	SD20	0.9	3.2	6.6	4.6	3.8	2.4
	SD21	15.0	3.4	2.9	10.6	8.0	5.9
	Survey Mean	3.9	3.7	3.3	5.4		
	Survey SD	5.0	1.0	1.7	2.6		

Ordination and classification of analyses of sites resulted in five major cluster groups (cluster groups A–E) during 2003 (see **Figure 6.3**). The dominant species composing each group are listed in **Table 6.3**. These assemblages differed in terms of their species composition, primarily reflecting different numbers of the more common species. No patterns were evident that suggest changes in the fish assemblages were associated with the initiation of the discharge.

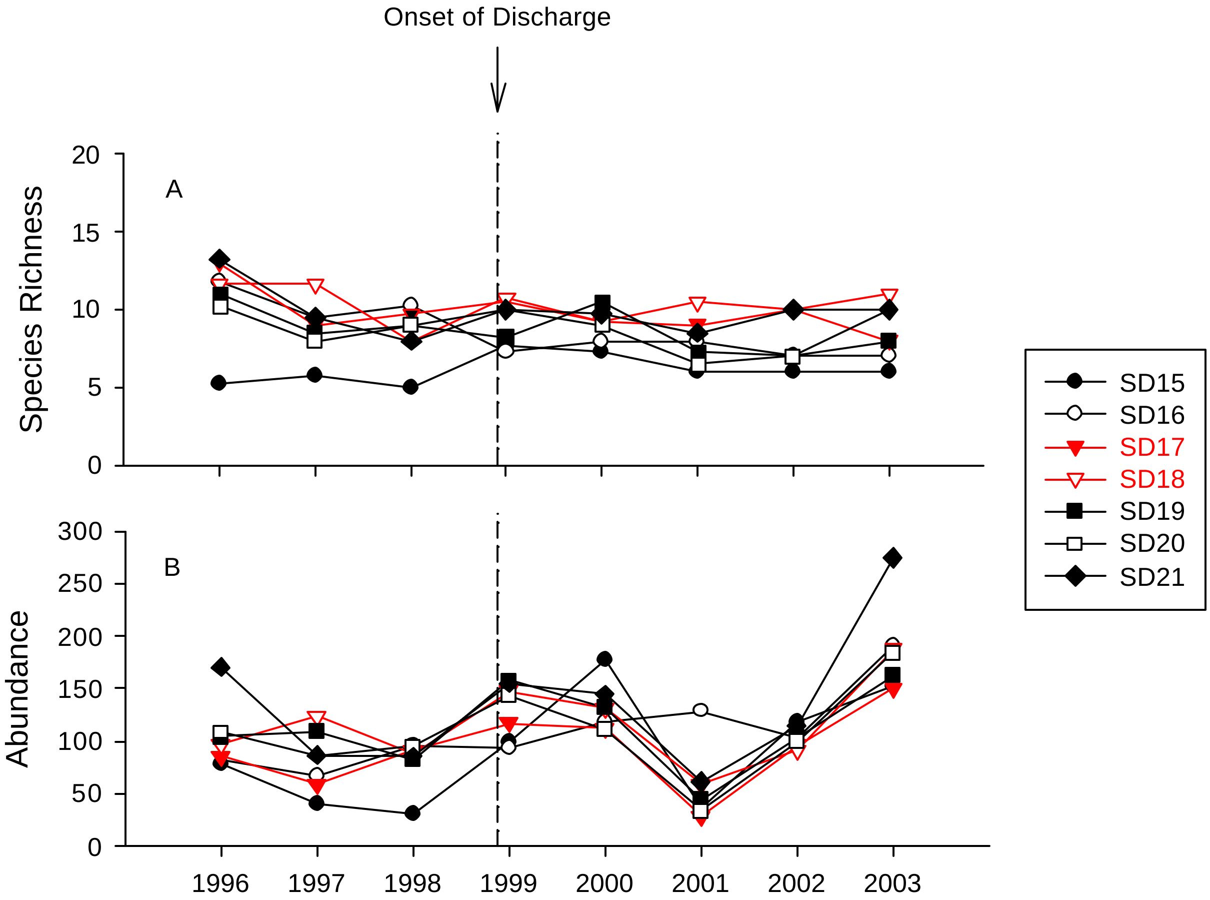


Figure 6.2

Annual mean species richness and abundance per station of demersal fish collected 1996 through 2003.

Differences among the five cluster groups were primarily due to seasonal variation and coincided with an increase of speckled sanddabs throughout the year, as well as other differences in species composition. For example, station group B included all but one site sampled in January (Figure 6.3) and had an average of 70 speckled sanddabs per haul (Table 6.3). Station group E included all sites sampled in April and had an average of 136 speckled sanddabs per haul. Station group D included all but one site sampled in July and October and had an average of 185 speckled sanddabs per haul. Station groups A and C both represented anomalous hauls at station SD21 during January and October, respectively. In January, the assemblage at SD21 was unique due to the presence of white croaker and the low number/absence of some of the more common species (e.g., fewer speckled sanddabs and the absence of California lizardfish, English sole, and sculpins). In October, the assemblage at SD21 was unique due to the huge number of speckled sanddabs collected.

Physical Abnormalities and Parasitism

Physical abnormalities were absent and the presence of external parasites was rare (i.e., 0.12%) among the fishes collected in 2003. External parasites were found on just six fish, including a single leech on each of four hornyhead turbots, a copepod on a California scorpionfish, and an isopod on a speckled sanddab. In addition, the ectoparasitic isopod, *Elthusa vulgaris,* was observed in several trawls. This isopod becomes detached

Table 6.3

Ten most abundant and frequently occurring fish species among the five main SBOO station cluster groups. Dominant taxa (by abundance) are indicated in bold.

	SGA	SGB	SGC	SGD	SGE
Number of hauls	1	6	1	13	7
Mean species richness per haul	10	3	14	2	3
Mean abundance per haul	102	78	667	218	163
Species	**Mean Abundance**				
White croaker	**35**	.	.	.	.
Speckled sanddab	**34**	**71**	**571**	**185**	**136**
Queenfish	**9**	.	.	.	.
California halibut	8	1	2	.	1
Hornyhead turbot	6	1	6	2	3
California tonguefish	5	<1	6	.	.
Giant kelpfish	2	<1	.	.	.
California scorpionfish	1	.	13	2	.
Round stingray	1	.	.	.	.
Spotted turbot	1	.	.	1	.
California lizardfish	.	1	14	**15**	1
California skate	.	<1	.	.	.
Pink seaperch	.	<1	.	.	.
Shiner perch	.	<1	.	.	1
Barred sand bass	.	<1	.	.	.
English sole	.	.	.	3	2
Longfin sanddab	.	.	.	2	**4**
Longspine combfish	.	.	.	.	1
Pacific sanddab	.	.	2	1	.
Plainfin midshipman	.	.	**18**	.	2
Roughback sculpin	.	.	**15**	2	**10**
Yellowchin sculpin	.	.	**15**	2	.

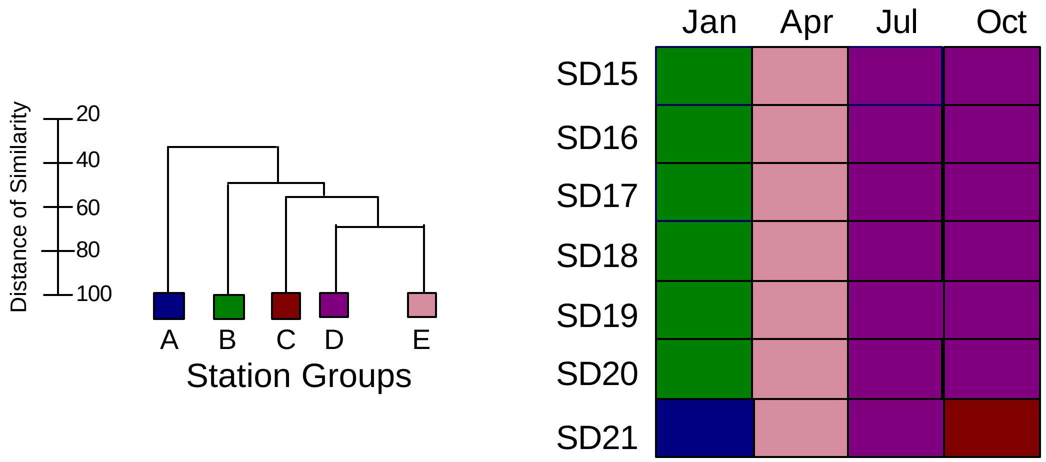


Figure 6.3

Results of classification analysis of demersal fish collected at stations SD15–SD21 during 2003. Data are presented as a dendrogram of major station groups and a matrix showing distribution through 2003.

from its host during sorting, therefore it is unknown which fish were actually parasitized. Although *E. vulgaris* occurs on a wide variety of fish species in southern California, it is especially common on sanddabs and California lizardfish, where it may reach infestation rates of 3% and 80%, respectively (Brusca 1978, 1981).

Invertebrate Community

A total of 1,685 megabenthic invertebrates (~ 60/trawl), representing 53 taxa, were collected during 2003 (**Appendix B.2**). The sea star *Astropecten verrilli* was the most abundant and most frequently captured species. This species was collected in 96% of the trawls and accounted for 43% of the total invertebrate catch (**Table 6.4**). Other species that occurred in at least 50% of the trawls included the shrimp *Crangon nigromaculata,* the sea urchin *Lytechinus pictus*, and the sea star *Pisaster brevispinus*.

As with fish, invertebrate community parameters varied among stations and between surveys during the year (**Table 6.5**). Species richness was generally low, and ranged from 4 to 13 species per haul. Abundance values were more variable, ranging from 17 to 148 individuals per haul. The biggest hauls were primarily high due to large numbers of *C. nirgomaculata* and *L. pictus* at SD18, and *C. nirgomaculata* at SD21 in January, and large numbers of *A. verrilli* and *Heptacarpus stimpsoni* collected at SD17 in April. Although biomass was also somewhat variable, high values generally corresponded to the collection of large species such as the sea star *P. brevispinus*, cancer crabs, or sheep crabs.

Megabenthic invertebrate community structure in the South Bay area has varied since sampling began (**Figure 6.4**). Although species richness has remained within a small range (e.g., 4–14 species per station per year), abundances have fluctuated substantially, with annual values averaging between 7–273 individuals per station. This wide range of values generally reflects fluctuations in the populations of the dominant species, especially the echinoderms *A. verrilli*, *L. pictus*, and *Dendraster terminalis*. For example, the high abundances recorded at SD17 in 1996 and SD15 in 1996 and 1997 were due to large hauls of *A. verrilli* and *L. pictus*, while the high abundances at SD15 in 1998 and 1999 were due to large hauls of *D. terminalis*. None of the observed variability in the invertebrate communities can be attributed to the initiation of discharge from the South Bay outfall.

SUMMARY and CONCLUSIONS

Speckled sanddabs once again dominated the fish assemblages surrounding the South Bay Ocean Outfall during 2003. Other fish, such as the hornyhead turbot, roughback sculpin, California halibut and California lizardfish were also collected frequently. The invertebrate assemblages were similarly dominated by a few, prominent species. The sea star *A. verrilli* was the most abundant species, while the sea urchin *L. pictus,* the sea star *P. brevispinus*, and the crangonid shrimp *C. nigromaculata* were also common.

As in previous years, variation in both fish and megabenthic invertebrate communities among stations and between surveys in the region were generally due to population fluctuations of the dominant species mentioned above. For example, speckled sanddab abundance increased tremendously from survey to survey during the year and resulted in a dramatic increase of sanddab abundance over previous years. Invertebrate abundances were largely affected by changes in three echinoderms: *A. verrilli*, *L. pictus*, and *D. terminalis*.

Table 6.4

Megabenthic invertebrate species collected in 28 trawls in the SBOO region during 2003. Data for each species are expressed as: (1) percent abundance (PA); (2) frequency of occurrence (FO); (3) mean abundance per haul (MAH); and (4) mean abundance per occurrence (MAO).

Species	PA	FO	MAH	MAO	Species	PA	FO	MAH	MAO
Astropecten verrilli	43	96	26	27	*Strongylocentrotus franciscanus*	<1	7	<1	2
Crangon nigromaculata	20	82	12	14	*Acanthodoris rhodoceras*	<1	4	<1	1
Lytechinus pictus	13	50	8	16	*Amphiodia psara*	<1	4	<1	1
Dendraster terminalis	8	25	5	18	*Amphissa undata*	<1	4	<1	1
Heptacarpus stimpsoni	2	18	1	8	*Aphrodita armifera*	<1	4	<1	1
Pisaster brevispinus	2	54	1	2	*Astropecten ornatissimus*	<1	4	<1	5
Heterocrypta occidentalis	1	29	1	3	*Calliostoma annulatum*	<1	4	<1	1
Crangon alba	1	14	1	5	*Calliostoma canaliculatum*	<1	4	<1	1
Hemisquilla ensigera californiensis	1	29	1	2	*Dendronotus frondosus*	<1	4	<1	1
Kelletia kelletii	1	36	1	1	*Dendronotus iris*	<1	4	<1	1
Cancer sp	1	32	1	1	*Elthusa* sp	<1	4	<1	1
Elthusa vulgaris	1	21	<1	2	*Euspira lewisii*	<1	4	<1	3
Pyromaia tuberculata	1	29	<1	1	*Hamatoscalpellum californicum*	<1	4	<1	1
Cancer gracilis	1	18	<1	2	*Lovenia cordiformis*	<1	4	<1	1
Cancer anthonyi	1	14	<1	2	*Loxorhynchus crispatus*	<1	4	<1	1
Crossata californica	<1	14	<1	1	*Loxorhynchus* sp	<1	4	<1	1
Pagurus spilocarpus	<1	14	<1	1	*Melibe leonina*	<1	4	<1	2
CYMOTHOIDAE	<1	11	<1	2	PAGURIDAE	<1	4	<1	1
HIRUDINEA	<1	11	<1	2	*Paguristes bakeri*	<1	4	<1	1
Loligo opalescens	<1	11	<1	1	*Pagurus armatus*	<1	4	<1	1
Ophiothrix spiculata	<1	11	<1	1	*Philine auriformis*	<1	4	<1	1
Crangon alaskensis	<1	7	<1	2	*Podochela hemphillii*	<1	4	<1	2
Loxorhynchus grandis	<1	7	<1	2	*Pteropurpura festiva*	<1	4	<1	4
Luidia armata	<1	7	<1	2	*Spirontocaris prionota*	<1	4	<1	1
Octopus rubescens	<1	7	<1	1	*Stylatula elongata*	<1	4	<1	1
Pugettia producta	<1	7	<1	2	*Thesea* sp B	<1	4	<1	1
Randallia ornata	<1	7	<1	1					

Table 6.5

Summary of megabenthic invertebrate community parameters for SBOO stations sampled during 2003. Data are expressed as means and standard deviations for species richness, abundance, diversity (H') and biomass (BM) (kg, wet weight); n = 4.

Parameter	**Station**	**Jan**	**Apr**	**Jul**	**Oct**	**Mean**	**SD**
Species Richness	SD15	8	5	7	6	7	1
	SD16	11	4	6	8	7	3
	SD17	10	11	4	11	9	3
	SD18	10	13	10	6	10	3
	SD19	6	5	4	7	6	1
	SD20	8	5	6	6	6	1
	SD21	12	10	8	5	9	3
	Survey Mean	9	8	6	7		
	Survey SD	2	4	2	2		
Abundance	SD15	51	89	61	48	62	19
	SD16	56	18	21	78	43	29
	SD17	63	148	35	82	82	48
	SD18	141	80	75	34	83	44
	SD19	30	91	70	47	60	27
	SD20	36	37	39	48	40	5
	SD21	111	24	17	55	52	43
	Survey Mean	70	70	45	56		
	Survey SD	41	46	23	18		
Diversity (H')	SD15	1.4	1.3	1.3	1.4	1.3	0.1
	SD16	1.6	1.0	1.2	0.8	1.2	0.4
	SD17	1.7	1.3	0.6	0.9	1.1	0.5
	SD18	1.1	1.7	1.4	1.3	1.4	0.2
	SD19	1.3	0.7	0.7	0.8	0.9	0.3
	SD20	1.1	1.0	1.0	0.8	1.0	0.1
	SD21	1.1	1.9	1.9	1.1	1.5	0.5
	Survery Mean	1.3	1.3	1.2	1.0		
	Survey SD	0.2	0.4	0.5	0.3		
Biomass	SD15	0.3	0.2	0.4	0.1	0.3	0.1
	SD16	3.7	0.1	1.2	0.3	1.3	1.7
	SD17	1.1	0.7	0.2	0.1	0.5	0.5
	SD18	1.8	0.6	0.6	0.1	0.8	0.7
	SD19	1.2	0.5	1.2	1.9	1.2	0.6
	SD20	1.2	1.2	1.0	0.5	1.0	0.3
	SD21	3.8	1.6	4.7	0.1	2.6	2.1
	Survey Mean	1.9	0.7	1.3	0.4		
	Survey SD	1.4	0.5	1.5	0.7		

Demersal fish and megabenthic invertebrate communities are inherently variable, and the observed changes in community structure may be influenced by both anthropogenic and natural factors. Anthropogenic influences include inputs from such things as ocean outfalls and storm drain runoff. Natural factors may include prey availability (Cross et al. 1985), bottom relief and sediment structure (Helvey and Smith 1985), and changes in water temperature associated with large scale oceanographic events such as El Niño (Karinen et al. 1985). The observed changes in the assemblages were more likely due to natural factors such as those mentioned above, that can impact the migration of adult fish or the recruitment of juveniles into an area (Murawski 1993). Population fluctuations that affect station diversity and abundance may also be due to the mobile nature of many species (e.g., schools of fish or aggregations of urchins).

Overall, the monitoring data provided no evidence that the discharge of waste water from the South Bay Ocean Outfall in 2003 affected either the fish or megabenthic invertebrate communities in the region. Despite the variable structure of these assemblages, patterns of species diversity, abundance, and biomass were similar at stations near the outfall and at those located further away. In addition, no changes have been found in these assemblages that correspond to the initiation of wastewater discharge. Furthermore, the absence of fin rot or other physical abnormalities on local fishes suggest that populations in the area continue to be healthy.

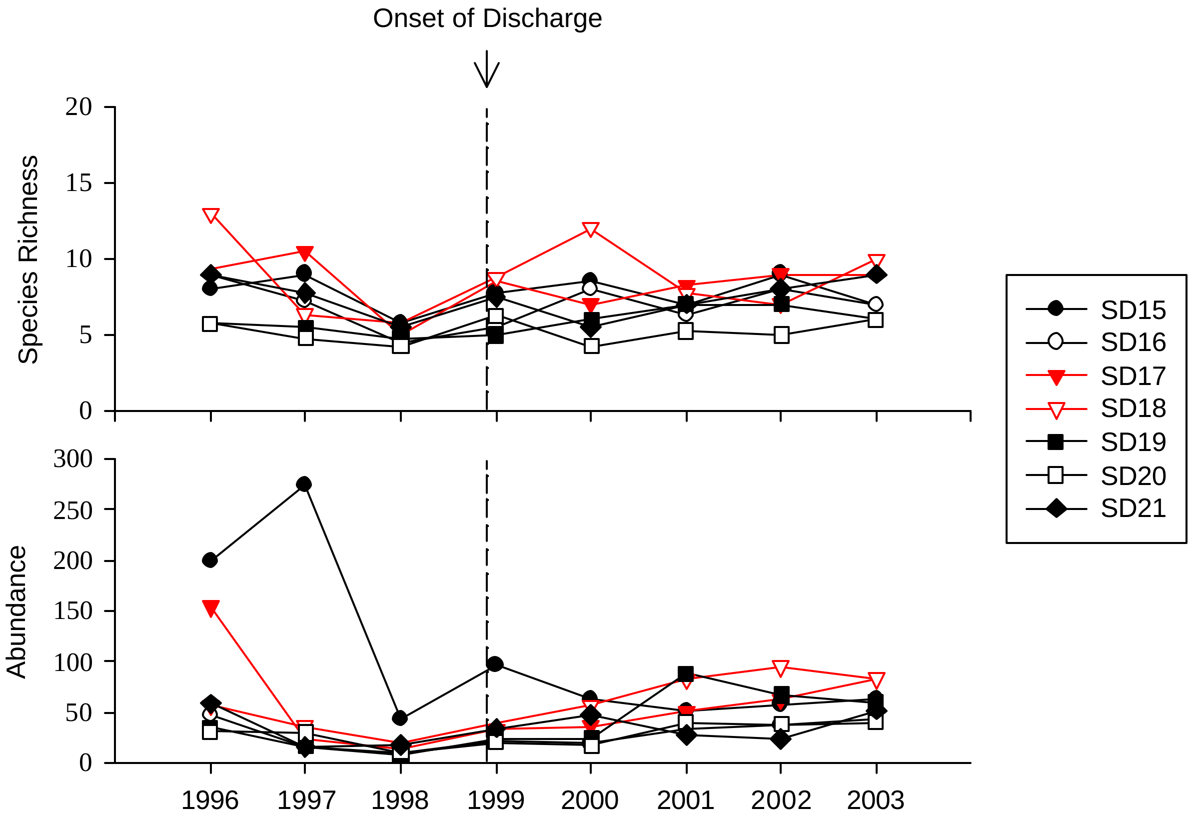


Figure 6.4
Annual mean species richness and abundance per station of megabenthic invertebrates collected from 1996 through 2003.

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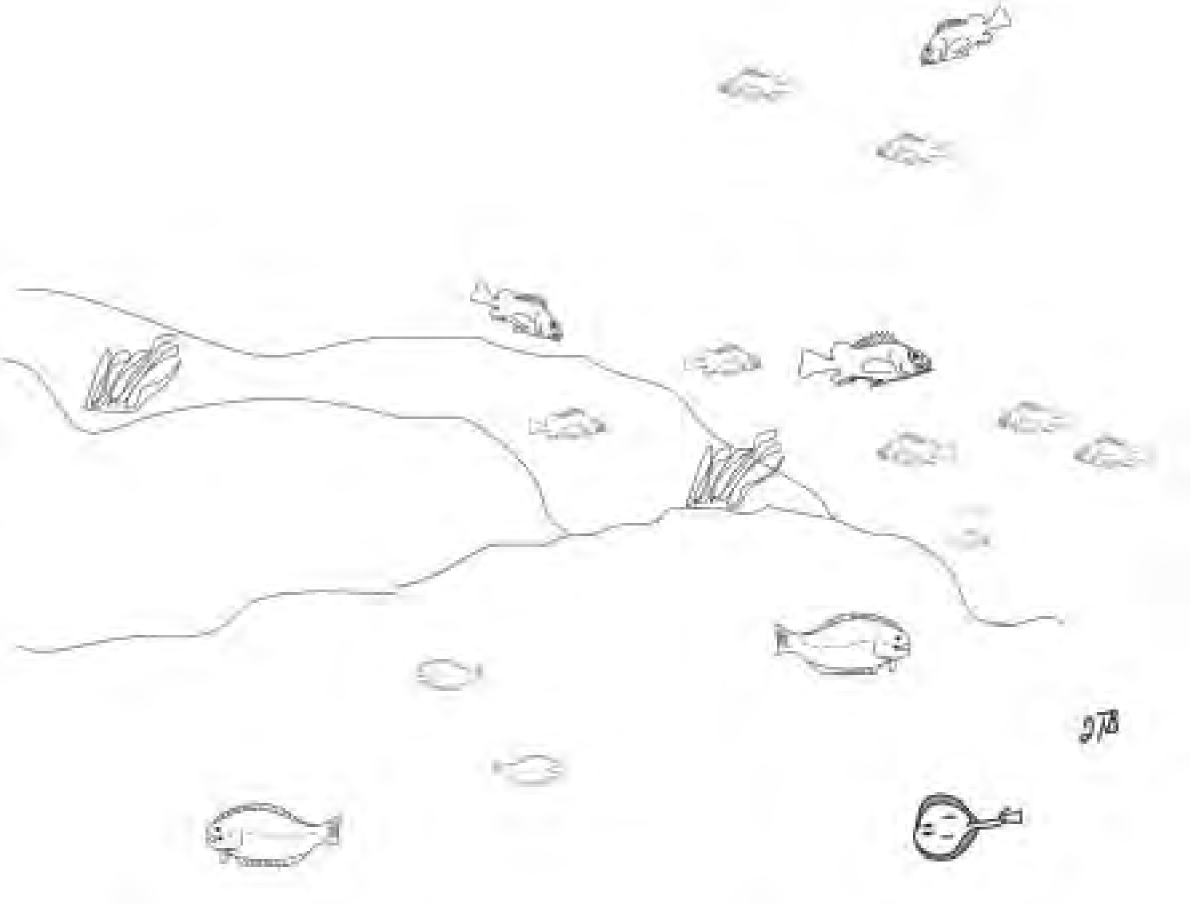
Bioaccumulation of Contaminants in Fish Tissues



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

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

All muscle and liver samples were analyzed for contaminants as specified in the NPDES discharge permits for the SBOO monitoring program. Most of these contaminants are also sampled for the NOAA National Status and Trends Program. NOAA initiated the National Status and Trends Program to detect changes in the environmental quality of our nation's estuarine and coastal waters by tracking contaminants thought to be of concern for the environment (Lauenstein and Cantillo 1993). This chapter presents the results of all tissue analyses that were performed during 2003.

MATERIALS and METHODS

Collection

Fishes were collected during the April and October surveys of 2003 at seven trawl and two rig fishing stations (**Figure 7.1**). Trawl-caught fishes were collected, measured and weighed following guidelines described in Chapter 6 of this report. Fishes targeted at the rig fishing sites were collected using rod and reel fishing tackle, and then measured and weighed following standard procedures (City of San Diego 2004a). Only fish >12 cm standard length were retained for tissue analyses. These fish were sorted into no more than three composite samples per station, each containing a minimum of three individuals. The fish were then wrapped in aluminum

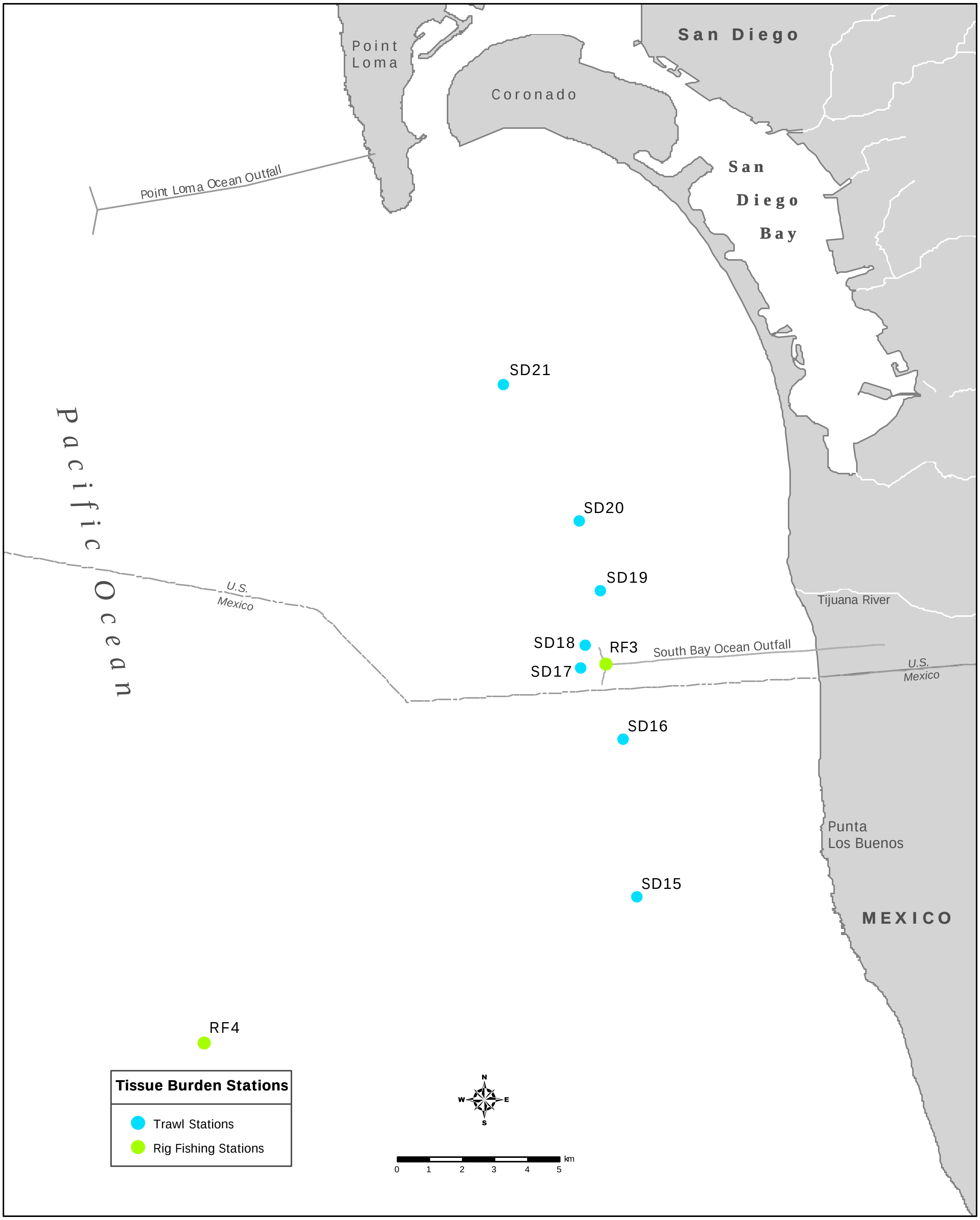


Figure 7.1
Otter trawl and rig fishing station locations, South Bay Ocean Outfall Monitoring Program.

Table 7.1

Species collected at each SBOO trawl and rig fishing station during April and October 2003; ns = samples not collected due to insufficient numbers of fish.

Station	Rep 1	Rep 2	Rep 3
April 2003			
SD15	California scorpionfish	ns	ns
SD16	Longfin sanddab	Hornyhead turbot	California scorpionfish
SD17	Longfin sanddab	Hornyhead turbot	English sole
SD18	Longfin sanddab	Hornyhead turbot	English sole
SD19	Hornyhead turbot	English sole	California scorpionfish
SD20	Longfin sanddab	English sole	Hornyhead turbot
SD21	Longfin sanddab	Hornyhead turbot	Longfin sanddab
RF3	Vermilion rockfish	Vermilion rockfish	Vermilion rockfish
RF4	California scorpionfish	California scorpionfish	California scorpionfish
October 2003			
SD15	California scorpionfish	California scorpionfish	Hornyhead turbot
SD16	California scorpionfish	California scorpionfish	Hornyhead turbot
SD17	California scorpionfish	California scorpionfish	California scorpionfish
SD18	California scorpionfish	Hornyhead turbot	California scorpionfish
SD19	Longfin sanddab	Longfin sanddab	Hornyhead turbot
SD20	Longfin sanddab	Hornyhead turbot	Hornyhead turbot
SD21	California scorpionfish	California scorpionfish	California scorpionfish
RF3	Vermilion rockfish	Vermilion rockfish	Brown rockfish
RF4	Mixed rockfish	California scorpionfish	California scorpionfish

foil, labeled, put in ziplock bags, and placed on dry ice for transport to the Marine Biology laboratory freezer. The species that were analyzed from each station are summarized in **Table 7.1**.

Tissue Processing and Chemical Analyses

All dissections were performed according to standard techniques for tissue analysis (see City of San Diego 2004a). Each fish was partially defrosted and then cleaned with a paper towel to remove loose scales and excess mucus prior to dissection. The standard length (cm) and weight (g) of each fish were recorded (**Appendix C.1**). Dissections were carried out on Teflon pads that were cleaned between samples. Tissue samples were then placed in glass jars, sealed, labeled and stored in a freezer at -20°C prior to chemical analyses. All samples were subsequently delivered to the City of San Diego Wastewater Chemistry Laboratory within seven days of dissection.

All tissue samples were analyzed for the chemical constituents specified by the permit under which this sampling was performed. These metals, chlorinated pesticides, PCBs and PAHs are listed in **Appendix C.2**. A summary of all parameters detected at each station during each survey is listed in **Appendix C.3**. Detected parameters include some that were determined to be present in a sample with high confidence (i.e., peaks are confirmed by mass-spectrometry), but at levels below the MDL. These were included in the data as estimated values. No PAHs were detected during 2003. A detailed description of the analytical protocols may be obtained from the City of San Diego Wastewater Chemistry Laboratory (City of San Diego 2004b).

A disparity in trace metal detection rates occurred between the April and October surveys as a result of a change in instrumentation. A more sensitive Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) technique for analysis of metals was introduced mid-year of 2003. An IRIS axial ICP-AES system replaced the Atomscan radial ICP-AES. The superior abilities of the IRIS axial ICP-AES lowered the method detection limits approximately an order of magnitude. Consequently, low concentrations of metals that would not have been detected in the April samples were detected during the October survey.

RESULTS

Contaminants in Liver Tissues

Distribution among Species

Aluminum, arsenic, barium, cadmium, chromium, copper, iron, manganese, mercury, nickel, selenium, silver, tin, and zinc occurred frequently in the liver tissues of all species sampled (**Table 7.2**). Each of these metals was detected in over 70% of the samples from at least one survey, although in highly variable concentrations. Beryllium and lead were also detected, but much less frequently. Differences in detection rates between surveys were mostly due to equipment changes that resulted in much lower MDLs in October (see Materials and Methods). For example, while silver was not detected at all in April, it was found in 100% of the samples in October.

Several chlorinated pesticides were also detected in the liver tissues (**Table 7.3**). Total DDT (the sum of three DDT derivatives and their isomers) was found in all samples, with concentrations averaging from 113 ppb in English sole to 1,696 ppb in California scorpionfish. Other pesticides that were detected included chlordane, hexachlorobenzene (HCB), mirex, and nonachlor (trans and cis). Of these, HCB and trans nonachlor were the most common, occurring in >40% of the samples. Chlordane occurred only as alpha (cis) chlordane (28% detection rate) at concentrations ranging from 2.8 to 8.2 ppb. Cis nonachlor and mirex were detected only twice each.

PCBs occurred in all samples from each species. Concentrations for the individual PCB congeners are listed separately in Appendix C.3. Total PCB concentrations (i.e., the sum of all congeners detected in a sample) were variable, ranging from about 10 ppb to 1,122 ppb.

Distribution among Stations

Concentrations of the frequently detected metals in fish liver tissues varied across all stations (**Figure 7.2**). However, intraspecific comparisons between the two stations closest to the discharge (SD17, SD18) and those location farther away (SD15–SD16, SD19–SD21) suggest that there was no clear relationship between contaminant loads and proximity to the outfall. Further, most contaminant concentrations were close to or below the maximum levels detected in the same species prior to discharge. The most notable exception was an elevated amount of arsenic detected in an English sole sample collected at station SD17 in April.

Several pesticides (i.e., DDT, HCB, trans nonachlor) and PCBs were detected in fishes collected from all stations (**Figure 7.3**). As with the metals, there was no clear relationship between concentrations of these parameters and proximity to the outfall, and most values were below the maximum concentrations detected in the same species prior to discharge. The most notable exception was for a scorpionfish sample collected at

Table 7.2

Metals detected in liver samples from fish collected at SBOO trawl stations during 2003. Values are expressed as parts per million (ppm). N = number of detected values, ns = not sampled.

	Al	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Sn	Zn
Ca. Scorpionfish																
N (out of 15)	15	12	12	8	15	13	15	15	1	14	14	12	15	12	12	15
Min	5.1	0.6	0.069	0.003	0.6	0.21	4.9	52.1	0.43	0.35	0.049	0.11	0.64	0.11	0.84	53.5
Max	18.9	2.8	0.139	0.005	6.9	0.62	33.5	364.0	0.43	0.80	0.459	0.37	1.03	0.51	1.53	270.0
Mean	10.4	1.1	0.112	0.004	2.5	0.32	18.3	157.2	0.43	0.50	0.163	0.20	0.81	0.25	1.22	95.8
Hornyhead turbot																
N (out of 12)	12	10	6	1	12	6	12	12	0	12	12	5	12	6	6	12
Min	4.6	0.8	0.058	0.003	2.0	0.21	3.0	19.4	—-	0.61	0.066	0.11	0.57	0.12	0.69	31.0
Max	15.4	4.3	0.084	0.003	11.7	0.55	24.9	250.0	—-	2.54	0.407	0.43	1.27	0.50	1.05	90.2
Mean	7.2	2.5	0.0763	0.003	5.8	0.30	8.5	65.9	—-	1.38	0.164	0.23	0.82	0.22	0.92	49.5
Longfin sanddab																
N (out of 9)	9	9	3	3	9	6	9	9	0	9	9	3	9	3	3	9
Min	4.2	2.9	0.130	0.004	1.1	0.27	6.5	50.1	—-	0.71	0.048	0.17	0.76	0.16	1.41	20.5
Max	17.5	14.5	0.365	0.006	6.6	0.51	12.6	202.0	—-	1.81	0.238	0.25	2.18	0.18	1.77	39.6
Mean	10.3	7.0	0.208	0.005	3.5	0.36	9.4	122.6	—-	1.2897	0.130	0.20	1.26	0.17	1.54	26.8
English sole																
N (out of 4)	3	4	0	0	4	0	4	4	0	4	4	0	4	0	0	4
Min	4.6	6.8	—-	—-	0.9	—-	6.7	181.0	—-	1.44	0.052	—-	1.52	—-	—-	24.7
Max	6.4	44.6	—-	—-	2.4	—-	20.7	400.0	—-	2.48	0.501	—-	1.95	—-	—-	28.4
Mean	5.5	19.1	—-	—-	1.8	—-	11.1	289.5	—-	2.10	0.199	—-	1.72	—-	—-	26.6
ALL SPECIES																
% Detect. (April)	95	74	ns	0	100	21	100	100	0	95	100	0	100	0	0	100
% Detect. (Oct)	100	100	100	57	100	100	100	100	5	100	95	95	100	100	100	100

Table 7.3

Chlorinated pesticides, PCBs, and lipids detected in liver samples from fish collected at SBOO trawl stations during 2003. Values are expressed as parts per billion (ppb) for all parameters except lipids, which are presented as percent weight (% wt). N = number of detected values.

	Chlorinated Pesticides							
	Chlordane	Nonachlor					Total	Total
	Alpha	Trans	Cis	HCB	Mirex	DDT	PCB	Lipids
Ca. Scorpionfish								
N (out of 15)	4	10	1	13	0	15	15	
Min	3.8	6.2	5.1	1.3	—-	133	29.0	11.0
Max	6.7	17.5	5.1	5.5	—-	15503	1122.2	31.9
Mean	5.5	10.7	5.1	3.2	—-	1696	311.5	20.9
Hornyhead turbot								
N (out of 12)	0	1	0	3	0	12	12	
Min	—-	4.7	—-	0.8	—-	49	10.1	3.2
Max	—-	4.7	—-	2.2	—-	324	189.7	16.5
Mean	—-	4.7	—-	1.3	—-	118	44.3	8.5
Longfin sanddab								
N (out of 9)	7	7	1	6	2	9	9	
Min	2.8	2.4	5.9	3.3	1.8	88	48.0	4.4
Max	8.2	14.0	5.9	5.8	2.4	2920	778.0	49.9
Mean	5.1	7.0	5.9	4.3	2.1	984	382.4	26.9
English sole								
N (out of 4)	0	0	0	0	0	4	4	
Min	—-	—-	—-	—-	—-	64	43.9	4.9
Max	—-	—-	—-	—-	—-	139	69.4	6.0
Mean	—-	—-	—-	—-	—-	113	56.9	5.5
ALL SPECIES								
% Dect.	28	45	5	55	5	100	100	

SD16 in October that had a substantial amount of DDT. DDT levels are typically low or non-detected in the sediments surrounding the SBOO (see Chapter 4). In addition, California scorpionfish are known to travel over vast areas (Hartmann 1987, Love et al. 1987). Consequently, this high level of DDT was most likely due to exposure in another area that had higher levels of sediment contamination.

Contaminants in Muscle Tissues

To address human health concerns, concentrations of various constituents found in muscle tissue samples were compared to national and international limits and standards (**Table 7.4**). The United States Food and Drug Administration (USFDA) has set mercury and total DDT limits for seafood that is to be sold for human consumption (Mearns et al. 1991). In addition, there are international standards for acceptable concentrations of various metals (Mearns et al. 1991). While many compounds were detected in the muscle tissues of fish collected as part of the SBOO monitoring program, only arsenic, chromium and selenium had concentrations that were higher than international standards.

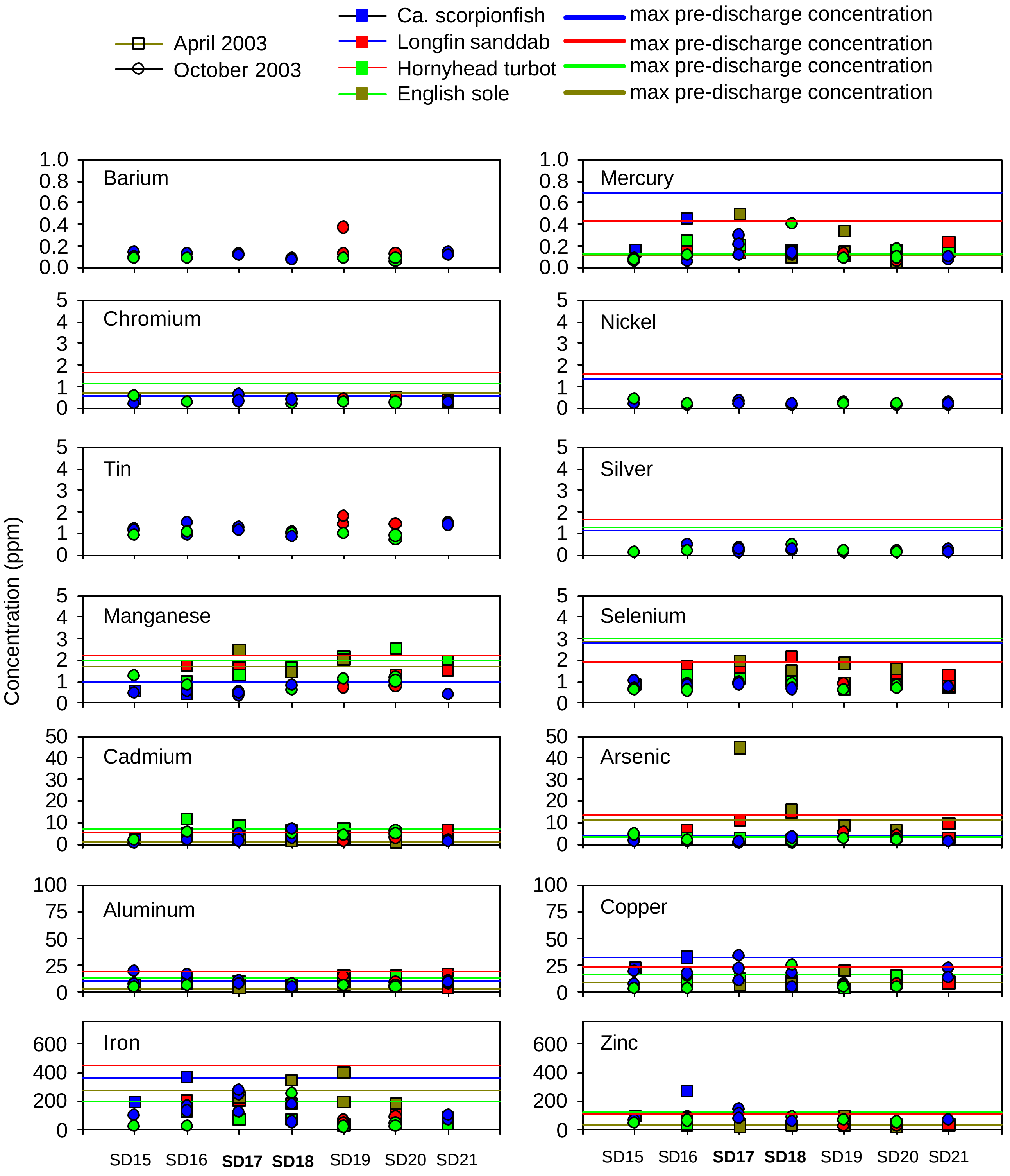


Figure 7.2

Concentrations of frequently detected metals in liver tissues of fish collected from each trawl station during 2003. Only four samples were collected at station SD15; otherwise missing data represent concentrations below detection limits. Reference lines are maximum values detected during the pre-discharge period (1995–1998). Stations closest to the discharge site are in bold type.

In addition to addressing health concerns, spatial patterns were assessed for total DDT and total PCB, as well as all metals that occurred frequently in fish muscle tissue samples (**Figure 7.4**). Concentrations of these parameters were variable in the tissues of fish collected at both stations and no clear relationship with proximity to the outfall was evident; contaminants, including those that exceeded international standards, had similar values at both the nearfield station (RF3) and the farfield station (RF4). Further, most California scorpionfish and mixed rockfish samples had values close to or below the maximum concentrations detected in the same species prior to discharge.

SUMMARY and CONCLUSIONS

Demersal fish collected around the South Bay Ocean Outfall in 2003 were characterized by contaminant values within the range of those 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, concentrations of most contaminants were not substantially different from pre-discharge data (City of San Diego 2000b).

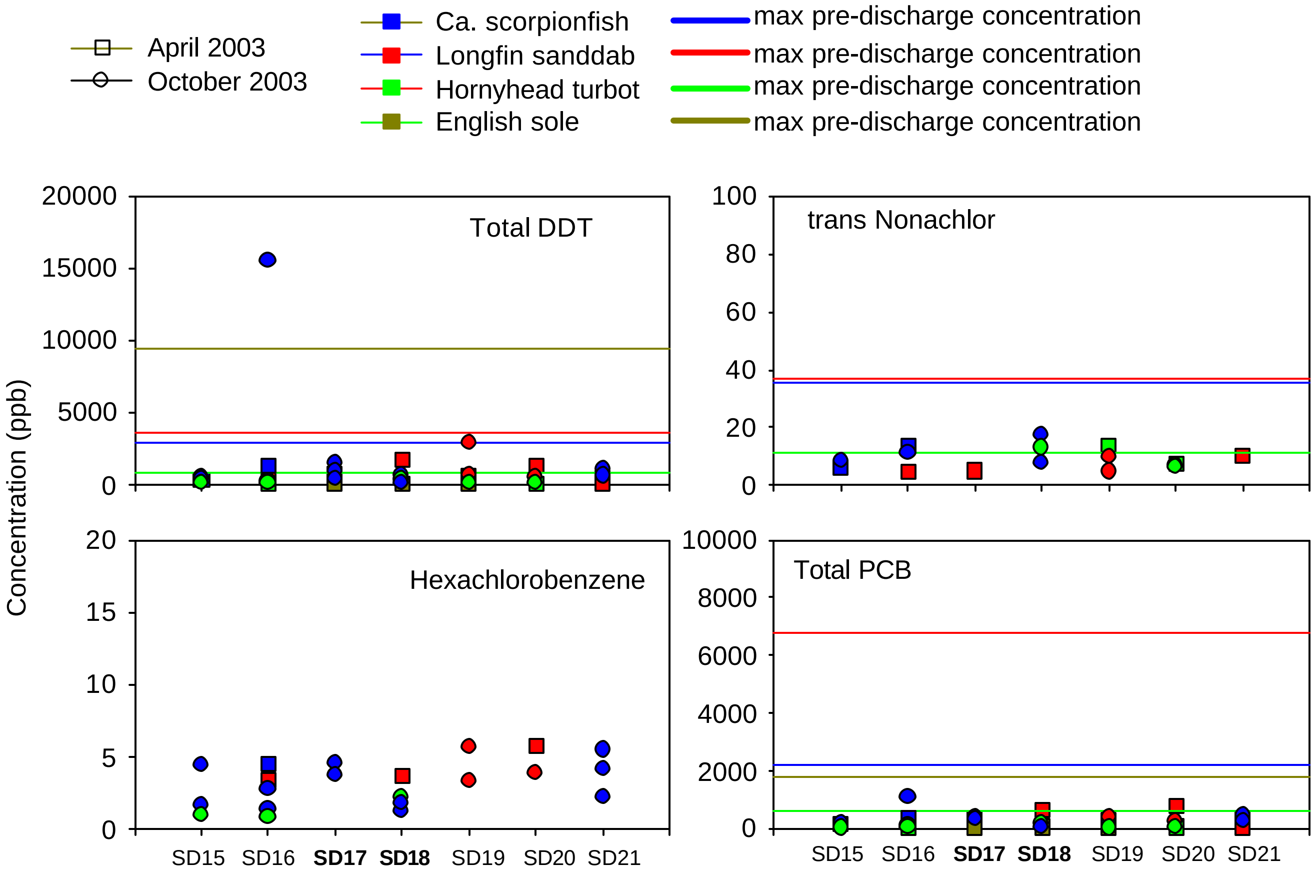


Figure 7.3

Concentrations of frequently detected chlorinated pesticides (total DDT, trans Nonachlor, hexachlorobenzene) and total PCBs in liver tissues of fish collected from each trawl station during 2003. Only four samples were collected at station SD15; otherwise missing data represent concentrations below detection limits. Reference lines are maximum values detected during the pre-discharge period (1995–1998). Stations closest to the discharge site are in bold type.

Table 7.4

Concentrations of various metals and total DDT detected in muscle samples from fish collected at SBOO rig fishing stations during 2003. Values are parts per million (ppm) for all parameters. Data for each species are compared to USFDA action limits and median international standards. Bolded values exceed these standards.

	As	Cd	Cr	Cu	Pb	Hg	Se	Sn	Zinc	tDDT
California scorpionfish										
N (out of 5)	4	0	3	2	0	4	5	2	5	5
Min	0.6	—-	0.13	0.38	—-	0.030	0.23	0.409	2.6	0.0006
Max	**1.9**	—-	**1.79**	0.41	—-	0.053	**0.44**	0.455	3.9	0.0057
Mean	1.3	—-	0.68	0.39	—-	0.041	**0.30**	0.432	3.4	0.0035
Vermilion rockfish										
N (out of 5)	5	0	3	4	0	5	5	2	5	5
Min	**1.7**	—-	0.14	0.27	—-	0.145	0.17	0.438	1.9	0.0046
Max	**2.8**	—-	**1.70**	14.70	—-	0.273	0.28	0.485	4.1	0.0244
Mean	**2.1**	—-	0.66	4.08	—-	0.179	0.23	0.462	2.9	0.0117
Brown rockfish										
N (out of 1)	1	0	1	1	0	1	1	1	1	1
Min	1.0	—-	0.13	0.18	—-	0.123	**0.48**	0.428	3.2	0.0014
Max	1.0	—-	0.13	0.18	—-	0.123	**0.48**	0.428	3.2	0.0014
Mean	1.0	—-	0.13	0.18	—-	0.123	**0.48**	0.428	3.2	0.0014
Mixed rockfish										
N (out of 1)	1	0	1	1	0	1	1	1	1	1
Min	**2.4**	—-	0.15	0.31	—-	0.076	0.27	0.465	4.4	0.0093
Max	**2.4**	—-	0.15	0.31	—-	0.076	0.27	0.465	4.4	0.0093
Mean	**2.4**	—-	0.15	0.31	—-	0.076	0.27	0.465	4.4	0.0093
USFDA Action Limit*						1				5
Median International Standard*	1.4	1.0	1.0	20	2.0	0.5	0.3	175	70	5

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

The frequent occurrence of metals and chlorinated hydrocarbons in SBOO fish tissues may be due to many factors. Mearns et al. (1991) described the distribution of several contaminants, including arsenic, mercury, DDT, and PCBs as being ubiquitous in the SCB. In fact, many metals occur naturally in the environment, although little information is available on their background levels in fish tissues. Brown et al. (1986) determined that no areas of the SCB are sufficiently free of chemical contaminants to be considered reference sites. This has been supported by more recent work regarding PCBs and DDTs (e.g., Allen et al. 1998). 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 the discharge (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. For example, exposure to contaminants can vary greatly between species and among individuals of the same species depending on migration habits (Otway 1991). Fish may be exposed to contaminants in one highly contaminated area and then move into an area that is less contaminated. This 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. 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 nearby areas (see Appendix D, Figure D.3).

Overall, there was no evidence that fishes collected in 2003 were contaminated by the discharge of waste water from the South Bay Ocean Outfall. In addition, concentrations of mercury and DDT in muscle tissues from sport fish collected in the area were below USFDA human consumption limits. Finally, there was no other indication of poor fish health in the region, such as the presence of fin rot or other physical anomalies (see Chapter 6).

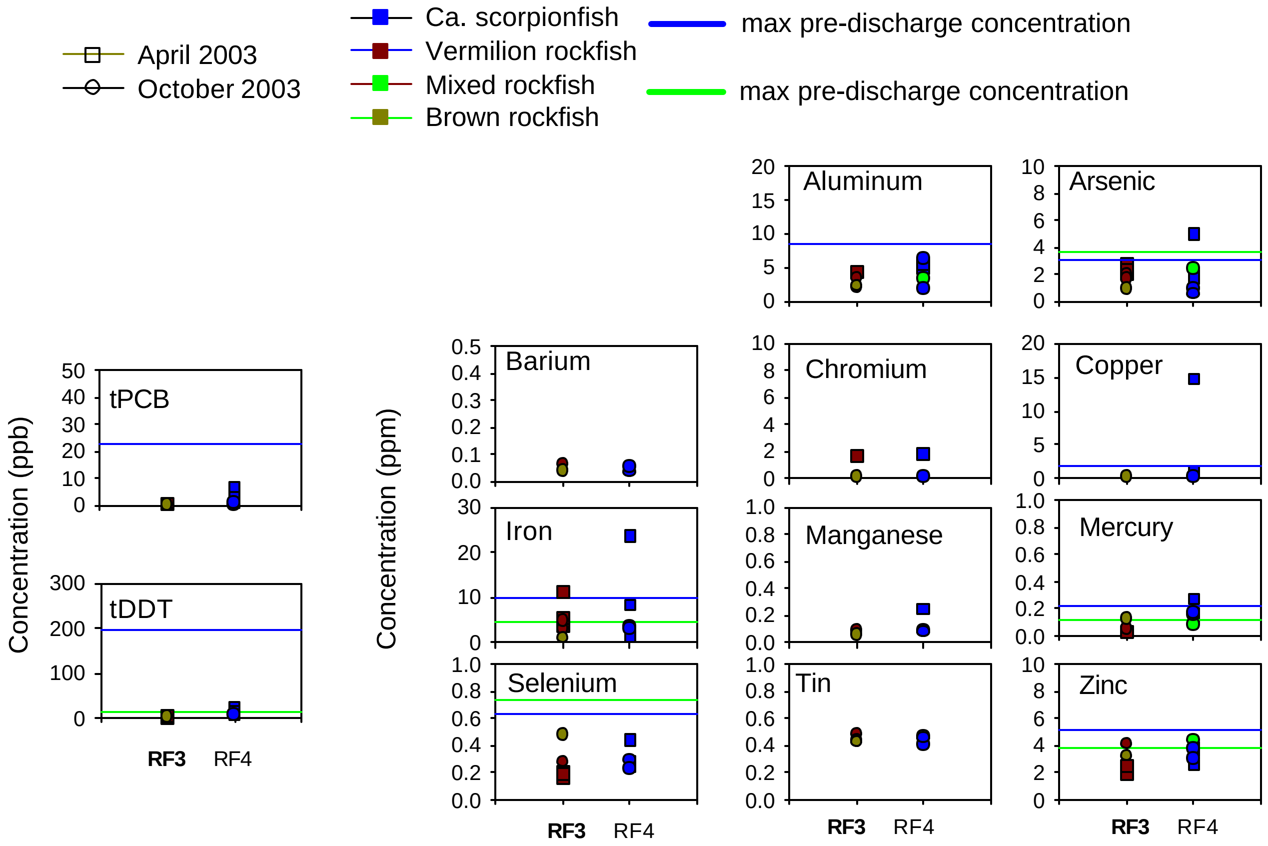


Figure 7.4

Concentrations of frequently detected metals, total DDT and total PCB in muscle tissues of fish collected from each rig fishing station during 2003. Missing data represent concentrations below detection limits. Reference lines are maximum values detected during the pre-discharge period (1995–1998) for California scorpionfish and mixed rockfish. No vermilion or brown rockfish were collected during that period. The station closest to the discharge site (RF3) is in bold type.

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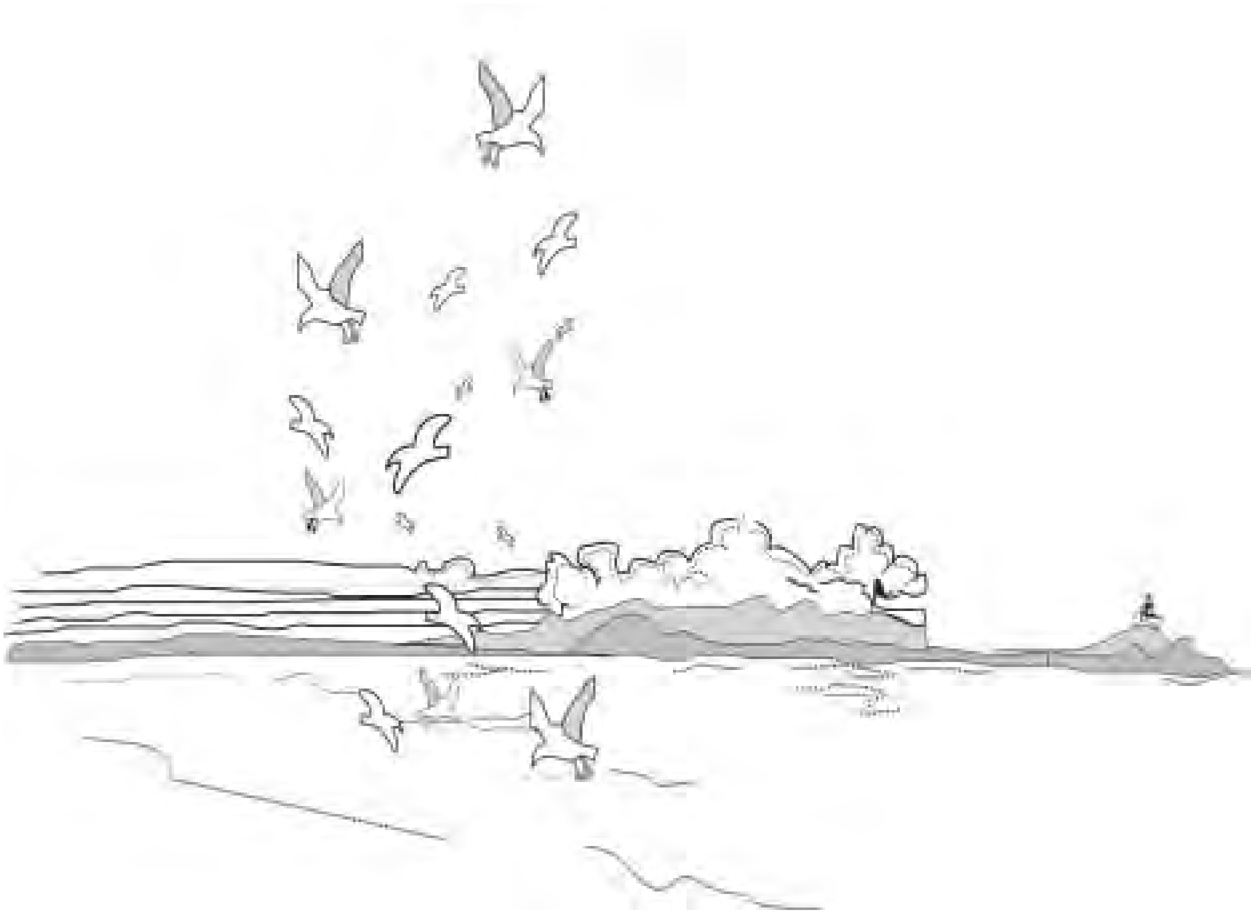
Glossary



Glossary

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

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

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

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

BACIP (Before-After-Control-Impact-Paired) An analytical tool for assessing environmental impacts. Samples are collected from control and impacted sites before and after wastewater is released. A statistical test is applied to distinguish change (e.g., in a population or organisms), accounting for variability, caused by the effects of pollution from natural variation over time and between sites.

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 concentration of a chemical in animal tissue that becomes accumulated over time by direct intake via contaminated water, the consumption of contaminated prey, or absorption through the skin.

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

Biota The living organisms within a habitat or region.

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

CDF (cummulative distribution function) or 50% CDF Used herein to refer to the median value of a chemical parameter (e.g., concentrations of trace metals, organic indicators) occurring within throughout the Southern California Bight (SCB). These values are based upon results from the 1994 Southern California Bight Pilot Project (see http://www.sccwrp.org/regional/94scbpp/sedchem/sedchem_app.html). Fifty percent of the concentrations of a chemical parameter sampled in 1994 occurred at or below the 50% CDF.

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

Congeners Used herein in reference to any one of 209 different PCB compounds (see below). A congener may have between 1 and 10 chlorine atoms, which may be located at various positions on the PCB molecule.

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

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

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

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

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

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

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

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

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

Epibenthic Referring to organisms that live on or near the sediments or other substrates (e.g., rock). See demersal. Compare with infauna.

Epifauna Animals living on the surface of sea bottom sediments or other substrates (e.g., rock).

Impact site A geographic location that has been altered by the effects of a disturbance (e.g., pollution source or anthropogenic activity), 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 environmental disturbance or anthropogenic impact.

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

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

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

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

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

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

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

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

Motile Self-propelled or actively moving.

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

NPDES (National Pollutant Discharge Elimination System) A federal permit program that controls water pollution by regulating point source discharge 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 (Polynuclear aromatic hydrocarbons) Hydrocarbon compounds with multiple benzene rings which are typical components of asphalts, fuels, oils, and greases. They are also refered to as polycyclic aromatic hydrocarbons. PAHs are potent carcinogens and mutagens.

PCBs (Polychlorinated biphenyls) A category, or family, of organic compounds that includes 209 synthetically halogenated aromatic hydrocarbons formed by the addition of chlorine (C_{l2}) to biphenyl ($C_{12}H_{10}$). PCB are used in wide ranging industrial applications (e.g., insulation materials in electrical capacitors, hydrolic fluids, paint additives) and have been linked to reproductive and nervous system disorders and cancer in humans.

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

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

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

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

Pycnocline A depth zone in the ocean where density increases rapidly with depth, in association with a decline in temperature and increase in salinity.

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

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

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

Shell hash Fragments and remnants of bivalve and gastropod shells commonly found in marine sediments, and which frequently have the size and consistency of very coarse sand.

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

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

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

SCB (Southern California Bight) The geographic region that stretches from Point Conception, U.S.A. to the Cabo Colnett, Mexico, and encompasses nearly 80,000 km2 of coastal land and sea.

Species Richness The number of species per unit area, frequently used to assess community diversity.

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

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

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 along the coastline.

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

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

ZID (zone of initial dilution) The region of initial mixing of treated wastewater from the diffuser ports of the outfall with the surrounding receiving waters. The area with the ZID, including the underlying seabed, is chronically exposed to pollutants and is likely to be the area of greatest impact.

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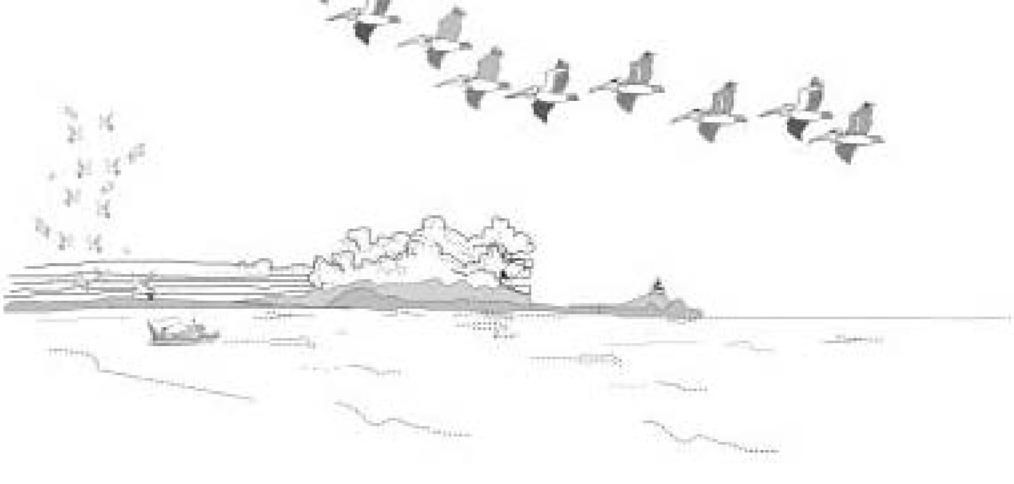
Appendices



Appendix A

Supporting Data

2003 SBOO Stations

Sediment Characteristics

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Appendix A.1

Sediment chemistry constituents analyzed for South Bay Ocean Outfall sampling during 2003.

Cholorinated Pesticides

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

Polycylic Aromatic Hydrocarbons

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

Metals

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

PCB Congeners

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

Appendix A.2

SBOO Sediment Statistics January 2003

Station	Mean Phi	Std. Dev. Phi	Median Phi	Mean mm	Skewness	Kurtosis	Coarse %	Sand %	Silt %	Clay %
19 m stations										
I35	3.9	1.3	3.8	0.07	0.2	1.1	0.0	56.0	42.1	1.8
I34	1.6	0.8	1.8	0.33	-0.3	0.9	3.5	96.4	0.0	0.0
I31	3.1	0.6	3.1	0.12	0.1	1.1	0.2	93.3	6.3	0.0
I23	3.1	0.8	3.1	0.12	0.1	1.3	0.2	91.7	7.5	0.2
I18	3.1	0.7	3.1	0.12	0.0	1.2	0.2	92.1	7.6	0.1
I10	3.1	0.7	3.0	0.12	0.1	3.7	0.3	91.8	7.8	0.1
I4	2.9	0.9	2.9	0.13	0.0	1.3	0.0	91.7	8.1	0.1
28 m stations										
I33	2.9	1.0	2.8	0.13	0.2	1.8	0.3	89.5	9.5	0.6
I30	3.2	0.9	3.1	0.11	0.3	1.6	0.2	85.5	13.8	0.4
I27	3.2	0.8	3.1	0.11	0.2	1.5	0.2	87.0	12.4	0.4
I22	3.1	0.9	3.0	0.12	0.2	1.5	0.0	89.0	8.7	0.1
I14	3.3	0.7	3.2	0.10	0.2	1.3	0.0	86.8	12.9	0.3
I15	1.6	1.0	1.5	0.33	0.1	1.0	4.7	92.8	2.4	0.0
I16	2.5	2.3	2.5	0.18	0.3	3.4	1.7	87.4	4.8	1.1
I12	1.5	0.9	1.6	0.35	-0.1	0.9	4.7	95.1	0.2	0.0
I9	3.4	0.7	3.3	0.09	0.1	1.1	0.0	85.6	14.0	0.4
I6	0.8	0.7	0.8	0.57	0.1	1.0	9.1	90.9	0.0	0.0
I2	1.6	0.8	1.8	0.33	-0.2	0.9	4.4	95.6	0.0	0.0
I3	1.3	0.8	1.3	0.41	0.0	0.9	5.1	94.9	0.0	0.0
38 m stations										
I29	3.4	1.2	3.2	0.09	0.3	1.4	0.0	77.5	21.2	1.3
I21	1.1	0.8	1.0	0.47	0.1	0.9	6.7	93.1	0.2	0.0
I13	0.8	0.7	0.8	0.57	0.1	1.0	9.3	90.7	0.0	0.0
I8	1.0	0.8	0.9	0.50	0.2	1.0	9.0	89.8	1.2	0.0
55 m stations										
I28	3.3	2.4	3.2	0.10	0.0	2.1	8.8	58.3	30.1	2.9
I20	0.7	0.7	0.5	0.62	0.3	1.1	13.7	86.3	0.0	0.0
I7	0.9	0.8	0.8	0.54	0.2	1.1	10.6	88.6	0.8	0.0
I1	2.8	0.9	2.7	0.14	0.3	1.8	0.0	91.5	8.0	0.3

Appendix A.2

SBOO Sediment Statistics July 2003

Station	Mean Phi	Std. Dev. Phi	Median Phi	Mean mm	Skewness	Kurtosis	Coarse %	Sand %	Silt %	Clay %
19 m stations										
I35	3.7	1.2	3.6	0.08	0.2	1.1	0.0	63.6	35.2	1.2
I34	1.8	0.8	2.0	0.29	-0.3	0.9	2.6	97.3	0.1	0.0
I31	3.1	0.7	3.1	0.12	0.2	1.3	0.0	92.5	7.1	0.1
I23	3.0	0.8	3.0	0.13	0.2	1.3	0.0	91.7	7.9	0.1
I18	3.2	0.7	3.1	0.11	0.2	1.3	0.0	89.9	9.6	0.1
I10	3.1	0.7	3.1	0.12	0.2	1.3	0.0	91.5	7.9	0.1
I4	1.4	1.0	1.3	0.38	0.2	0.9	6.0	93.1	0.9	0.0
28 m stations										
I33	3.0	1.0	2.9	0.13	0.4	1.8	0.0	88.0	11.1	0.8
I30	3.3	0.8	3.3	0.10	0.1	1.4	0.0	85.3	14.2	0.5
I27	3.2	0.8	3.2	0.11	0.1	1.3	0.0	87.7	11.9	0.4
I22	3.1	0.8	3.1	0.12	0.2	1.3	0.0	88.5	10.9	0.2
I14	2.9	1.0	2.9	0.13	0.0	1.4	0.0	90.6	9.3	0.1
I15	2.7	1.1	2.7	0.15	0.0	1.2	0.0	89.9	10.0	0.1
I16	2.0	1.7	1.9	0.25	0.3	1.2	5.9	81.4	11.8	0.6
I12	1.4	0.9	1.4	0.38	0.0	0.9	5.0	94.2	0.8	0.0
I9	3.3	0.7	3.3	0.10	0.1	1.2	0.0	86.0	13.7	0.3
I6	0.9	0.7	0.9	0.54	0.2	1.0	8.6	91.2	0.1	0.0
I2	1.6	0.8	1.7	0.33	-0.2	0.9	4.0	95.9	0.0	0.0
I3	1.4	0.8	1.4	0.38	-0.1	0.9	5.1	94.9	0.0	0.0
38 m stations										
I29	3.4	1.2	3.3	0.09	0.2	1.4	0.0	76.1	22.8	1.0
I21	1.2	0.8	1.1	0.44	0.1	0.9	5.8	94.0	0.3	0.0
I13	0.9	0.7	0.9	0.54	0.2	1.1	8.1	91.7	0.2	0.0
I8	1.5	0.9	1.4	0.35	0.0	0.9	5.3	92.2	2.5	0.0
55 m stations										
I28	3.9	1.9	3.5	0.07	0.3	1.2	0.0	63.0	34.3	2.7
I20	0.6	0.9	0.5	0.66	0.4	1.8	16.9	78.8	4.1	0.1
I7	0.7	0.7	0.6	0.62	0.2	1.2	14.2	84.9	0.8	0.0
I1	2.8	1.0	2.7	0.14	0.3	1.8	0.0	91.3	8.1	0.4

Appendix A.3

List of PAHs detected at two SBOO stations during January and July 2003.

PAH Compound	MDL	January Station I12	July Station I1
2-methylnaphthalene	39	39.0	nd
Anthracene	35	nd	38.1
Benzo[A]anthracene	23	nd	32.1
Benzo[A]pyrene	18	nd	24.4
Benzo[K]fluoranthene	20	nd	18.0
Chrysene	21	nd	23.9
Fluoranthene	39	nd	66.5
Fluorene	46	nd	56.5
Naphthalene	36	36.0	45.4
Phenanthrene	37	nd	82.0
Pyrene	27	nd	30.5

Appendix B

Supporting Data

2003 SBOO Stations

Demersal Fishes and Megabenthic Invertebrates

Appendix B.1

Summary of demersal fish species captured during 2003 at SBOO stations. Data are number of fish collected (N) and minimum, maximum and mean length (cm SL).

			LENGTH		
Taxon/Species	**Common Name**	**N**	**Min**	**Max**	**Mean**
RAJIFORMES					
Rajoidei					
Platyrhinoidis triseriata	thornback	1	44	55	51
Rhinobatos productus	shovelnose guitarfish	2	29	56	43
Rajidae					
Raja inornata	California skate	5	23	49	38
Myliobatidoidei					
Urolophus halleri	round stingray	2	28	40	34
AULOPIFORMES					
Synodontidae					
Synodus lucioceps	California lizardfish	228	7	28	12
BATRACHOIDIFORMES					
Batrachoididae					
Porichthys myriaster	specklefin midshipman	1	35	35	35
Porichthys notatus	plainfin midshipman	37	4	14	6
GASTEROSTEIFORMES					
Syngnathidae					
Syngnathus californiensis	kelp pipefish	2	18	27	23
SCORPAENIFORMES					
Scorpaenidae					
Scorpaena guttata	California scorpionfish	38	14	29	21
Hexagrammidae					
Ophiodon elongatus	lingcod	11	10	14	12
Zaniolepis latipinnis	longspine combfish	5	13	16	14
Cottidae					
Chitonotus pugetensis	roughback sculpin	104	4	12	8
Icelinus quadriseriatus	yellowchin sculpin	46	4	7	6
Agonidae					
Odontopyxis trispinosa	pygmy poacher	1	8	8	8
Liparidae					
Liparis mucosus	slimy snailfish	1	5	5	5
PERCIFORMES					
Serranidae					
Paralabrax nebulifer	barred sand bass	1	26	26	26
Sciaenidae					
Genyonemus lineatus	white croaker	36	11	25	17
Seriphus politus	queenfish	9	9	15	12
Embiotocidae					
Cymatogaster aggregata	shiner perch	8	8	14	12
Zalembius rosaceus	pink seaperch	2	8	9	9
Clinidae					
Heterostichus rostratus	giant kelpfish	5	12	18	15
Gobiidae					
Lepidogobius lepidus	bay goby	1	7	7	7

Appendix B.1 continued

			LENGTH		
Taxon/Species	**Common Name**	**N**	**Min**	**Max**	**Mean**
PLEURONECTIFORMES		2	3	3	3
Paralichthyidae					
Citharichthys sordidus	Pacific sanddab	17	12	20	15
Citharichthys stigmaeus	speckled sanddab	4378	3	12	8
Citharichthys xanthostigma	longfin sanddab	61	10	19	15
Hippoglossina stomata	bigmouth sole	3	20	22	21
Paralichthys californicus	California halibut	30	23	47	32
Xystreurys liolepis	fantail sole	7	19	29	24
Pleuronectidae					
Hypsopsetta guttulata	diamond turbot	1	22	22	22
Pleuronectes vetulus	English sole	49	6	30	16
Pleuronichthys decurrens	curlfin sole	1	13	13	13
Pleuronichthys ritteri	spotted turbot	20	13	19	16
Pleuronichthys verticalis	hornyhead turbot	75	4	22	15
Cynoglossidae					
Symphurus atricauda	California tonguefish	18	6	17	12

Taxonomic arrangement from Nelson 1994.

Appendix B.2

Summary of megabenthic invertebrate taxa captured during 2003 at SBOO stations. Data are number of individuals collected (N).

Taxon/ Species	N
CNIDARIA	
ANTHOZOA	
ALCYONACEA	
Muriceidae	
Thesea sp B	1
PENNATULACEA	
Virgulariidae	
Stylatula elongata	1
MOLLUSCA	
GASTROPODA	
VETIGASTROPODA	
Calliostomatidae	
Calliostoma annulatum	1
Calliostoma canaliculatum	1
NEOTAENIOGLOSSA	
Naticidae	
Euspira lewisii	3
Bursidae	
Crossata californica	5
NEOGASTROPODA	
Muricidae	
Pteropurpura festiva	4
Columbellidae	
Amphissa undata	1
Buccinidae	
Kelletia kelletii	14
CEPHALASPIDEA	
Philinidae	
Philine auriformis	1
NUDIBRANCHIA	
Onchidorididae	
Acanthodoris rhodoceras	1
Tethyidae	
Melibe leonina	2
Dendronotidae	
Dendronotus frondosus	1
Dendronotus iris	1
CEPHALOPODA	
TEUTHIDA	
Loliginidae	
Loligo opalescens	3
OCTOPODA	
Octopodidae	
Octopus rubescens	2

Appendix B.2 continued

Taxon/ Species	N
ANNELIDA	
POLYCHATEA	
PHYLLODOCIDA	
Aphrodita armifera	1
HIRUDINEA	5
ARTHROPODA	
CIRRIPEDIA	
THORACICA	
Scalpellidae	
Hamatoscalpellum californicium	1
MALACOSTRACA	
STOMATOPODA	
Hemisquillidae	
Hemisquilla ensigera californiensis	18
ISOPODA	
Cymothoidae	5
Elthusa vulgaris	12
Elthusa sp	1
DECAPODA	
Hippolytidae	
Heptacarpus stimpsoni	38
Spirontocaris prionota	1
Crangonidae	
Crangon alaskensis	3
Crangon alba	21
Crangon nigromaculata	331
Diogenidae	
Paguristes bakeri	1
Paguridae	1
Pagurus armatus	1
Pagurus spilocarpus	5
Leucosiidae	
Randallia ornata	2
Majidae	
Loxorhynchus crispatus	1
Loxorhynchus grandis	4
Loxorhynchus sp	1
Podochela hemphillii	2
Pugettia producta	4
Pyromaia tuberculata	10
Parthenopidae	
Heterocrypta occidentalis	23
Cancridae	
Cancer anthonyi	8
Cancer gracilis	9
Cancer sp	13

Taxon/ Species	N
ECHINODERMATA	
ASTEROIDEA	
PAXILLOSIDA	
Luidiidae	
Luidia armata	3
Astropectinidae	
Astropecten ornatissimus	5
Astropecten verrilli	730
FORCIPULATIDA	
Asteriidae	
Pisaster brevispinus	27
OPHIUROIDEA	
OPHIURIDA	
Amphiuridae	
Amphiodia psara	1
Ophiotricidae	
Ophiothrix spiculata	3
ECHINOIDEA	
TEMNOPLEUROIDA	
Toxopneustidae	
Lytechinus pictus	219
ECHINOIDA	
Strongylocentrotidae	
Strongylocentrotus franciscanus	3
CLYPEASTEROIDA	
Dendrasteridae	
Dendraster terminalis	129
SPATANGOIDA	
Loveniidae	
Lovenia cordiformis	1

Taxonomic arrangement from SCAMIT listing 4th edition 2001.

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Appendix C

Supporting Data

2003 SBOO Stations

Bioaccumulation of Contaminants in Fish Tissue

Appendix C. 1

Lengths and weights of fishes used in composite samples for April and October 2003.

Station	Rep	Species	N	min lnth	max lnth	avg lnth	min wt	max wt	avg wt
April 2003									
RF3	1	Vermilion rockfish	3	23	26	24	332.4	477.1	385.0
RF3	2	Vermilion rockfish	3	27	28	27	528.1	600.0	555.1
RF3	3	Vermilion rockfish	3	21	29	26	274.0	600.0	474.7
RF4	1	California scorpionfish	3	24	30	27	448.6	900.0	628.4
RF4	2	California scorpionfish	3	24	28	26	396.0	700.0	532.0
RF4	3	California scorpionfish	3	23	25	24	430.3	546.3	496.5
SD15	1	California scorpionfish	3	22	27	24	320.8	530.3	436.5
SD16	1	Longfin sanddab	5	15	19	17	63.3	150.3	93.2
SD16	2	Hornyhead turbot	5	17	19	17	109.4	172.6	131.1
SD16	3	Scorpaena guttata	3	22	26	24	338.2	520.3	431.6
SD17	1	Longfin sanddab	13	14	18	15	51.1	116.1	72.6
SD17	2	Hornyhead turbot	8	16	20	18	104.3	209.8	159.2
SD17	3	English sole	5	17	29	22	67.7	394.5	182.5
SD18	1	Longfin sanddab	13	13	20	16	41.7	149.4	86.6
SD18	2	Hornyhead turbot	7	16	20	18	111.4	186.4	141.0
SD18	3	English sole	7	21	26	23	108.0	271.4	169.0
SD19	1	Hornyhead turbot	9	14	19	16	68.4	193.4	122.7
SD19	2	English sole	3	25	27	26	232.1	318.5	272.5
SD19	3	California scorpionfish	3	23	28	26	360.5	1300.0	820.2
SD20	1	Longfin sanddab	8	14	20	16	50.5	164.1	86.0
SD20	2	English sole	4	20	27	24	132.1	282.9	218.9
SD20	3	Hornyhead turbot	6	13	18	16	55.0	151.6	97.2
SD21	1	Longfin sanddab	6	16	19	18	84.1	148.2	114.0
SD21	2	Hornyhead turbot	5	18	20	19	173.8	220.9	195.5
SD21	3	Longfin sanddab	6	15	20	18	125.9	204.2	162.6
October 2003									
RF3	1	Vermilion rockfish	3	25	30	27	431.4	800.0	643.8
RF3	2	Vermilion rockfish	3	26	30	29	553.3	800.0	701.1
RF3	3	Brown rockfish	3	22	25	24	343.7	482.3	409.0
RF4	1	Mixed rockfish	3	17	22	20	118.8	325.3	244.5
RF4	2	California scorpionfish	3	23	24	23	382.7	440.5	414.4
RF4	3	California scorpionfish	3	22	23	22	351.1	386.2	362.9
SD15	1	California scorpionfish	3	15	21	19	125.0	319.7	237.4
SD15	2	California scorpionfish	3	17	22	19	158.4	358.2	245.4
SD15	3	Hornyhead turbot	3	14	18	17	95.7	201.3	165.5
SD16	1	California scorpionfish	3	20	23	21	195.2	364.2	276.4
SD16	2	California scorpionfish	3	19	21	20	232.2	304.2	259.1
SD16	3	Hornyhead turbot	5	17	21	19	131.2	252.3	185.0
SD17	1	California scorpionfish	3	20	21	20	239.8	370.3	295.4
SD17	2	California scorpionfish	3	21	28	25	276.5	600.1	444.0
SD17	3	California scorpionfish	3	17	28	22	161.0	800.0	412.0
SD18	1	California scorpionfish	3	21	22	22	292.3	392.9	335.4
SD18	2	California scorpionfish	3	19	30	24	189.8	1000.0	513.0
SD18	3	Hornyhead turbot	4	16	21	19	112.0	259.0	198.5
SD19	1	Longfin sanddab	3	17	20	18	103.0	176.0	139.3
SD19	2	Longfin sanddab	3	17	21	19	114.0	208.0	158.0
SD19	3	Hornyhead turbot	3	19	21	20	198.0	277.0	236.3
SD20	1	Longfin sanddab	6	15	20	17	67.0	168.0	121.0
SD20	2	Hornyhead turbot	5	16	23	19	102.0	354.0	191.2
SD20	3	Hornyhead turbot	7	14	19	16	81.0	185.0	121.6
SD21	1	California scorpionfish	3	17	21	19	216.4	293.2	259.2
SD21	2	California scorpionfish	3	16	20	18	191.7	275.9	224.0
SD21	3	California scorpionfish	3	17	22	19	167.4	329.8	225.7

Appendix C.2

Analyzed constituents for fish tissue samples for April and October 2003.

Chlorinated Pesticides

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

Polycyclic Aromatic Hydrocarbons

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

Metals

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

PCB Congeners

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

Appendix C.3 April 2003

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
RF3	1	Vermilion rockfish	Muscle	Aluminum		4.3	mg/kg	2.6
RF3	1	Vermilion rockfish	Muscle	Arsenic		2	mg/kg	1.4
RF3	1	Vermilion rockfish	Muscle	Iron		3.7	mg/kg	1.3
RF3	1	Vermilion rockfish	Muscle	Lipids		0.08	%wt	0.005
RF3	1	Vermilion rockfish	Muscle	p,p-DDE	E	0.6	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 206	E	0.1	ug/kg	
RF3	1	Vermilion rockfish	Muscle	Selenium		0.165	mg/kg	0.06
RF3	1	Vermilion rockfish	Muscle	Total Solids		20	%wt	0.4
RF3	1	Vermilion rockfish	Muscle	Zinc		2.02	mg/kg	0.58
RF3	2	Vermilion rockfish	Muscle	Arsenic		2.8	mg/kg	1.4
RF3	2	Vermilion rockfish	Muscle	Iron		5.6	mg/kg	1.3
RF3	2	Vermilion rockfish	Muscle	Lipids		0.3	%wt	0.005
RF3	2	Vermilion rockfish	Muscle	Mercury		0.031	mg/kg	0.03
RF3	2	Vermilion rockfish	Muscle	p,p-DDD	E	0.1	ug/kg	
RF3	2	Vermilion rockfish	Muscle	p,p-DDE		4.2	ug/kg	1.33
RF3	2	Vermilion rockfish	Muscle	PCB 101	E	0.2	ug/kg	
RF3	2	Vermilion rockfish	Muscle	PCB 138	E	0.2	ug/kg	
RF3	2	Vermilion rockfish	Muscle	PCB 153/168	E	0.4	ug/kg	
RF3	2	Vermilion rockfish	Muscle	PCB 206	E	0.1	ug/kg	
RF3	2	Vermilion rockfish	Muscle	Selenium		0.215	mg/kg	0.06
RF3	2	Vermilion rockfish	Muscle	Total Solids		20.2	%wt	0.4
RF3	2	Vermilion rockfish	Muscle	Zinc		1.89	mg/kg	0.58
RF3	3	Vermilion rockfish	Muscle	Arsenic		2.3	mg/kg	1.4
RF3	3	Vermilion rockfish	Muscle	Chromium		1.7	mg/kg	0.3
RF3	3	Vermilion rockfish	Muscle	Iron		11.3	mg/kg	1.3
RF3	3	Vermilion rockfish	Muscle	Lipids		0.85	%wt	0.005
RF3	3	Vermilion rockfish	Muscle	Mercury		0.03	mg/kg	0.03
RF3	3	Vermilion rockfish	Muscle	p,p-DDD	E	0.25	ug/kg	
RF3	3	Vermilion rockfish	Muscle	p,p-DDE		5.4	ug/kg	1.33
RF3	3	Vermilion rockfish	Muscle	PCB 101	E	0.2	ug/kg	
RF3	3	Vermilion rockfish	Muscle	PCB 138	E	0.2	ug/kg	
RF3	3	Vermilion rockfish	Muscle	PCB 153/168	E	0.4	ug/kg	
RF3	3	Vermilion rockfish	Muscle	Selenium		0.195	mg/kg	0.06
RF3	3	Vermilion rockfish	Muscle	Total Solids		20	%wt	0.4
RF3	3	Vermilion rockfish	Muscle	Zinc		2.51	mg/kg	0.58
RF4	1	Ca. scorpionfish	Muscle	Aluminum		5	mg/kg	2.6
RF4	1	Ca. scorpionfish	Muscle	Chromium		1.79	mg/kg	0.3
RF4	1	Ca. scorpionfish	Muscle	Copper		0.92	mg/kg	0.76
RF4	1	Ca. scorpionfish	Muscle	Iron		23.6	mg/kg	1.3
RF4	1	Ca. scorpionfish	Muscle	Lipids		1.53	%wt	0.005
RF4	1	Ca. scorpionfish	Muscle	Manganese		0.25	mg/kg	0.23
RF4	1	Ca. scorpionfish	Muscle	Mercury		0.162	mg/kg	0.03
RF4	1	Ca. scorpionfish	Muscle	p,p-DDD	E	1.1	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	p,p-DDE		23	ug/kg	1.33
RF4	1	Ca. scorpionfish	Muscle	p,p-DDT	E	0.3	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 101	E	0.6	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 110	E	0.2	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 118	E	0.9	ug/kg	

Appendix C.3 April 2003

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
RF4	1	Ca. scorpionfish	Muscle	PCB 138	E	0.4	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 149	E	0.3	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 153/168		2	ug/kg	1.33
RF4	1	Ca. scorpionfish	Muscle	PCB 180	E	0.6	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 183	E	0.2	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 187	E	0.6	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 206	E	0.2	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 99	E	0.5	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Selenium		0.437	mg/kg	0.06
RF4	1	Ca. scorpionfish	Muscle	Total Solids		23.8	%wt	0.4
RF4	1	Ca. scorpionfish	Muscle	Trans Nonachlor	E	0.4	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Zinc		3.87	mg/kg	0.58
RF4	2	Ca. scorpionfish	Muscle	Aluminum		5.5	mg/kg	2.6
RF4	2	Ca. scorpionfish	Muscle	Arsenic		1.9	mg/kg	1.4
RF4	2	Ca. scorpionfish	Muscle	Iron		8.4	mg/kg	1.3
RF4	2	Ca. scorpionfish	Muscle	Lipids		0.21	%wt	0.005
RF4	2	Ca. scorpionfish	Muscle	Mercury		0.145	mg/kg	0.03
RF4	2	Ca. scorpionfish	Muscle	o,p-DDE	E	0.4	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	p,p-DDE		6.9	ug/kg	1.33
RF4	2	Ca. scorpionfish	Muscle	PCB 138	E	0.2	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 153/168	E	0.4	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 206	E	0.2	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Selenium		0.254	mg/kg	0.06
RF4	2	Ca. scorpionfish	Muscle	Total Solids		22.6	%wt	0.4
RF4	2	Ca. scorpionfish	Muscle	Zinc		2.57	mg/kg	0.58
RF4	3	Ca. scorpionfish	Muscle	Arsenic		1.7	mg/kg	1.4
RF4	3	Ca. scorpionfish	Muscle	Copper		14.7	mg/kg	0.76
RF4	3	Ca. scorpionfish	Muscle	Iron		1.5	mg/kg	1.3
RF4	3	Ca. scorpionfish	Muscle	Lipids		0.36	%wt	0.005
RF4	3	Ca. scorpionfish	Muscle	Mercury		0.273	mg/kg	0.03
RF4	3	Ca. scorpionfish	Muscle	o,p-DDE	E	1	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	p,p-DDE		14	ug/kg	1.33
RF4	3	Ca. scorpionfish	Muscle	PCB 101	E	0.3	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 105	E	0.1	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 118	E	0.6	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 138	E	0.5	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 153/168	E	0.4	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 180	E	0.2	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 206	E	0.2	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 52	E	0.2	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 99	E	0.3	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Selenium		0.276	mg/kg	0.06
RF4	3	Ca. scorpionfish	Muscle	Total Solids		23.1	%wt	0.4
RF4	3	Ca. scorpionfish	Muscle	Zinc		3.61	mg/kg	0.58
SD15	1	Ca. scorpionfish	Liver	Aluminum		7.7	mg/kg	2.6
SD15	1	Ca. scorpionfish	Liver	Cadmium		2.22	mg/kg	0.34
SD15	1	Ca. scorpionfish	Liver	Chromium		0.48	mg/kg	0.3
SD15	1	Ca. scorpionfish	Liver	Copper		22.5	mg/kg	0.76

Appendix C.3 April 2003

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD15	1	Ca. scorpionfish	Liver	Iron		196	mg/kg	1.3
SD15	1	Ca. scorpionfish	Liver	Lipids		16.9	%wt	0.005
SD15	1	Ca. scorpionfish	Liver	Manganese		0.57	mg/kg	0.23
SD15	1	Ca. scorpionfish	Liver	Mercury		0.156	mg/kg	0.03
SD15	1	Ca. scorpionfish	Liver	o,p-DDE	E	1.4	ug/kg	
SD15	1	Ca. scorpionfish	Liver	p,p-DDD	E	5	ug/kg	
SD15	1	Ca. scorpionfish	Liver	p,p-DDE		290	ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	p,p-DDT	E	6	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 101	E	8.6	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 105	E	3.6	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 110	E	4.5	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 118		14	ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 128	E	4.1	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 138		18	ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 149	E	5.3	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 151	E	3.7	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 153/168		37	ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 158	E	1.5	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 170	E	8.4	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 177	E	2.8	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 180		17	ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 183	E	4.6	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 187	E	13	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 194	E	3.4	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 206	E	2.4	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 52	E	2.3	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 66	E	2.2	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 70	E	1.1	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 74	E	1.1	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 99	E	7.6	ug/kg	
SD15	1	Ca. scorpionfish	Liver	Selenium		0.861	mg/kg	0.06
SD15	1	Ca. scorpionfish	Liver	Total Solids		45	%wt	0.4
SD15	1	Ca. scorpionfish	Liver	Trans Nonachlor	E	6.2	ug/kg	
SD15	1	Ca. scorpionfish	Liver	Zinc		98.6	mg/kg	0.58
SD16	1	Longfin sanddab	Liver	Alpha (cis) Chlordane	E	4.9	ug/kg	
SD16	1	Longfin sanddab	Liver	Aluminum		10.7	mg/kg	2.6
SD16	1	Longfin sanddab	Liver	Arsenic		6.7	mg/kg	1.4
SD16	1	Longfin sanddab	Liver	Cadmium		3.72	mg/kg	0.34
SD16	1	Longfin sanddab	Liver	Copper		12.6	mg/kg	0.76
SD16	1	Longfin sanddab	Liver	Hexachlorobenzene	E	3.4	ug/kg	
SD16	1	Longfin sanddab	Liver	Iron		200	mg/kg	1.3
SD16	1	Longfin sanddab	Liver	Lipids		17.7	%wt	0.005
SD16	1	Longfin sanddab	Liver	Manganese		1.72	mg/kg	0.23
SD16	1	Longfin sanddab	Liver	Mercury		0.145	mg/kg	0.03
SD16	1	Longfin sanddab	Liver	o,p-DDE	E	12	ug/kg	
SD16	1	Longfin sanddab	Liver	p,p-DDD	E	5.9	ug/kg	
SD16	1	Longfin sanddab	Liver	p,p-DDE		410	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	p,p-DDT		17	ug/kg	13.3

Appendix C.3 April 2003

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD16	1	Longfin sanddab	Liver	PCB 101	E	11	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 105	E	7.7	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 110	E	7.5	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 118		25	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 123	E	3.1	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 128	E	7.8	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 138		41	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 149	E	6.9	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 151	E	4.2	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 153/168		83	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 156	E	2.8	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 157	E	1.1	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 158	E	3.3	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 167	E	1.6	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 170	E	13	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 177	E	4.6	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 180		26	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 183	E	8.4	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 187		25	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 194	E	7.9	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 206	E	5.2	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 52	E	3.6	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 66	E	3	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 99		19	ug/kg	13.3
SD16	1	Longfin sanddab	Liver	Selenium		1.72	mg/kg	0.06
SD16	1	Longfin sanddab	Liver	Total Solids		26.8	%wt	0.4
SD16	1	Longfin sanddab	Liver	Trans Nonachlor	E	4.5	ug/kg	
SD16	1	Longfin sanddab	Liver	Zinc		27.4	mg/kg	0.58
SD16	2	Hornyhead turbot	Liver	Aluminum		8.4	mg/kg	2.6
SD16	2	Hornyhead turbot	Liver	Arsenic		2.8	mg/kg	1.4
SD16	2	Hornyhead turbot	Liver	Cadmium		11.7	mg/kg	0.34
SD16	2	Hornyhead turbot	Liver	Copper		8.27	mg/kg	0.76
SD16	2	Hornyhead turbot	Liver	Iron		126	mg/kg	1.3
SD16	2	Hornyhead turbot	Liver	Lipids		3.2	%wt	0.005
SD16	2	Hornyhead turbot	Liver	Manganese		0.97	mg/kg	0.23
SD16	2	Hornyhead turbot	Liver	Mercury		0.252	mg/kg	0.03
SD16	2	Hornyhead turbot	Liver	p,p-DDE		49	ug/kg	13.3
SD16	2	Hornyhead turbot	Liver	PCB 138	E	1.9	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 153/168	E	3.9	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 180	E	2	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 187	E	1	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 206	E	1.3	ug/kg	
SD16	2	Hornyhead turbot	Liver	Selenium		1.27	mg/kg	0.06
SD16	2	Hornyhead turbot	Liver	Total Solids		21.8	%wt	0.4
SD16	2	Hornyhead turbot	Liver	Zinc		43	mg/kg	0.58
SD16	3	Ca. scorpionfish	Liver	Alpha (cis) Chlordane	E	6.7	ug/kg	
SD16	3	Ca. scorpionfish	Liver	Aluminum		9.05	mg/kg	2.6
SD16	3	Ca. scorpionfish	Liver	Cadmium		4.79	mg/kg	0.34

Appendix C.3 April 2003

Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD16	3	Ca. scorpionfish	Liver	Copper		32.5	mg/kg	0.76
SD16	3	Ca. scorpionfish	Liver	Hexachlorobenzene	E	4.5	ug/kg	
SD16	3	Ca. scorpionfish	Liver	Iron		364	mg/kg	1.3
SD16	3	Ca. scorpionfish	Liver	Lipids		29.1	%wt	0.005
SD16	3	Ca. scorpionfish	Liver	Manganese		0.395	mg/kg	0.23
SD16	3	Ca. scorpionfish	Liver	Mercury		0.459	mg/kg	0.03
SD16	3	Ca. scorpionfish	Liver	o,p-DDE	E	3	ug/kg	
SD16	3	Ca. scorpionfish	Liver	p,p-DDD	E	13	ug/kg	
SD16	3	Ca. scorpionfish	Liver	p,p-DDE		1280	ug/kg	
SD16	3	Ca. scorpionfish	Liver	p,p-DDT		14	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 101		19	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 105	E	8.6	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 110	E	7.9	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 118		30	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 123	E	3.3	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 128	E	7.7	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 138		41	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 149	E	11	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 151	E	6.6	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 153/168		82	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 156	E	3.2	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 157	E	1.3	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 158	E	3.2	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 167	E	1.9	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 170	E	13	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 177	E	7.1	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 180		33	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 183	E	9.3	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 187		31	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 194	E	7.8	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 206	E	4.5	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 52	E	4.3	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 66	E	5.2	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 74	E	2.3	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 87	E	3.3	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 99		15	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	Selenium		0.79	mg/kg	0.06
SD16	3	Ca. scorpionfish	Liver	Total Solids		37.9	%wt	0.4
SD16	3	Ca. scorpionfish	Liver	Trans Nonachlor	E	14	ug/kg	
SD16	3	Ca. scorpionfish	Liver	Zinc		270	mg/kg	0.58
SD17	1	Longfin sanddab	Liver	Alpha (cis) Chlordane	E	2.9	ug/kg	
SD17	1	Longfin sanddab	Liver	Aluminum		10.5	mg/kg	2.6
SD17	1	Longfin sanddab	Liver	Arsenic		10.9	mg/kg	1.4
SD17	1	Longfin sanddab	Liver	Cadmium		3.56	mg/kg	0.34
SD17	1	Longfin sanddab	Liver	Copper		10.9	mg/kg	0.76
SD17	1	Longfin sanddab	Liver	Iron		202	mg/kg	1.3
SD17	1	Longfin sanddab	Liver	Lipids		13.2	%wt	0.005
SD17	1	Longfin sanddab	Liver	Manganese		1.65	mg/kg	0.23

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD17	1	Longfin sanddab	Liver	Mercury		0.14	mg/kg	0.03
SD17	1	Longfin sanddab	Liver	o,p-DDE	E	10	ug/kg	
SD17	1	Longfin sanddab	Liver	p,p-DDD	E	5.5	ug/kg	
SD17	1	Longfin sanddab	Liver	p,p-DDE		710	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	p,p-DDT		19	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 101	E	7	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 105	E	6.4	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 110	E	4.8	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 118		24	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 123	E	2.1	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 128	E	7.5	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 138		46	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 149	E	5.5	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 151	E	5.5	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 153/168		83	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 156	E	1.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 157	E	1.2	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 158	E	2.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 167	E	2.1	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 170		14	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 177	E	4.8	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 180		31	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 183	E	9.3	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 187		30	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 194	E	9.7	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 201	E	9.6	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 206	E	5.4	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 52	E	2.4	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 66	E	2.8	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 74	E	1.9	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 99		15	ug/kg	13.3
SD17	1	Longfin sanddab	Liver	Selenium		1.59	mg/kg	0.06
SD17	1	Longfin sanddab	Liver	Total Solids		26.4	%wt	0.4
SD17	1	Longfin sanddab	Liver	Trans Nonachlor	E	5	ug/kg	
SD17	1	Longfin sanddab	Liver	Zinc		28.6	mg/kg	0.58
SD17	2	Hornyhead turbot	Liver	Aluminum		6.2	mg/kg	2.6
SD17	2	Hornyhead turbot	Liver	Arsenic		3.2	mg/kg	1.4
SD17	2	Hornyhead turbot	Liver	Cadmium		8.53	mg/kg	0.34
SD17	2	Hornyhead turbot	Liver	Copper		13.1	mg/kg	0.76
SD17	2	Hornyhead turbot	Liver	Iron		75.3	mg/kg	1.3
SD17	2	Hornyhead turbot	Liver	Lipids		4.76	%wt	0.005
SD17	2	Hornyhead turbot	Liver	Manganese		1.28	mg/kg	0.23
SD17	2	Hornyhead turbot	Liver	Mercury		0.209	mg/kg	0.03
SD17	2	Hornyhead turbot	Liver	o,p-DDE	E	2	ug/kg	
SD17	2	Hornyhead turbot	Liver	p,p-DDD	E	3.6	ug/kg	
SD17	2	Hornyhead turbot	Liver	p,p-DDE		120	ug/kg	13.3
SD17	2	Hornyhead turbot	Liver	p,p-DDT	E	1.9	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 101	E	5.3	ug/kg	

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD17	2	Hornyhead turbot	Liver	PCB 110	E	3.5	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 118	E	6	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 138	E	9.3	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 153/168		16	ug/kg	13.3
SD17	2	Hornyhead turbot	Liver	PCB 180	E	8.7	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 183	E	2.1	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 187	E	4.4	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 194	E	1.9	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 206	E	1.5	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 52	E	2.8	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 66	E	3.4	ug/kg	
SD17	2	Hornyhead turbot	Liver	PCB 99	E	5.1	ug/kg	
SD17	2	Hornyhead turbot	Liver	Selenium		1.17	mg/kg	0.06
SD17	2	Hornyhead turbot	Liver	Total Solids		20.9	%wt	0.4
SD17	2	Hornyhead turbot	Liver	Zinc		43	mg/kg	0.58
SD17	3	English sole	Liver	Aluminum		4.6	mg/kg	2.6
SD17	3	English sole	Liver	Arsenic		44.6	mg/kg	1.4
SD17	3	English sole	Liver	Cadmium		2.35	mg/kg	0.34
SD17	3	English sole	Liver	Copper		6.69	mg/kg	0.76
SD17	3	English sole	Liver	Iron		228	mg/kg	1.3
SD17	3	English sole	Liver	Lipids		5.21	%wt	0.005
SD17	3	English sole	Liver	Manganese		2.46	mg/kg	0.23
SD17	3	English sole	Liver	Mercury		0.501	mg/kg	0.03
SD17	3	English sole	Liver	o,p-DDE	E	2.5	ug/kg	
SD17	3	English sole	Liver	p,p-DDD	E	2.9	ug/kg	
SD17	3	English sole	Liver	p,p-DDE		130	ug/kg	13.3
SD17	3	English sole	Liver	p,p-DDT	E	2.3	ug/kg	
SD17	3	English sole	Liver	PCB 101	E	3.5	ug/kg	
SD17	3	English sole	Liver	PCB 105	E	1.1	ug/kg	
SD17	3	English sole	Liver	PCB 110	E	2	ug/kg	
SD17	3	English sole	Liver	PCB 118	E	4.2	ug/kg	
SD17	3	English sole	Liver	PCB 138	E	6.2	ug/kg	
SD17	3	English sole	Liver	PCB 149	E	4.3	ug/kg	
SD17	3	English sole	Liver	PCB 153/168	E	12	ug/kg	
SD17	3	English sole	Liver	PCB 180	E	6.6	ug/kg	
SD17	3	English sole	Liver	PCB 183	E	1.8	ug/kg	
SD17	3	English sole	Liver	PCB 187	E	6.1	ug/kg	
SD17	3	English sole	Liver	PCB 194	E	1.4	ug/kg	
SD17	3	English sole	Liver	PCB 206	E	1.5	ug/kg	
SD17	3	English sole	Liver	PCB 66	E	0.7	ug/kg	
SD17	3	English sole	Liver	PCB 70	E	0.8	ug/kg	
SD17	3	English sole	Liver	PCB 74	E	0.3	ug/kg	
SD17	3	English sole	Liver	PCB 99	E	2.3	ug/kg	
SD17	3	English sole	Liver	Selenium		1.95	mg/kg	0.06
SD17	3	English sole	Liver	Total Solids		24.1	%wt	0.4
SD17	3	English sole	Liver	Zinc		26	mg/kg	0.58
SD18	1	Longfin sanddab	Liver	Alpha (cis) Chlordane	E	6.2	ug/kg	
SD18	1	Longfin sanddab	Liver	Aluminum		7	mg/kg	2.6

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD18	1	Longfin sanddab	Liver	Arsenic		14.5	mg/kg	1.4
SD18	1	Longfin sanddab	Liver	Cadmium		5.62	mg/kg	0.34
SD18	1	Longfin sanddab	Liver	Cis Nonachlor	E	5.9	ug/kg	
SD18	1	Longfin sanddab	Liver	Copper		11.6	mg/kg	0.76
SD18	1	Longfin sanddab	Liver	Hexachlorobenzene	E	3.7	ug/kg	
SD18	1	Longfin sanddab	Liver	Iron		181	mg/kg	1.3
SD18	1	Longfin sanddab	Liver	Lipids		18.9	%wt	0.005
SD18	1	Longfin sanddab	Liver	Manganese		1.44	mg/kg	0.23
SD18	1	Longfin sanddab	Liver	Mercury		0.167	mg/kg	0.03
SD18	1	Longfin sanddab	Liver	Mirex	E	2.4	ug/kg	
SD18	1	Longfin sanddab	Liver	o,p-DDE		14	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	o,p-DDT	E	1.9	ug/kg	
SD18	1	Longfin sanddab	Liver	p,p-DDD	E	11	ug/kg	
SD18	1	Longfin sanddab	Liver	p,p-DDE		1630	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	p,p-DDT		40	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 101	E	13	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 105	E	12	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 110	E	5.8	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 118		44	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 123	E	5.1	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 128		15	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 138		90	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 149	E	11	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 151	E	9.3	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 153/168		160	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 156	E	6.3	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 157	E	1.8	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 158	E	5	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 167	E	4.5	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 170		29	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 177	E	11	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 180		56	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 183		18	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 187		63	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 194		19	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 201		21	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	PCB 206	E	9.2	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 52	E	3.8	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 74	E	1.8	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 87	E	1.3	ug/kg	
SD18	1	Longfin sanddab	Liver	PCB 99		29	ug/kg	13.3
SD18	1	Longfin sanddab	Liver	Selenium		2.18	mg/kg	0.06
SD18	1	Longfin sanddab	Liver	Total Solids		32	%wt	0.4
SD18	1	Longfin sanddab	Liver	Trans Nonachlor	E	14	ug/kg	
SD18	1	Longfin sanddab	Liver	Zinc		29.4	mg/kg	0.58
SD18	2	Hornyhead turbot	Liver	Aluminum		6.5	mg/kg	2.6
SD18	2	Hornyhead turbot	Liver	Arsenic		2.3	mg/kg	1.4
SD18	2	Hornyhead turbot	Liver	Cadmium		6.25	mg/kg	0.34

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD18	2	Hornyhead turbot	Liver	Copper		5.29	mg/kg	0.76
SD18	2	Hornyhead turbot	Liver	Iron		71.8	mg/kg	1.3
SD18	2	Hornyhead turbot	Liver	Lipids		5.45	%wt	0.005
SD18	2	Hornyhead turbot	Liver	Manganese		1.62	mg/kg	0.23
SD18	2	Hornyhead turbot	Liver	Mercury		0.145	mg/kg	0.03
SD18	2	Hornyhead turbot	Liver	p,p-DDD	E	2.7	ug/kg	
SD18	2	Hornyhead turbot	Liver	p,p-DDE		120	ug/kg	13.3
SD18	2	Hornyhead turbot	Liver	p,p-DDT	E	3.3	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 101	E	2.7	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 118	E	3.9	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 138	E	7.7	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 153/168		14	ug/kg	13.3
SD18	2	Hornyhead turbot	Liver	PCB 180	E	7.5	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 183	E	2.1	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 187	E	4	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 194	E	1.6	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 206	E	1.5	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 99	E	3	ug/kg	
SD18	2	Hornyhead turbot	Liver	Selenium		1.02	mg/kg	0.06
SD18	2	Hornyhead turbot	Liver	Total Solids		27	%wt	0.4
SD18	2	Hornyhead turbot	Liver	Zinc		34.9	mg/kg	0.58
SD18	3	English sole	Liver	Aluminum		5.4	mg/kg	2.6
SD18	3	English sole	Liver	Arsenic		16	mg/kg	1.4
SD18	3	English sole	Liver	Cadmium		1.73	mg/kg	0.34
SD18	3	English sole	Liver	Copper		8.16	mg/kg	0.76
SD18	3	English sole	Liver	Iron		349	mg/kg	1.3
SD18	3	English sole	Liver	Lipids		6.01	%wt	0.005
SD18	3	English sole	Liver	Manganese		1.44	mg/kg	0.23
SD18	3	English sole	Liver	Mercury		0.095	mg/kg	0.03
SD18	3	English sole	Liver	o,p-DDE	E	2.1	ug/kg	
SD18	3	English sole	Liver	p,p-DDD	E	1.9	ug/kg	
SD18	3	English sole	Liver	p,p-DDE		105	ug/kg	13.3
SD18	3	English sole	Liver	p,p-DDT	E	2.9	ug/kg	
SD18	3	English sole	Liver	PCB 101	E	4	ug/kg	
SD18	3	English sole	Liver	PCB 118	E	5.15	ug/kg	
SD18	3	English sole	Liver	PCB 138	E	7.8	ug/kg	
SD18	3	English sole	Liver	PCB 149	E	4.65	ug/kg	
SD18	3	English sole	Liver	PCB 153/168		15.5	ug/kg	13.3
SD18	3	English sole	Liver	PCB 180	E	6.2	ug/kg	
SD18	3	English sole	Liver	PCB 183	E	1.95	ug/kg	
SD18	3	English sole	Liver	PCB 187	E	6.2	ug/kg	
SD18	3	English sole	Liver	PCB 194	E	1.15	ug/kg	
SD18	3	English sole	Liver	PCB 206	E	1.3	ug/kg	
SD18	3	English sole	Liver	PCB 66	E	1.4	ug/kg	
SD18	3	English sole	Liver	PCB 74	E	0.8	ug/kg	
SD18	3	English sole	Liver	PCB 99	E	3.35	ug/kg	
SD18	3	English sole	Liver	Selenium		1.52	mg/kg	0.06
SD18	3	English sole	Liver	Total Solids		25.5	%wt	0.4

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD18	3	English sole	Liver	Zinc		27.2	mg/kg	0.58
SD19	1	Hornyhead turbot	Liver	Aluminum		6.7	mg/kg	2.6
SD19	1	Hornyhead turbot	Liver	Cadmium		7.05	mg/kg	0.34
SD19	1	Hornyhead turbot	Liver	Copper		4.63	mg/kg	0.76
SD19	1	Hornyhead turbot	Liver	Iron		36.1	mg/kg	1.3
SD19	1	Hornyhead turbot	Liver	Lipids		5.48	%wt	0.005
SD19	1	Hornyhead turbot	Liver	Manganese		2.16	mg/kg	0.23
SD19	1	Hornyhead turbot	Liver	Mercury		0.101	mg/kg	0.03
SD19	1	Hornyhead turbot	Liver	o,p-DDE	E	0.8	ug/kg	
SD19	1	Hornyhead turbot	Liver	p,p-DDD	E	2	ug/kg	
SD19	1	Hornyhead turbot	Liver	p,p-DDE		72	ug/kg	13.3
SD19	1	Hornyhead turbot	Liver	p,p-DDT	E	1.8	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 101	E	1	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 118	E	2.2	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 138	E	3.2	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 153/168	E	5.6	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 157	E	2.7	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 187	E	1.9	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 206	E	1.1	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 99	E	1.3	ug/kg	
SD19	1	Hornyhead turbot	Liver	Selenium		0.642	mg/kg	0.06
SD19	1	Hornyhead turbot	Liver	Total Solids		23.4	%wt	0.4
SD19	1	Hornyhead turbot	Liver	Zinc		36.1	mg/kg	0.58
SD19	2	English sole	Liver	Arsenic		8.9	mg/kg	1.4
SD19	2	English sole	Liver	Cadmium		2.05	mg/kg	0.34
SD19	2	English sole	Liver	Copper		20.7	mg/kg	0.76
SD19	2	English sole	Liver	Iron		400	mg/kg	1.3
SD19	2	English sole	Liver	Lipids		5.72	%wt	0.005
SD19	2	English sole	Liver	Manganese		2.02	mg/kg	0.23
SD19	2	English sole	Liver	Mercury		0.147	mg/kg	0.03
SD19	2	English sole	Liver	o,p-DDE	E	4.6	ug/kg	
SD19	2	English sole	Liver	p,p-DDD	E	2	ug/kg	
SD19	2	English sole	Liver	p,p-DDE		130	ug/kg	13.3
SD19	2	English sole	Liver	p,p-DDT	E	1.9	ug/kg	
SD19	2	English sole	Liver	PCB 101	E	3.8	ug/kg	
SD19	2	English sole	Liver	PCB 110	E	0.9	ug/kg	
SD19	2	English sole	Liver	PCB 118	E	5.5	ug/kg	
SD19	2	English sole	Liver	PCB 138	E	6.1	ug/kg	
SD19	2	English sole	Liver	PCB 149	E	3.1	ug/kg	
SD19	2	English sole	Liver	PCB 153/168	E	11	ug/kg	
SD19	2	English sole	Liver	PCB 180	E	3.1	ug/kg	
SD19	2	English sole	Liver	PCB 183	E	0.5	ug/kg	
SD19	2	English sole	Liver	PCB 187	E	3.1	ug/kg	
SD19	2	English sole	Liver	PCB 206	E	1.1	ug/kg	
SD19	2	English sole	Liver	PCB 66	E	1.1	ug/kg	
SD19	2	English sole	Liver	PCB 70	E	0.8	ug/kg	
SD19	2	English sole	Liver	PCB 74	E	0.6	ug/kg	
SD19	2	English sole	Liver	PCB 99	E	3.2	ug/kg	

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD19	2	English sole	Liver	Selenium		1.84	mg/kg	0.06
SD19	2	English sole	Liver	Total Solids		23.9	%wt	0.4
SD19	2	English sole	Liver	Zinc		28.4	mg/kg	0.58
SD19	3	Ca. scorpionfish	Liver	Alpha (cis) Chlordane	E	3.8	ug/kg	
SD19	3	Ca. scorpionfish	Liver	Aluminum		16	mg/kg	2.6
SD19	3	Ca. scorpionfish	Liver	Cadmium		3.33	mg/kg	0.34
SD19	3	Ca. scorpionfish	Liver	Copper		20.4	mg/kg	0.76
SD19	3	Ca. scorpionfish	Liver	Iron		190	mg/kg	1.3
SD19	3	Ca. scorpionfish	Liver	Lipids		22.8	%wt	0.005
SD19	3	Ca. scorpionfish	Liver	Mercury		0.332	mg/kg	0.03
SD19	3	Ca. scorpionfish	Liver	o,p-DDE	E	1.8	ug/kg	
SD19	3	Ca. scorpionfish	Liver	p,p-DDD	E	8.2	ug/kg	
SD19	3	Ca. scorpionfish	Liver	p,p-DDE		580	ug/kg	
SD19	3	Ca. scorpionfish	Liver	p,p-DDT	E	6.7	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 101	E	12	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 105	E	5.5	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 110	E	5	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 118		23	ug/kg	13.3
SD19	3	Ca. scorpionfish	Liver	PCB 123	E	2.3	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 128	E	5.7	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 138		33	ug/kg	13.3
SD19	3	Ca. scorpionfish	Liver	PCB 149	E	8.5	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 151	E	5.4	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 153/168		63	ug/kg	13.3
SD19	3	Ca. scorpionfish	Liver	PCB 156	E	1.1	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 157	E	0.8	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 158	E	2.4	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 167	E	1.4	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 170	E	11	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 177	E	4.7	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 180		27	ug/kg	13.3
SD19	3	Ca. scorpionfish	Liver	PCB 183	E	7.8	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 187		26	ug/kg	13.3
SD19	3	Ca. scorpionfish	Liver	PCB 194	E	6.3	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 206	E	3.8	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 52	E	2.9	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 66	E	3.2	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 70	E	0.9	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 74	E	1.5	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 87	E	1.9	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 99	E	11	ug/kg	
SD19	3	Ca. scorpionfish	Liver	Selenium		0.934	mg/kg	0.06
SD19	3	Ca. scorpionfish	Liver	Total Solids		52.8	%wt	0.4
SD19	3	Ca. scorpionfish	Liver	Trans Nonachlor	E	7.6	ug/kg	
SD19	3	Ca. scorpionfish	Liver	Zinc		100	mg/kg	0.58
SD20	1	Longfin sanddab	Liver	Alpha (cis) Chlordane	E	8.2	ug/kg	
SD20	1	Longfin sanddab	Liver	Aluminum		10.7	mg/kg	2.6
SD20	1	Longfin sanddab	Liver	Arsenic		4	mg/kg	1.4

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD20	1	Longfin sanddab	Liver	Cadmium		2.82	mg/kg	0.34
SD20	1	Longfin sanddab	Liver	Chromium		0.51	mg/kg	0.3
SD20	1	Longfin sanddab	Liver	Copper		8.19	mg/kg	0.76
SD20	1	Longfin sanddab	Liver	Hexachlorobenzene	E	5.8	ug/kg	
SD20	1	Longfin sanddab	Liver	Iron		140	mg/kg	1.3
SD20	1	Longfin sanddab	Liver	Lipids		33.6	%wt	0.005
SD20	1	Longfin sanddab	Liver	Manganese		1.27	mg/kg	0.23
SD20	1	Longfin sanddab	Liver	Mercury		0.048	mg/kg	0.03
SD20	1	Longfin sanddab	Liver	o,p-DDE		14	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	o,p-DDT	E	2.8	ug/kg	
SD20	1	Longfin sanddab	Liver	p,p-DDD		20	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	p,p-DDE		1190	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	p,p-DDT		65	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 101		19	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 105		17	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 110	E	12	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 118		53	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 119	E	1.7	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 123	E	7.1	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 128		21	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 138		110	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 149		17	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 151	E	10	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 153/168		180	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 156	E	7.7	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 157	E	3.4	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 158	E	8.9	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 167	E	5.2	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 170		31	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 177		14	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 180		55	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 183		20	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 187		65	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 194		19	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 201		21	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 206	E	11	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 52	E	7.5	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 66	E	9.2	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 70	E	1.4	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 74	E	4	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 87	E	1.9	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 99		45	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	Selenium		1.19	mg/kg	0.06
SD20	1	Longfin sanddab	Liver	Total Solids		42.5	%wt	0.4
SD20	1	Longfin sanddab	Liver	Trans Nonachlor	E	10	ug/kg	
SD20	1	Longfin sanddab	Liver	Zinc		20.5	mg/kg	0.58
SD20	2	English sole	Liver	Aluminum		6.4	mg/kg	2.6
SD20	2	English sole	Liver	Arsenic		6.8	mg/kg	1.4

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD20	2	English sole	Liver	Cadmium		0.87	mg/kg	0.34
SD20	2	English sole	Liver	Copper		8.8	mg/kg	0.76
SD20	2	English sole	Liver	Iron		181	mg/kg	1.3
SD20	2	English sole	Liver	Lipids		4.9	%wt	0.005
SD20	2	English sole	Liver	Manganese		2.48	mg/kg	0.23
SD20	2	English sole	Liver	Mercury		0.052	mg/kg	0.03
SD20	2	English sole	Liver	o,p-DDE	E	1.5	ug/kg	
SD20	2	English sole	Liver	p,p-DDD	E	1.4	ug/kg	
SD20	2	English sole	Liver	p,p-DDE		61	ug/kg	13.3
SD20	2	English sole	Liver	PCB 101	E	6	ug/kg	
SD20	2	English sole	Liver	PCB 105	E	1.4	ug/kg	
SD20	2	English sole	Liver	PCB 110	E	3.2	ug/kg	
SD20	2	English sole	Liver	PCB 118	E	6.1	ug/kg	
SD20	2	English sole	Liver	PCB 138	E	9.1	ug/kg	
SD20	2	English sole	Liver	PCB 149	E	5.3	ug/kg	
SD20	2	English sole	Liver	PCB 151	E	1.4	ug/kg	
SD20	2	English sole	Liver	PCB 153/168		16	ug/kg	13.3
SD20	2	English sole	Liver	PCB 158	E	0.8	ug/kg	
SD20	2	English sole	Liver	PCB 180	E	5	ug/kg	
SD20	2	English sole	Liver	PCB 183	E	1.5	ug/kg	
SD20	2	English sole	Liver	PCB 187	E	6.1	ug/kg	
SD20	2	English sole	Liver	PCB 206	E	1.8	ug/kg	
SD20	2	English sole	Liver	PCB 66	E	1.1	ug/kg	
SD20	2	English sole	Liver	PCB 87	E	0.7	ug/kg	
SD20	2	English sole	Liver	PCB 99	E	3.9	ug/kg	
SD20	2	English sole	Liver	Selenium		1.56	mg/kg	0.06
SD20	2	English sole	Liver	Total Solids		23	%wt	0.4
SD20	2	English sole	Liver	Zinc		24.7	mg/kg	0.58
SD20	3	Hornyhead turbot	Liver	Aluminum		15.4	mg/kg	2.6
SD20	3	Hornyhead turbot	Liver	Arsenic		3.8	mg/kg	1.4
SD20	3	Hornyhead turbot	Liver	Cadmium		5.3	mg/kg	0.34
SD20	3	Hornyhead turbot	Liver	Copper		15.6	mg/kg	0.76
SD20	3	Hornyhead turbot	Liver	Iron		40.5	mg/kg	1.3
SD20	3	Hornyhead turbot	Liver	Lipids		3.92	%wt	0.005
SD20	3	Hornyhead turbot	Liver	Manganese		2.54	mg/kg	0.23
SD20	3	Hornyhead turbot	Liver	Mercury		0.162	mg/kg	0.03
SD20	3	Hornyhead turbot	Liver	p,p-DDD	E	1.7	ug/kg	
SD20	3	Hornyhead turbot	Liver	p,p-DDE		81	ug/kg	13.3
SD20	3	Hornyhead turbot	Liver	p,p-DDT	E	3.1	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 101	E	1.6	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 118	E	1.8	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 138	E	2.9	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 153/168	E	6.6	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 180	E	3.4	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 183	E	1.1	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 187	E	2.1	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 194	E	0.8	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 206	E	1.5	ug/kg	

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD20	3	Hornyhead turbot	Liver	Selenium		0.85	mg/kg	0.06
SD20	3	Hornyhead turbot	Liver	Total Solids		24.1	%wt	0.4
SD20	3	Hornyhead turbot	Liver	Zinc		41.1	mg/kg	0.58
SD21	1	Longfin sanddab	Liver	Alpha (cis) Chlordane	E	2.8	ug/kg	
SD21	1	Longfin sanddab	Liver	Aluminum		17.5	mg/kg	2.6
SD21	1	Longfin sanddab	Liver	Arsenic		9.6	mg/kg	1.4
SD21	1	Longfin sanddab	Liver	Cadmium		3.02	mg/kg	0.34
SD21	1	Longfin sanddab	Liver	Chromium		0.35	mg/kg	0.3
SD21	1	Longfin sanddab	Liver	Copper		11.6	mg/kg	0.76
SD21	1	Longfin sanddab	Liver	Iron		88.4	mg/kg	1.3
SD21	1	Longfin sanddab	Liver	Lipids		17.7	%wt	0.005
SD21	1	Longfin sanddab	Liver	Manganese		1.81	mg/kg	0.23
SD21	1	Longfin sanddab	Liver	Mercury		0.144	mg/kg	0.03
SD21	1	Longfin sanddab	Liver	o,p-DDE	E	8.4	ug/kg	
SD21	1	Longfin sanddab	Liver	p,p-DDD	E	6.5	ug/kg	
SD21	1	Longfin sanddab	Liver	p,p-DDE		390	ug/kg	13.3
SD21	1	Longfin sanddab	Liver	p,p-DDT		16	ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 101	E	11	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 105	E	7.3	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 110	E	6.6	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 118		27	ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 123	E	2.5	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 128	E	9.5	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 138		50	ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 149	E	9.4	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 151	E	5.4	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 153/168		85	ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 156	E	3.1	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 157	E	1	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 158	E	2.6	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 167	E	2.4	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 170		14	ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 177	E	6.1	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 180		28	ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 183	E	8.7	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 187		36	ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 194	E	9.1	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 201	E	11	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 206	E	6	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 52	E	3.4	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 66	E	4.1	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 74	E	2.3	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 87	E	1.2	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 99		20	ug/kg	13.3
SD21	1	Longfin sanddab	Liver	Selenium		1.3	mg/kg	0.06
SD21	1	Longfin sanddab	Liver	Total Solids		32.2	%wt	0.4
SD21	1	Longfin sanddab	Liver	Trans Nonachlor	E	2.4	ug/kg	
SD21	1	Longfin sanddab	Liver	Zinc		28.4	mg/kg	0.58

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD21	2	Hornyhead turbot	Liver	Aluminum		7	mg/kg	2.6
SD21	2	Hornyhead turbot	Liver	Cadmium		3.98	mg/kg	0.34
SD21	2	Hornyhead turbot	Liver	Copper		9.46	mg/kg	0.76
SD21	2	Hornyhead turbot	Liver	Iron		44.5	mg/kg	1.3
SD21	2	Hornyhead turbot	Liver	Lipids		4.21	%wt	0.005
SD21	2	Hornyhead turbot	Liver	Manganese		1.91	mg/kg	0.23
SD21	2	Hornyhead turbot	Liver	Mercury		0.171	mg/kg	0.03
SD21	2	Hornyhead turbot	Liver	o,p-DDD	E	4	ug/kg	
SD21	2	Hornyhead turbot	Liver	o,p-DDE	E	2.4	ug/kg	
SD21	2	Hornyhead turbot	Liver	o,p-DDT	E	1.6	ug/kg	
SD21	2	Hornyhead turbot	Liver	p,p-DDD	E	4	ug/kg	
SD21	2	Hornyhead turbot	Liver	p,p-DDE		57	ug/kg	13.3
SD21	2	Hornyhead turbot	Liver	p,p-DDT	E	6	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 101	E	2.2	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 118	E	4	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 138	E	6.2	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 153/168	E	11	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 180	E	4	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 187	E	4	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 206	E	1.4	ug/kg	
SD21	2	Hornyhead turbot	Liver	PCB 99	E	2.5	ug/kg	
SD21	2	Hornyhead turbot	Liver	Selenium		0.741	mg/kg	0.06
SD21	2	Hornyhead turbot	Liver	Total Solids		23.2	%wt	0.4
SD21	2	Hornyhead turbot	Liver	Zinc		31	mg/kg	0.58
SD21	3	Longfin sanddab	Liver	Aluminum		4.2	mg/kg	2.6
SD21	3	Longfin sanddab	Liver	Arsenic		2.9	mg/kg	1.4
SD21	3	Longfin sanddab	Liver	Cadmium		6.6	mg/kg	0.34
SD21	3	Longfin sanddab	Liver	Chromium		0.35	mg/kg	0.3
SD21	3	Longfin sanddab	Liver	Copper		8.41	mg/kg	0.76
SD21	3	Longfin sanddab	Liver	Iron		82.2	mg/kg	1.3
SD21	3	Longfin sanddab	Liver	Lipids		4.43	%wt	0.005
SD21	3	Longfin sanddab	Liver	Manganese		1.51	mg/kg	0.23
SD21	3	Longfin sanddab	Liver	Mercury		0.238	mg/kg	0.03
SD21	3	Longfin sanddab	Liver	o,p-DDE	E	1.1	ug/kg	
SD21	3	Longfin sanddab	Liver	p,p-DDD	E	2.1	ug/kg	
SD21	3	Longfin sanddab	Liver	p,p-DDE		81	ug/kg	13.3
SD21	3	Longfin sanddab	Liver	p,p-DDT	E	3.4	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 101	E	2.8	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 118	E	3.6	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 138	E	7.5	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 153/168		14	ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 180	E	5.9	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 183	E	2.1	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 187	E	5.9	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 194	E	1.5	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 206	E	1.9	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 99	E	2.8	ug/kg	
SD21	3	Longfin sanddab	Liver	Selenium		0.777	mg/kg	0.06

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Station	Rep	Species	Tissue	Parameter	Value	Units	MDL
SD21	3	Longfin sanddab	Liver	Total Solids	23.9	%wt	0.4
SD21	3	Longfin sanddab	Liver	Zinc	39.6	mg/kg	0.58

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
RF3	1	Vermilion rockfish	Muscle	Aluminum		3.5	mg/kg	0.583
RF3	1	Vermilion rockfish	Muscle	Arsenic		1.91	mg/kg	0.375
RF3	1	Vermilion rockfish	Muscle	Barium		0.047	mg/kg	0.007
RF3	1	Vermilion rockfish	Muscle	Chromium		0.139	mg/kg	0.08
RF3	1	Vermilion rockfish	Muscle	Copper		0.406	mg/kg	0.068
RF3	1	Vermilion rockfish	Muscle	Iron		2.97	mg/kg	0.096
RF3	1	Vermilion rockfish	Muscle	Lipids		0.67	%wt	0.005
RF3	1	Vermilion rockfish	Muscle	Manganese		0.093	mg/kg	0.007
RF3	1	Vermilion rockfish	Muscle	Mercury		0.048	mg/kg	0.03
RF3	1	Vermilion rockfish	Muscle	p,p-DDE		3.7	ug/kg	1.33
RF3	1	Vermilion rockfish	Muscle	PCB 118	E	0.1	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 153/168	E	0.3	ug/kg	
RF3	1	Vermilion rockfish	Muscle	Selenium		0.282	mg/kg	0.06
RF3	1	Vermilion rockfish	Muscle	Tin		0.485	mg/kg	0.24
RF3	1	Vermilion rockfish	Muscle	Total Solids		22.1	%wt	0.4
RF3	1	Vermilion rockfish	Muscle	Zinc		3.76	mg/kg	0.049
RF3	2	Vermilion rockfish	Muscle	Aluminum		2.07	mg/kg	0.583
RF3	2	Vermilion rockfish	Muscle	Arsenic		1.68	mg/kg	0.375
RF3	2	Vermilion rockfish	Muscle	Barium		0.065	mg/kg	0.007
RF3	2	Vermilion rockfish	Muscle	Chromium		0.136	mg/kg	0.08
RF3	2	Vermilion rockfish	Muscle	Copper		0.375	mg/kg	0.068
RF3	2	Vermilion rockfish	Muscle	Iron		4.69	mg/kg	0.096
RF3	2	Vermilion rockfish	Muscle	Lipids		0.37	%wt	0.005
RF3	2	Vermilion rockfish	Muscle	Manganese		0.089	mg/kg	0.007
RF3	2	Vermilion rockfish	Muscle	Mercury		0.053	mg/kg	0.03
RF3	2	Vermilion rockfish	Muscle	p,p-DDE		3.3	ug/kg	1.33
RF3	2	Vermilion rockfish	Muscle	PCB 138	E	0.25	ug/kg	
RF3	2	Vermilion rockfish	Muscle	PCB 153/168	E	0.3	ug/kg	
RF3	2	Vermilion rockfish	Muscle	Selenium		0.277	mg/kg	0.06
RF3	2	Vermilion rockfish	Muscle	Tin		0.438	mg/kg	0.24
RF3	2	Vermilion rockfish	Muscle	Total Solids		22.3	%wt	0.4
RF3	2	Vermilion rockfish	Muscle	Zinc		4.13	mg/kg	0.049
RF3	3	Brown rockfish	Muscle	Aluminum		2.29	mg/kg	0.583
RF3	3	Brown rockfish	Muscle	Arsenic		0.954	mg/kg	0.375
RF3	3	Brown rockfish	Muscle	Barium		0.039	mg/kg	0.007
RF3	3	Brown rockfish	Muscle	Chromium		0.132	mg/kg	0.08
RF3	3	Brown rockfish	Muscle	Copper		0.178	mg/kg	0.068
RF3	3	Brown rockfish	Muscle	Iron		0.986	mg/kg	0.096
RF3	3	Brown rockfish	Muscle	Lipids		0.43	%wt	0.005
RF3	3	Brown rockfish	Muscle	Manganese		0.059	mg/kg	0.007
RF3	3	Brown rockfish	Muscle	Mercury		0.123	mg/kg	0.03
RF3	3	Brown rockfish	Muscle	p,p-DDE		1.4	ug/kg	1.33
RF3	3	Brown rockfish	Muscle	PCB 153/168	E	0.1	ug/kg	
RF3	3	Brown rockfish	Muscle	Selenium		0.482	mg/kg	0.06
RF3	3	Brown rockfish	Muscle	Tin		0.428	mg/kg	0.24
RF3	3	Brown rockfish	Muscle	Total Solids		21.9	%wt	0.4
RF3	3	Brown rockfish	Muscle	Zinc		3.22	mg/kg	0.049
RF4	1	Mixed rockfish	Muscle	Aluminum		3.34	mg/kg	0.583

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
RF4	1	Mixed rockfish	Muscle	Arsenic		2.43	mg/kg	0.375
RF4	1	Mixed rockfish	Muscle	Barium		0.051	mg/kg	0.007
RF4	1	Mixed rockfish	Muscle	Chromium		0.148	mg/kg	0.08
RF4	1	Mixed rockfish	Muscle	Copper		0.311	mg/kg	0.068
RF4	1	Mixed rockfish	Muscle	Hexachlorobenzene	E	0.1	ug/kg	
RF4	1	Mixed rockfish	Muscle	Iron		2.79	mg/kg	0.096
RF4	1	Mixed rockfish	Muscle	Lipids		0.61	%wt	0.005
RF4	1	Mixed rockfish	Muscle	Manganese		0.087	mg/kg	0.007
RF4	1	Mixed rockfish	Muscle	Mercury		0.076	mg/kg	0.03
RF4	1	Mixed rockfish	Muscle	p,p-DDE		9.3	ug/kg	1.33
RF4	1	Mixed rockfish	Muscle	PCB 101	E	0.2	ug/kg	
RF4	1	Mixed rockfish	Muscle	PCB 118	E	0.2	ug/kg	
RF4	1	Mixed rockfish	Muscle	PCB 153/168	E	0.5	ug/kg	
RF4	1	Mixed rockfish	Muscle	PCB 99	E	0.2	ug/kg	
RF4	1	Mixed rockfish	Muscle	Selenium		0.269	mg/kg	0.06
RF4	1	Mixed rockfish	Muscle	Tin		0.465	mg/kg	0.24
RF4	1	Mixed rockfish	Muscle	Total Solids		22	%wt	0.4
RF4	1	Mixed rockfish	Muscle	Zinc		4.41	mg/kg	0.049
RF4	2	Ca. scorpionfish	Muscle	Aluminum		1.9	mg/kg	0.583
RF4	2	Ca. scorpionfish	Muscle	Arsenic		0.941	mg/kg	0.375
RF4	2	Ca. scorpionfish	Muscle	Barium		0.035	mg/kg	0.007
RF4	2	Ca. scorpionfish	Muscle	Chromium		0.125	mg/kg	0.08
RF4	2	Ca. scorpionfish	Muscle	Copper		0.414	mg/kg	0.068
RF4	2	Ca. scorpionfish	Muscle	Iron		3.32	mg/kg	0.096
RF4	2	Ca. scorpionfish	Muscle	Lipids		0.76	%wt	0.005
RF4	2	Ca. scorpionfish	Muscle	Manganese		0.083	mg/kg	0.007
RF4	2	Ca. scorpionfish	Muscle	Mercury		0.149	mg/kg	0.03
RF4	2	Ca. scorpionfish	Muscle	p,p-DDE		4.6	ug/kg	1.33
RF4	2	Ca. scorpionfish	Muscle	PCB 118	E	0.1	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Selenium		0.293	mg/kg	0.06
RF4	2	Ca. scorpionfish	Muscle	Tin		0.409	mg/kg	0.24
RF4	2	Ca. scorpionfish	Muscle	Total Solids		20.7	%wt	0.4
RF4	2	Ca. scorpionfish	Muscle	Zinc		3.76	mg/kg	0.049
RF4	3	Ca. scorpionfish	Muscle	Aluminum		6.22	mg/kg	0.583
RF4	3	Ca. scorpionfish	Muscle	Arsenic		0.564	mg/kg	0.375
RF4	3	Ca. scorpionfish	Muscle	Barium		0.053	mg/kg	0.007
RF4	3	Ca. scorpionfish	Muscle	Chromium		0.134	mg/kg	0.08
RF4	3	Ca. scorpionfish	Muscle	Copper		0.267	mg/kg	0.068
RF4	3	Ca. scorpionfish	Muscle	Iron		2.95	mg/kg	0.096
RF4	3	Ca. scorpionfish	Muscle	Lipids		0.46	%wt	0.005
RF4	3	Ca. scorpionfish	Muscle	Manganese		0.08	mg/kg	0.007
RF4	3	Ca. scorpionfish	Muscle	Mercury		0.168	mg/kg	0.03
RF4	3	Ca. scorpionfish	Muscle	p,p-DDE		7.2	ug/kg	1.33
RF4	3	Ca. scorpionfish	Muscle	PCB 101	E	0.1	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 118	E	0.1	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 153/168	E	0.5	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Selenium		0.23	mg/kg	0.06
RF4	3	Ca. scorpionfish	Muscle	Tin		0.455	mg/kg	0.24

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
RF4	3	Ca. scorpionfish	Muscle	Total Solids		20.3	%wt	0.4
RF4	3	Ca. scorpionfish	Muscle	Zinc		2.99	mg/kg	0.049
SD15	1	Ca. scorpionfish	Liver	Aluminum		18.9	mg/kg	0.583
SD15	1	Ca. scorpionfish	Liver	Arsenic		1.07	mg/kg	0.375
SD15	1	Ca. scorpionfish	Liver	Barium		0.139	mg/kg	0.007
SD15	1	Ca. scorpionfish	Liver	Beryllium		0.004	mg/kg	0.003
SD15	1	Ca. scorpionfish	Liver	Cadmium		0.58	mg/kg	0.029
SD15	1	Ca. scorpionfish	Liver	Chromium		0.28	mg/kg	0.08
SD15	1	Ca. scorpionfish	Liver	Copper		8.45	mg/kg	0.068
SD15	1	Ca. scorpionfish	Liver	Hexachlorobenzene	E	1.65	ug/kg	
SD15	1	Ca. scorpionfish	Liver	Iron		71.2	mg/kg	0.096
SD15	1	Ca. scorpionfish	Liver	Lipids		15.1	%wt	0.005
SD15	1	Ca. scorpionfish	Liver	Manganese		0.426	mg/kg	0.007
SD15	1	Ca. scorpionfish	Liver	Mercury		0.058	mg/kg	0.03
SD15	1	Ca. scorpionfish	Liver	Nickel		0.252	mg/kg	0.094
SD15	1	Ca. scorpionfish	Liver	o,p-DDE	E	3.85	ug/kg	
SD15	1	Ca. scorpionfish	Liver	p,p-DDD	E	10.5	ug/kg	
SD15	1	Ca. scorpionfish	Liver	p,p-DDE		575	ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	p,p-DDT	E	2.55	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 101	E	6.95	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 105	E	3.8	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 110	E	6.2	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 118		14.5	ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 128	E	3.85	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 138		18	ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 149	E	6.4	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 151	E	3.05	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 153/168		32	ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 180	E	8.95	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 183	E	3.1	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 187	E	12	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 66	E	2.45	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 74	E	1.5	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 87	E	1.85	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 99	E	6.7	ug/kg	
SD15	1	Ca. scorpionfish	Liver	Selenium		1.03	mg/kg	0.06
SD15	1	Ca. scorpionfish	Liver	Silver		0.107	mg/kg	0.057
SD15	1	Ca. scorpionfish	Liver	Tin		1.21	mg/kg	0.24
SD15	1	Ca. scorpionfish	Liver	Total Solids		47.2	%wt	0.4
SD15	1	Ca. scorpionfish	Liver	Zinc		53.5	mg/kg	0.049
SD15	2	Ca. scorpionfish	Liver	Aluminum		7.98	mg/kg	0.583
SD15	2	Ca. scorpionfish	Liver	Arsenic		1.39	mg/kg	0.375
SD15	2	Ca. scorpionfish	Liver	Barium		0.098	mg/kg	0.007
SD15	2	Ca. scorpionfish	Liver	Cadmium		1.75	mg/kg	0.029
SD15	2	Ca. scorpionfish	Liver	Chromium		0.214	mg/kg	0.08
SD15	2	Ca. scorpionfish	Liver	Copper		19.4	mg/kg	0.068
SD15	2	Ca. scorpionfish	Liver	Hexachlorobenzene	E	4.5	ug/kg	
SD15	2	Ca. scorpionfish	Liver	Iron		103	mg/kg	0.096

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD15	2	Ca. scorpionfish	Liver	Lipids		27.4	%wt	0.005
SD15	2	Ca. scorpionfish	Liver	Manganese		0.456	mg/kg	0.007
SD15	2	Ca. scorpionfish	Liver	Mercury		0.087	mg/kg	0.03
SD15	2	Ca. scorpionfish	Liver	Nickel		0.189	mg/kg	0.094
SD15	2	Ca. scorpionfish	Liver	o,p-DDE	E	2.7	ug/kg	
SD15	2	Ca. scorpionfish	Liver	p,p-DDD	E	6	ug/kg	
SD15	2	Ca. scorpionfish	Liver	p,p-DDE		410	ug/kg	13.3
SD15	2	Ca. scorpionfish	Liver	p,p-DDT	E	2.9	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 101	E	7.3	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 105	E	4.8	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 110	E	7.1	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 118		18	ug/kg	13.3
SD15	2	Ca. scorpionfish	Liver	PCB 123	E	2.3	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 128	E	5.7	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 138		26	ug/kg	13.3
SD15	2	Ca. scorpionfish	Liver	PCB 149	E	5.7	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 151	E	4.1	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 153/168		43	ug/kg	13.3
SD15	2	Ca. scorpionfish	Liver	PCB 158	E	1.8	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 170	E	6.7	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 177	E	3.7	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 180		16	ug/kg	13.3
SD15	2	Ca. scorpionfish	Liver	PCB 183	E	4.1	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 187		18	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 194	E	3.5	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 201	E	5.3	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 206	E	2	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 66	E	3	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 74	E	1.4	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 99	E	8.3	ug/kg	
SD15	2	Ca. scorpionfish	Liver	Selenium		0.692	mg/kg	0.06
SD15	2	Ca. scorpionfish	Liver	Silver		0.153	mg/kg	0.057
SD15	2	Ca. scorpionfish	Liver	Tin		1.12	mg/kg	0.24
SD15	2	Ca. scorpionfish	Liver	Total Solids		49.5	%wt	0.4
SD15	2	Ca. scorpionfish	Liver	Trans Nonachlor	E	8.7	ug/kg	
SD15	2	Ca. scorpionfish	Liver	Zinc		72.7	mg/kg	0.049
SD15	3	Hornyhead turbot	Liver	Aluminum		4.64	mg/kg	0.583
SD15	3	Hornyhead turbot	Liver	Arsenic		4.25	mg/kg	0.375
SD15	3	Hornyhead turbot	Liver	Barium		0.079	mg/kg	0.007
SD15	3	Hornyhead turbot	Liver	Cadmium		1.97	mg/kg	0.029
SD15	3	Hornyhead turbot	Liver	Chromium		0.554	mg/kg	0.08
SD15	3	Hornyhead turbot	Liver	Copper		3.02	mg/kg	0.068
SD15	3	Hornyhead turbot	Liver	Hexachlorobenzene	E	1	ug/kg	
SD15	3	Hornyhead turbot	Liver	Iron		27.5	mg/kg	0.096
SD15	3	Hornyhead turbot	Liver	Lipids		11.9	%wt	0.005
SD15	3	Hornyhead turbot	Liver	Manganese		1.28	mg/kg	0.007
SD15	3	Hornyhead turbot	Liver	Mercury		0.066	mg/kg	0.03
SD15	3	Hornyhead turbot	Liver	Nickel		0.426	mg/kg	0.094

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD15	3	Hornyhead turbot	Liver	p,p-DDD	E	2.2	ug/kg	
SD15	3	Hornyhead turbot	Liver	p,p-DDE		100	ug/kg	13.3
SD15	3	Hornyhead turbot	Liver	p,p-DDT	E	3.3	ug/kg	
SD15	3	Hornyhead turbot	Liver	PCB 101	E	1.2	ug/kg	
SD15	3	Hornyhead turbot	Liver	PCB 118	E	2.5	ug/kg	
SD15	3	Hornyhead turbot	Liver	PCB 138	E	4	ug/kg	
SD15	3	Hornyhead turbot	Liver	PCB 153/168	E	7.6	ug/kg	
SD15	3	Hornyhead turbot	Liver	PCB 180	E	3.5	ug/kg	
SD15	3	Hornyhead turbot	Liver	PCB 187	E	5.1	ug/kg	
SD15	3	Hornyhead turbot	Liver	Selenium		0.576	mg/kg	0.06
SD15	3	Hornyhead turbot	Liver	Silver		0.119	mg/kg	0.057
SD15	3	Hornyhead turbot	Liver	Tin		0.914	mg/kg	0.24
SD15	3	Hornyhead turbot	Liver	Total Solids		33.6	%wt	0.4
SD15	3	Hornyhead turbot	Liver	Zinc		43.1	mg/kg	0.049
SD16	1	Ca. scorpionfish	Liver	Aluminum		11.5	mg/kg	0.583
SD16	1	Ca. scorpionfish	Liver	Arsenic		0.925	mg/kg	0.375
SD16	1	Ca. scorpionfish	Liver	Barium		0.106	mg/kg	0.007
SD16	1	Ca. scorpionfish	Liver	Cadmium		1.85	mg/kg	0.029
SD16	1	Ca. scorpionfish	Liver	Chromium		0.251	mg/kg	0.08
SD16	1	Ca. scorpionfish	Liver	Copper		15.6	mg/kg	0.068
SD16	1	Ca. scorpionfish	Liver	Hexachlorobenzene	E	1.4	ug/kg	
SD16	1	Ca. scorpionfish	Liver	Iron		167	mg/kg	0.096
SD16	1	Ca. scorpionfish	Liver	Lipids		13.6	%wt	0.005
SD16	1	Ca. scorpionfish	Liver	Manganese		0.541	mg/kg	0.007
SD16	1	Ca. scorpionfish	Liver	Nickel		0.159	mg/kg	0.094
SD16	1	Ca. scorpionfish	Liver	p,p-DDD	E	2.5	ug/kg	
SD16	1	Ca. scorpionfish	Liver	p,p-DDE		260	ug/kg	13.3
SD16	1	Ca. scorpionfish	Liver	PCB 101	E	4.2	ug/kg	
SD16	1	Ca. scorpionfish	Liver	PCB 105	E	3.2	ug/kg	
SD16	1	Ca. scorpionfish	Liver	PCB 118	E	13	ug/kg	
SD16	1	Ca. scorpionfish	Liver	PCB 128	E	3.7	ug/kg	
SD16	1	Ca. scorpionfish	Liver	PCB 138		21	ug/kg	13.3
SD16	1	Ca. scorpionfish	Liver	PCB 151	E	2.9	ug/kg	
SD16	1	Ca. scorpionfish	Liver	PCB 153/168		41	ug/kg	13.3
SD16	1	Ca. scorpionfish	Liver	PCB 180		14	ug/kg	13.3
SD16	1	Ca. scorpionfish	Liver	PCB 183	E	5.6	ug/kg	
SD16	1	Ca. scorpionfish	Liver	PCB 187		20	ug/kg	13.3
SD16	1	Ca. scorpionfish	Liver	PCB 201	E	5.1	ug/kg	
SD16	1	Ca. scorpionfish	Liver	PCB 99	E	5	ug/kg	
SD16	1	Ca. scorpionfish	Liver	Selenium		0.86	mg/kg	0.06
SD16	1	Ca. scorpionfish	Liver	Silver		0.336	mg/kg	0.057
SD16	1	Ca. scorpionfish	Liver	Tin		0.951	mg/kg	0.24
SD16	1	Ca. scorpionfish	Liver	Total Solids		36	%wt	0.4
SD16	1	Ca. scorpionfish	Liver	Zinc		89	mg/kg	0.049
SD16	2	Ca. scorpionfish	Liver	Alpha (cis) Chlordane	E	5	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Aluminum		16.3	mg/kg	0.583
SD16	2	Ca. scorpionfish	Liver	Arsenic		0.795	mg/kg	0.375
SD16	2	Ca. scorpionfish	Liver	Barium		0.126	mg/kg	0.007

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD16	2	Ca. scorpionfish	Liver	Beryllium		0.004	mg/kg	0.003
SD16	2	Ca. scorpionfish	Liver	Cadmium		1.48	mg/kg	0.029
SD16	2	Ca. scorpionfish	Liver	Chromium		0.255	mg/kg	0.08
SD16	2	Ca. scorpionfish	Liver	Cis Nonachlor	E	5.1	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Copper		17.2	mg/kg	0.068
SD16	2	Ca. scorpionfish	Liver	Hexachlorobenzene	E	2.8	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Iron		128	mg/kg	0.096
SD16	2	Ca. scorpionfish	Liver	Lipids		19.6	%wt	0.005
SD16	2	Ca. scorpionfish	Liver	Manganese		0.525	mg/kg	0.007
SD16	2	Ca. scorpionfish	Liver	Mercury		0.049	mg/kg	0.03
SD16	2	Ca. scorpionfish	Liver	Nickel		0.185	mg/kg	0.094
SD16	2	Ca. scorpionfish	Liver	o,p-DDE		250	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	p,p-DDD		230	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	p,p-DDE		15000	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	p,p-DDT		23	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 101		69	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 105		46	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 110		54	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 118		140	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 123	E	12	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 128		25	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 138		110	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 149		20	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 151		16	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 153/168		160	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 156	E	11	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 157	E	2	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 158	E	12	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 167	E	4.1	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 170		25	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 177	E	8.4	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 180		66	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 183		19	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 187		48	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 194	E	12	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 201		17	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 206	E	6.4	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 28	E	14	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 44	E	12	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 49		22	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 52		33	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 66		47	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 70	E	6.3	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 74		30	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 87		19	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 99		56	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	Selenium		0.834	mg/kg	0.06
SD16	2	Ca. scorpionfish	Liver	Silver		0.509	mg/kg	0.057

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD16	2	Ca. scorpionfish	Liver	Tin		1.53	mg/kg	0.24
SD16	2	Ca. scorpionfish	Liver	Total Solids		47.9	%wt	0.4
SD16	2	Ca. scorpionfish	Liver	Trans Nonachlor	E	11	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Zinc		76	mg/kg	0.049
SD16	3	Hornyhead turbot	Liver	Aluminum		5.84	mg/kg	0.583
SD16	3	Hornyhead turbot	Liver	Arsenic		1.77	mg/kg	0.375
SD16	3	Hornyhead turbot	Liver	Barium		0.079	mg/kg	0.007
SD16	3	Hornyhead turbot	Liver	Cadmium		5.38	mg/kg	0.029
SD16	3	Hornyhead turbot	Liver	Chromium		0.257	mg/kg	0.08
SD16	3	Hornyhead turbot	Liver	Copper		3.71	mg/kg	0.068
SD16	3	Hornyhead turbot	Liver	Hexachlorobenzene	E	0.8	ug/kg	
SD16	3	Hornyhead turbot	Liver	Iron		28.3	mg/kg	0.096
SD16	3	Hornyhead turbot	Liver	Lipids		13.1	%wt	0.005
SD16	3	Hornyhead turbot	Liver	Manganese		0.845	mg/kg	0.007
SD16	3	Hornyhead turbot	Liver	Mercury		0.107	mg/kg	0.03
SD16	3	Hornyhead turbot	Liver	Nickel		0.184	mg/kg	0.094
SD16	3	Hornyhead turbot	Liver	p,p-DDD	E	2.5	ug/kg	
SD16	3	Hornyhead turbot	Liver	p,p-DDE		140	ug/kg	13.3
SD16	3	Hornyhead turbot	Liver	PCB 101	E	1.2	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 118	E	2.3	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 138	E	5.9	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 153/168	E	10	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 180	E	4.3	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 187	E	4.1	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 99	E	1.6	ug/kg	
SD16	3	Hornyhead turbot	Liver	Selenium		0.571	mg/kg	0.06
SD16	3	Hornyhead turbot	Liver	Silver		0.205	mg/kg	0.057
SD16	3	Hornyhead turbot	Liver	Tin		1.05	mg/kg	0.24
SD16	3	Hornyhead turbot	Liver	Total Solids		35.8	%wt	0.4
SD16	3	Hornyhead turbot	Liver	Zinc		63	mg/kg	0.049
SD17	1	Ca. scorpionfish	Liver	Aluminum		10.2	mg/kg	0.583
SD17	1	Ca. scorpionfish	Liver	Arsenic		1.23	mg/kg	0.375
SD17	1	Ca. scorpionfish	Liver	Barium		0.122	mg/kg	0.007
SD17	1	Ca. scorpionfish	Liver	Beryllium		0.003	mg/kg	0.003
SD17	1	Ca. scorpionfish	Liver	Cadmium		3.79	mg/kg	0.029
SD17	1	Ca. scorpionfish	Liver	Chromium		0.292	mg/kg	0.08
SD17	1	Ca. scorpionfish	Liver	Copper		11.1	mg/kg	0.068
SD17	1	Ca. scorpionfish	Liver	Hexachlorobenzene	E	3.8	ug/kg	
SD17	1	Ca. scorpionfish	Liver	Iron		239	mg/kg	0.096
SD17	1	Ca. scorpionfish	Liver	Lipids		22.9	%wt	0.005
SD17	1	Ca. scorpionfish	Liver	Manganese		0.347	mg/kg	0.007
SD17	1	Ca. scorpionfish	Liver	Mercury		0.294	mg/kg	0.03
SD17	1	Ca. scorpionfish	Liver	Nickel		0.187	mg/kg	0.094
SD17	1	Ca. scorpionfish	Liver	o,p-DDE	E	2.8	ug/kg	
SD17	1	Ca. scorpionfish	Liver	o,p-DDT	E	1.35	ug/kg	
SD17	1	Ca. scorpionfish	Liver	p,p-DDD	E	9.25	ug/kg	
SD17	1	Ca. scorpionfish	Liver	p,p-DDE		1500	ug/kg	13.3
SD17	1	Ca. scorpionfish	Liver	p,p-DDT	E	6.35	ug/kg	

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD17	1	Ca. scorpionfish	Liver	PCB 101	E	11	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 105	E	12	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 110	E	12.5	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 118		39.5	ug/kg	13.3
SD17	1	Ca. scorpionfish	Liver	PCB 123	E	4.2	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 128	E	10.5	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 138		52.5	ug/kg	13.3
SD17	1	Ca. scorpionfish	Liver	PCB 149	E	7.25	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 151	E	8.05	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 153/168		88.5	ug/kg	13.3
SD17	1	Ca. scorpionfish	Liver	PCB 156	E	4.7	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 158	E	4.35	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 167	E	2.8	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 170	E	13	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 177	E	8.25	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 180		39	ug/kg	13.3
SD17	1	Ca. scorpionfish	Liver	PCB 183	E	10.5	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 187		36.5	ug/kg	13.3
SD17	1	Ca. scorpionfish	Liver	PCB 194	E	6.8	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 201	E	9.5	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 206	E	2.9	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 66	E	4.15	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 74	E	2.05	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 87	E	3.25	ug/kg	
SD17	1	Ca. scorpionfish	Liver	PCB 99	E	13.5	ug/kg	13.3
SD17	1	Ca. scorpionfish	Liver	Selenium		0.889	mg/kg	0.06
SD17	1	Ca. scorpionfish	Liver	Silver		0.158	mg/kg	0.057
SD17	1	Ca. scorpionfish	Liver	Tin		1.25	mg/kg	0.24
SD17	1	Ca. scorpionfish	Liver	Total Solids		44.4	%wt	0.4
SD17	1	Ca. scorpionfish	Liver	Trans Nonachlor	E	17.5	ug/kg	
SD17	1	Ca. scorpionfish	Liver	Zinc		146	mg/kg	0.049
SD17	2	Ca. scorpionfish	Liver	Alpha (cis) Chlordane	E	6.4	ug/kg	
SD17	2	Ca. scorpionfish	Liver	Aluminum		11.2	mg/kg	0.583
SD17	2	Ca. scorpionfish	Liver	Arsenic		0.555	mg/kg	0.375
SD17	2	Ca. scorpionfish	Liver	Barium		0.122	mg/kg	0.007
SD17	2	Ca. scorpionfish	Liver	Beryllium		0.003	mg/kg	0.003
SD17	2	Ca. scorpionfish	Liver	Cadmium		4.25	mg/kg	0.029
SD17	2	Ca. scorpionfish	Liver	Chromium		0.62	mg/kg	0.08
SD17	2	Ca. scorpionfish	Liver	Copper		33.5	mg/kg	0.068
SD17	2	Ca. scorpionfish	Liver	Hexachlorobenzene	E	4.6	ug/kg	
SD17	2	Ca. scorpionfish	Liver	Iron		274	mg/kg	0.096
SD17	2	Ca. scorpionfish	Liver	Lead		0.428	mg/kg	0.3
SD17	2	Ca. scorpionfish	Liver	Lipids		23.5	%wt	0.005
SD17	2	Ca. scorpionfish	Liver	Manganese		0.557	mg/kg	0.007
SD17	2	Ca. scorpionfish	Liver	Mercury		0.212	mg/kg	0.03
SD17	2	Ca. scorpionfish	Liver	Nickel		0.368	mg/kg	0.094
SD17	2	Ca. scorpionfish	Liver	o,p-DDE	E	2.9	ug/kg	
SD17	2	Ca. scorpionfish	Liver	p,p-DDD		14	ug/kg	13.3

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD17	2	Ca. scorpionfish	Liver	p,p-DDE		1000	ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	p,p-DDT	E	4.5	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 101	E	12	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 105	E	8.2	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 110	E	10	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 118		29	ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 123	E	2.6	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 128	E	8.5	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 138		42	ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 149	E	7.9	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 151	E	6.2	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 153/168		78	ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 156	E	3.4	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 158	E	3.2	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 170		14	ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 177	E	7.6	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 180		32	ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 183	E	10	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 187		38	ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 194	E	6.1	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 201	E	10	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 66	E	3.4	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 70	E	1.6	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 74	E	1.9	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 87	E	2.7	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 99	E	11	ug/kg	
SD17	2	Ca. scorpionfish	Liver	Selenium		0.929	mg/kg	0.06
SD17	2	Ca. scorpionfish	Liver	Silver		0.353	mg/kg	0.057
SD17	2	Ca. scorpionfish	Liver	Tin		1.28	mg/kg	0.24
SD17	2	Ca. scorpionfish	Liver	Total Solids		44.6	%wt	0.4
SD17	2	Ca. scorpionfish	Liver	Trans Nonachlor	E	13	ug/kg	
SD17	2	Ca. scorpionfish	Liver	Zinc		113	mg/kg	0.049
SD17	3	Ca. scorpionfish	Liver	Aluminum		7.61	mg/kg	0.583
SD17	3	Ca. scorpionfish	Liver	Arsenic		0.731	mg/kg	0.375
SD17	3	Ca. scorpionfish	Liver	Barium		0.106	mg/kg	0.007
SD17	3	Ca. scorpionfish	Liver	Cadmium		1.35	mg/kg	0.029
SD17	3	Ca. scorpionfish	Liver	Chromium		0.308	mg/kg	0.08
SD17	3	Ca. scorpionfish	Liver	Copper		21.6	mg/kg	0.068
SD17	3	Ca. scorpionfish	Liver	Hexachlorobenzene	E	3.7	ug/kg	
SD17	3	Ca. scorpionfish	Liver	Iron		126	mg/kg	0.096
SD17	3	Ca. scorpionfish	Liver	Lipids		19.7	%wt	0.005
SD17	3	Ca. scorpionfish	Liver	Manganese		0.472	mg/kg	0.007
SD17	3	Ca. scorpionfish	Liver	Mercury		0.118	mg/kg	0.03
SD17	3	Ca. scorpionfish	Liver	Nickel		0.211	mg/kg	0.094
SD17	3	Ca. scorpionfish	Liver	p,p-DDD	E	6.6	ug/kg	
SD17	3	Ca. scorpionfish	Liver	p,p-DDE		430	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	p,p-DDT	E	4.5	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 101	E	11	ug/kg	

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD17	3	Ca. scorpionfish	Liver	PCB 105	E	8.3	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 110	E	8	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 118		31	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 123	E	3.6	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 128	E	7.7	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 138		42	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 149	E	6.4	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 151	E	5.1	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 153/168		79	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 156	E	3.7	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 158	E	3.2	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 167	E	2.4	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 170	E	10	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 177	E	6.3	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 180		32	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 183	E	8.4	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 187		33	ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 194	E	4.9	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 52	E	2.8	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 66	E	2.6	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 87	E	2.1	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 99	E	10	ug/kg	
SD17	3	Ca. scorpionfish	Liver	Selenium		0.862	mg/kg	0.06
SD17	3	Ca. scorpionfish	Liver	Silver		0.258	mg/kg	0.057
SD17	3	Ca. scorpionfish	Liver	Tin		1.15	mg/kg	0.24
SD17	3	Ca. scorpionfish	Liver	Total Solids		40.9	%wt	0.4
SD17	3	Ca. scorpionfish	Liver	Trans Nonachlor	E	8	ug/kg	
SD17	3	Ca. scorpionfish	Liver	Zinc		79.8	mg/kg	0.049
SD18	1	Ca. scorpionfish	Liver	Aluminum		5.95	mg/kg	0.583
SD18	1	Ca. scorpionfish	Liver	Arsenic		0.677	mg/kg	0.375
SD18	1	Ca. scorpionfish	Liver	Barium		0.086	mg/kg	0.007
SD18	1	Ca. scorpionfish	Liver	Beryllium		0.004	mg/kg	0.003
SD18	1	Ca. scorpionfish	Liver	Cadmium		2.41	mg/kg	0.029
SD18	1	Ca. scorpionfish	Liver	Chromium		0.254	mg/kg	0.08
SD18	1	Ca. scorpionfish	Liver	Copper		18.6	mg/kg	0.068
SD18	1	Ca. scorpionfish	Liver	Hexachlorobenzene	E	1.25	ug/kg	
SD18	1	Ca. scorpionfish	Liver	Iron		174	mg/kg	0.096
SD18	1	Ca. scorpionfish	Liver	Lipids		17.6	%wt	0.005
SD18	1	Ca. scorpionfish	Liver	Manganese		0.655	mg/kg	0.007
SD18	1	Ca. scorpionfish	Liver	Mercury		0.112	mg/kg	0.03
SD18	1	Ca. scorpionfish	Liver	Nickel		0.109	mg/kg	0.094
SD18	1	Ca. scorpionfish	Liver	p,p-DDD	E	5.65	ug/kg	
SD18	1	Ca. scorpionfish	Liver	p,p-DDE		655	ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	p,p-DDT	E	2.65	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 101	E	6.6	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 105	E	5.55	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 110	E	5.6	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 118		18.5	ug/kg	13.3

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD18	1	Ca. scorpionfish	Liver	PCB 128	E	5.45	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 138		27.5	ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 149	E	3.45	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 151	E	3.25	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 153/168		45	ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 158	E	1.8	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 180		18.5	ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 183	E	6.2	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 187		19	ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 87	E	1.8	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 99	E	7.4	ug/kg	
SD18	1	Ca. scorpionfish	Liver	Selenium		0.775	mg/kg	0.06
SD18	1	Ca. scorpionfish	Liver	Silver		0.204	mg/kg	0.057
SD18	1	Ca. scorpionfish	Liver	Tin		1.04	mg/kg	0.24
SD18	1	Ca. scorpionfish	Liver	Total Solids		40.4	%wt	0.4
SD18	1	Ca. scorpionfish	Liver	Trans Nonachlor	E	9.6	ug/kg	
SD18	1	Ca. scorpionfish	Liver	Zinc		77.7	mg/kg	0.049
SD18	2	Hornyhead turbot	Liver	Aluminum		8.37	mg/kg	0.583
SD18	2	Hornyhead turbot	Liver	Arsenic		0.847	mg/kg	0.375
SD18	2	Hornyhead turbot	Liver	Barium		0.084	mg/kg	0.007
SD18	2	Hornyhead turbot	Liver	Cadmium		4.49	mg/kg	0.029
SD18	2	Hornyhead turbot	Liver	Chromium		0.207	mg/kg	0.08
SD18	2	Hornyhead turbot	Liver	Copper		24.9	mg/kg	0.068
SD18	2	Hornyhead turbot	Liver	Hexachlorobenzene	E	2.2	ug/kg	
SD18	2	Hornyhead turbot	Liver	Iron		250	mg/kg	0.096
SD18	2	Hornyhead turbot	Liver	Lipids		16.5	%wt	0.005
SD18	2	Hornyhead turbot	Liver	Manganese		0.614	mg/kg	0.007
SD18	2	Hornyhead turbot	Liver	Mercury		0.407	mg/kg	0.03
SD18	2	Hornyhead turbot	Liver	p,p-DDD	E	3.5	ug/kg	
SD18	2	Hornyhead turbot	Liver	p,p-DDE		320	ug/kg	13.3
SD18	2	Hornyhead turbot	Liver	PCB 101	E	5.2	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 105	E	4.5	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 110	E	6.3	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 118		18	ug/kg	13.3
SD18	2	Hornyhead turbot	Liver	PCB 128	E	5	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 138		28	ug/kg	13.3
SD18	2	Hornyhead turbot	Liver	PCB 149	E	4.4	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 151	E	4.1	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 153/168		50	ug/kg	13.3
SD18	2	Hornyhead turbot	Liver	PCB 177	E	4.7	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 180		19	ug/kg	13.3
SD18	2	Hornyhead turbot	Liver	PCB 183	E	6.7	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 187		25	ug/kg	13.3
SD18	2	Hornyhead turbot	Liver	PCB 87	E	1.8	ug/kg	
SD18	2	Hornyhead turbot	Liver	PCB 99	E	7	ug/kg	
SD18	2	Hornyhead turbot	Liver	Selenium		0.918	mg/kg	0.06
SD18	2	Hornyhead turbot	Liver	Silver		0.5	mg/kg	0.057
SD18	2	Hornyhead turbot	Liver	Tin		0.99	mg/kg	0.24

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD18	2	Hornyhead turbot	Liver	Total Solids		34.8	%wt	0.4
SD18	2	Hornyhead turbot	Liver	Trans Nonachlor	E	4.7	ug/kg	
SD18	2	Hornyhead turbot	Liver	Zinc		90.2	mg/kg	0.049
SD18	3	Ca. scorpionfish	Liver	Aluminum		5.1	mg/kg	0.583
SD18	3	Ca. scorpionfish	Liver	Arsenic		2.8	mg/kg	0.375
SD18	3	Ca. scorpionfish	Liver	Barium		0.069	mg/kg	0.007
SD18	3	Ca. scorpionfish	Liver	Cadmium		6.87	mg/kg	0.029
SD18	3	Ca. scorpionfish	Liver	Chromium		0.38	mg/kg	0.08
SD18	3	Ca. scorpionfish	Liver	Copper		4.91	mg/kg	0.068
SD18	3	Ca. scorpionfish	Liver	Hexachlorobenzene	E	1.8	ug/kg	
SD18	3	Ca. scorpionfish	Liver	Iron		52.1	mg/kg	0.096
SD18	3	Ca. scorpionfish	Liver	Lipids		11	%wt	0.005
SD18	3	Ca. scorpionfish	Liver	Manganese		0.797	mg/kg	0.007
SD18	3	Ca. scorpionfish	Liver	Mercury		0.135	mg/kg	0.03
SD18	3	Ca. scorpionfish	Liver	Nickel		0.226	mg/kg	0.094
SD18	3	Ca. scorpionfish	Liver	p,p-DDD	E	2.6	ug/kg	
SD18	3	Ca. scorpionfish	Liver	p,p-DDE		130	ug/kg	13.3
SD18	3	Ca. scorpionfish	Liver	PCB 101	E	1.5	ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 118	E	2.1	ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 138	E	5.4	ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 153/168	E	7.9	ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 180	E	4.7	ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 183	E	1.2	ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 187	E	4.6	ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 99	E	1.6	ug/kg	
SD18	3	Ca. scorpionfish	Liver	Selenium		0.64	mg/kg	0.06
SD18	3	Ca. scorpionfish	Liver	Silver		0.268	mg/kg	0.057
SD18	3	Ca. scorpionfish	Liver	Tin		0.839	mg/kg	0.24
SD18	3	Ca. scorpionfish	Liver	Total Solids		29.9	%wt	0.4
SD18	3	Ca. scorpionfish	Liver	Zinc		60	mg/kg	0.049
SD19	1	Longfin sanddab	Liver	Alpha (cis) Chlordane	E	6.3	ug/kg	
SD19	1	Longfin sanddab	Liver	Aluminum		8.74	mg/kg	0.583
SD19	1	Longfin sanddab	Liver	Arsenic		5.17	mg/kg	0.375
SD19	1	Longfin sanddab	Liver	Barium		0.13	mg/kg	0.007
SD19	1	Longfin sanddab	Liver	Beryllium		0.004	mg/kg	0.003
SD19	1	Longfin sanddab	Liver	Cadmium		1.99	mg/kg	0.029
SD19	1	Longfin sanddab	Liver	Chromium		0.269	mg/kg	0.08
SD19	1	Longfin sanddab	Liver	Copper		7.35	mg/kg	0.068
SD19	1	Longfin sanddab	Liver	Hexachlorobenzene	E	3.3	ug/kg	
SD19	1	Longfin sanddab	Liver	Iron		73	mg/kg	0.096
SD19	1	Longfin sanddab	Liver	Lipids		48.2	%wt	0.005
SD19	1	Longfin sanddab	Liver	Manganese		0.708	mg/kg	0.007
SD19	1	Longfin sanddab	Liver	Mercury		0.109	mg/kg	0.03
SD19	1	Longfin sanddab	Liver	Mirex	E	1.8	ug/kg	
SD19	1	Longfin sanddab	Liver	Nickel		0.189	mg/kg	0.094
SD19	1	Longfin sanddab	Liver	o,p-DDD	E	1.8	ug/kg	
SD19	1	Longfin sanddab	Liver	o,p-DDE	E	10	ug/kg	
SD19	1	Longfin sanddab	Liver	o,p-DDT	E	3.1	ug/kg	

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD19	1	Longfin sanddab	Liver	p,p-DDD	E	10	ug/kg	
SD19	1	Longfin sanddab	Liver	p,p-DDE		680	ug/kg	13.3
SD19	1	Longfin sanddab	Liver	p,p-DDT	E	11	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 101	E	8.6	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 105	E	5.3	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 110	E	7.8	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 118		22	ug/kg	13.3
SD19	1	Longfin sanddab	Liver	PCB 123	E	2	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 128	E	5.4	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 138		34	ug/kg	13.3
SD19	1	Longfin sanddab	Liver	PCB 149	E	7.6	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 151	E	5.4	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 153/168		58	ug/kg	13.3
SD19	1	Longfin sanddab	Liver	PCB 156	E	2	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 158	E	2.3	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 167	E	1.5	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 170	E	7.7	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 177	E	3.7	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 180		20	ug/kg	13.3
SD19	1	Longfin sanddab	Liver	PCB 183	E	4.8	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 187		21	ug/kg	13.3
SD19	1	Longfin sanddab	Liver	PCB 201	E	6.7	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 66	E	3	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 99	E	9.5	ug/kg	
SD19	1	Longfin sanddab	Liver	Selenium		0.862	mg/kg	0.06
SD19	1	Longfin sanddab	Liver	Silver		0.158	mg/kg	0.057
SD19	1	Longfin sanddab	Liver	Tin		1.41	mg/kg	0.24
SD19	1	Longfin sanddab	Liver	Total Solids		56.9	%wt	0.4
SD19	1	Longfin sanddab	Liver	Trans Nonachlor	E	7.1	ug/kg	
SD19	1	Longfin sanddab	Liver	Zinc		22.7	mg/kg	0.049
SD19	2	Longfin sanddab	Liver	Alpha (cis) Chlordane	E	4.7	ug/kg	
SD19	2	Longfin sanddab	Liver	Aluminum		14.5	mg/kg	0.583
SD19	2	Longfin sanddab	Liver	Arsenic		5.36	mg/kg	0.375
SD19	2	Longfin sanddab	Liver	Barium		0.365	mg/kg	0.007
SD19	2	Longfin sanddab	Liver	Beryllium		0.006	mg/kg	0.003
SD19	2	Longfin sanddab	Liver	Cadmium		1.11	mg/kg	0.029
SD19	2	Longfin sanddab	Liver	Chromium		0.417	mg/kg	0.08
SD19	2	Longfin sanddab	Liver	Copper		6.52	mg/kg	0.068
SD19	2	Longfin sanddab	Liver	Hexachlorobenzene	E	5.7	ug/kg	
SD19	2	Longfin sanddab	Liver	Iron		50.1	mg/kg	0.096
SD19	2	Longfin sanddab	Liver	Lipids		49.9	%wt	0.005
SD19	2	Longfin sanddab	Liver	Manganese		0.713	mg/kg	0.007
SD19	2	Longfin sanddab	Liver	Mercury		0.124	mg/kg	0.03
SD19	2	Longfin sanddab	Liver	Nickel		0.249	mg/kg	0.094
SD19	2	Longfin sanddab	Liver	o,p-DDE		69	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	o,p-DDT	E	3.4	ug/kg	
SD19	2	Longfin sanddab	Liver	p,p-DDD		18	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	p,p-DDE		2800	ug/kg	13.3

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD19	2	Longfin sanddab	Liver	p,p-DDT		30	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 101	E	7.4	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 105	E	11	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 110	E	7.4	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 118		36	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 123	E	3.1	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 128	E	12	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 138		57	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 149	E	8.2	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 151	E	7.4	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 153/168		97	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 156	E	4.1	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 158	E	4.3	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 167	E	2.6	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 170		15	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 177	E	7	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 180		37	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 183	E	11	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 187		40	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 194	E	8.5	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 201	E	13	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 206	E	4.7	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 28	E	1.6	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 66	E	4	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 74	E	3.1	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 99		18	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	Selenium		0.926	mg/kg	0.06
SD19	2	Longfin sanddab	Liver	Silver		0.164	mg/kg	0.057
SD19	2	Longfin sanddab	Liver	Tin		1.77	mg/kg	0.24
SD19	2	Longfin sanddab	Liver	Total Solids		61.5	%wt	0.4
SD19	2	Longfin sanddab	Liver	Trans Nonachlor	E	6.3	ug/kg	
SD19	2	Longfin sanddab	Liver	Zinc		22.6	mg/kg	0.049
SD19	3	Hornyhead turbot	Liver	Aluminum		6.47	mg/kg	0.583
SD19	3	Hornyhead turbot	Liver	Arsenic		2.56	mg/kg	0.375
SD19	3	Hornyhead turbot	Liver	Barium		0.081	mg/kg	0.007
SD19	3	Hornyhead turbot	Liver	Beryllium		0.003	mg/kg	0.003
SD19	3	Hornyhead turbot	Liver	Cadmium		3.71	mg/kg	0.029
SD19	3	Hornyhead turbot	Liver	Chromium		0.288	mg/kg	0.08
SD19	3	Hornyhead turbot	Liver	Copper		4.74	mg/kg	0.068
SD19	3	Hornyhead turbot	Liver	Iron		19.4	mg/kg	0.096
SD19	3	Hornyhead turbot	Liver	Lipids		11.9	%wt	0.005
SD19	3	Hornyhead turbot	Liver	Manganese		1.11	mg/kg	0.007
SD19	3	Hornyhead turbot	Liver	Mercury		0.085	mg/kg	0.03
SD19	3	Hornyhead turbot	Liver	Nickel		0.211	mg/kg	0.094
SD19	3	Hornyhead turbot	Liver	p,p-DDD	E	1.7	ug/kg	
SD19	3	Hornyhead turbot	Liver	p,p-DDE		88	ug/kg	13.3
SD19	3	Hornyhead turbot	Liver	PCB 101	E	1.7	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 118	E	2.2	ug/kg	

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD19	3	Hornyhead turbot	Liver	PCB 153/168	E	7.6	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 180	E	3.4	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 187	E	5.1	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 99	E	1.6	ug/kg	
SD19	3	Hornyhead turbot	Liver	Selenium		0.596	mg/kg	0.06
SD19	3	Hornyhead turbot	Liver	Silver		0.212	mg/kg	0.057
SD19	3	Hornyhead turbot	Liver	Tin		1.02	mg/kg	0.24
SD19	3	Hornyhead turbot	Liver	Total Solids		35.5	%wt	0.4
SD19	3	Hornyhead turbot	Liver	Zinc		68.2	mg/kg	0.049
SD20	1	Longfin sanddab	Liver	Aluminum		8.94	mg/kg	0.583
SD20	1	Longfin sanddab	Liver	Arsenic		4.16	mg/kg	0.375
SD20	1	Longfin sanddab	Liver	Barium		0.13	mg/kg	0.007
SD20	1	Longfin sanddab	Liver	Beryllium		0.004	mg/kg	0.003
SD20	1	Longfin sanddab	Liver	Cadmium		2.85	mg/kg	0.029
SD20	1	Longfin sanddab	Liver	Chromium		0.283	mg/kg	0.08
SD20	1	Longfin sanddab	Liver	Copper		7.34	mg/kg	0.068
SD20	1	Longfin sanddab	Liver	Hexachlorobenzene	E	3.9	ug/kg	
SD20	1	Longfin sanddab	Liver	Iron		86.3	mg/kg	0.096
SD20	1	Longfin sanddab	Liver	Lipids		38.5	%wt	0.005
SD20	1	Longfin sanddab	Liver	Manganese		0.786	mg/kg	0.007
SD20	1	Longfin sanddab	Liver	Mercury		0.056	mg/kg	0.03
SD20	1	Longfin sanddab	Liver	Nickel		0.171	mg/kg	0.094
SD20	1	Longfin sanddab	Liver	o,p-DDE	E	7.1	ug/kg	
SD20	1	Longfin sanddab	Liver	o,p-DDT	E	2.6	ug/kg	
SD20	1	Longfin sanddab	Liver	p,p-DDD	E	10	ug/kg	
SD20	1	Longfin sanddab	Liver	p,p-DDE		500	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	p,p-DDT	E	12	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 101	E	5.7	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 105	E	5.3	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 118		21	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 128	E	8.2	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 138		41	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 149	E	8.9	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 151	E	6	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 153/168		72	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 156	E	2	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 167	E	1.5	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 170	E	11	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 177	E	4.5	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 180		26	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 183	E	8.7	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 187		37	ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 201	E	8	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 66	E	2.7	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 99	E	12	ug/kg	
SD20	1	Longfin sanddab	Liver	Selenium		0.761	mg/kg	0.06
SD20	1	Longfin sanddab	Liver	Silver		0.181	mg/kg	0.057
SD20	1	Longfin sanddab	Liver	Tin		1.45	mg/kg	0.24

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD20	1	Longfin sanddab	Liver	Total Solids		54.8	%wt	0.4
SD20	1	Longfin sanddab	Liver	Zinc		22.2	mg/kg	0.049
SD20	2	Hornyhead turbot	Liver	Aluminum		6.57	mg/kg	0.583
SD20	2	Hornyhead turbot	Liver	Arsenic		2.37	mg/kg	0.375
SD20	2	Hornyhead turbot	Liver	Barium		0.058	mg/kg	0.007
SD20	2	Hornyhead turbot	Liver	Cadmium		6.02	mg/kg	0.029
SD20	2	Hornyhead turbot	Liver	Chromium		0.247	mg/kg	0.08
SD20	2	Hornyhead turbot	Liver	Copper		4.51	mg/kg	0.068
SD20	2	Hornyhead turbot	Liver	Iron		43.1	mg/kg	0.096
SD20	2	Hornyhead turbot	Liver	Lipids		11.1	%wt	0.005
SD20	2	Hornyhead turbot	Liver	Manganese		1.18	mg/kg	0.007
SD20	2	Hornyhead turbot	Liver	Mercury		0.173	mg/kg	0.03
SD20	2	Hornyhead turbot	Liver	Nickel		0.108	mg/kg	0.094
SD20	2	Hornyhead turbot	Liver	p,p-DDD	E	2.2	ug/kg	
SD20	2	Hornyhead turbot	Liver	p,p-DDE		95	ug/kg	13.3
SD20	2	Hornyhead turbot	Liver	PCB 101	E	2.5	ug/kg	
SD20	2	Hornyhead turbot	Liver	PCB 118	E	3.2	ug/kg	
SD20	2	Hornyhead turbot	Liver	PCB 138	E	5.6	ug/kg	
SD20	2	Hornyhead turbot	Liver	PCB 153/168	E	9.1	ug/kg	
SD20	2	Hornyhead turbot	Liver	PCB 180	E	3.7	ug/kg	
SD20	2	Hornyhead turbot	Liver	PCB 187	E	6.1	ug/kg	
SD20	2	Hornyhead turbot	Liver	PCB 99	E	1.1	ug/kg	
SD20	2	Hornyhead turbot	Liver	Selenium		0.796	mg/kg	0.06
SD20	2	Hornyhead turbot	Liver	Silver		0.135	mg/kg	0.057
SD20	2	Hornyhead turbot	Liver	Tin		0.686	mg/kg	0.24
SD20	2	Hornyhead turbot	Liver	Total Solids		27.2	%wt	0.4
SD20	2	Hornyhead turbot	Liver	Zinc		48.2	mg/kg	0.049
SD20	3	Hornyhead turbot	Liver	Aluminum		4.83	mg/kg	0.583
SD20	3	Hornyhead turbot	Liver	Arsenic		1.56	mg/kg	0.375
SD20	3	Hornyhead turbot	Liver	Barium		0.077	mg/kg	0.007
SD20	3	Hornyhead turbot	Liver	Cadmium		4.82	mg/kg	0.029
SD20	3	Hornyhead turbot	Liver	Chromium		0.243	mg/kg	0.08
SD20	3	Hornyhead turbot	Liver	Copper		4.35	mg/kg	0.068
SD20	3	Hornyhead turbot	Liver	Iron		28.3	mg/kg	0.096
SD20	3	Hornyhead turbot	Liver	Lipids		10.6	%wt	0.005
SD20	3	Hornyhead turbot	Liver	Manganese		0.998	mg/kg	0.007
SD20	3	Hornyhead turbot	Liver	Mercury		0.09	mg/kg	0.03
SD20	3	Hornyhead turbot	Liver	Nickel		0.2	mg/kg	0.094
SD20	3	Hornyhead turbot	Liver	p,p-DDD	E	2.9	ug/kg	
SD20	3	Hornyhead turbot	Liver	p,p-DDE		110	ug/kg	13.3
SD20	3	Hornyhead turbot	Liver	PCB 101	E	1.1	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 118	E	3.2	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 138	E	5.9	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 153/168	E	9.9	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 180	E	3.9	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 187	E	6.1	ug/kg	
SD20	3	Hornyhead turbot	Liver	PCB 99	E	1.9	ug/kg	
SD20	3	Hornyhead turbot	Liver	Selenium		0.685	mg/kg	0.06

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD20	3	Hornyhead turbot	Liver	Silver		0.152	mg/kg	0.057
SD20	3	Hornyhead turbot	Liver	Tin		0.889	mg/kg	0.24
SD20	3	Hornyhead turbot	Liver	Total Solids		29.1	%wt	0.4
SD20	3	Hornyhead turbot	Liver	Zinc		51.7	mg/kg	0.049
SD21	1	Ca. scorpionfish	Liver	Aluminum		10	mg/kg	0.583
SD21	1	Ca. scorpionfish	Liver	Arsenic		1.11	mg/kg	0.375
SD21	1	Ca. scorpionfish	Liver	Barium		0.139	mg/kg	0.007
SD21	1	Ca. scorpionfish	Liver	Beryllium		0.004	mg/kg	0.003
SD21	1	Ca. scorpionfish	Liver	Cadmium		1.42	mg/kg	0.029
SD21	1	Ca. scorpionfish	Liver	Chromium		0.307	mg/kg	0.08
SD21	1	Ca. scorpionfish	Liver	Copper		21.8	mg/kg	0.068
SD21	1	Ca. scorpionfish	Liver	Hexachlorobenzene	E	5.5	ug/kg	
SD21	1	Ca. scorpionfish	Liver	Iron		75.1	mg/kg	0.096
SD21	1	Ca. scorpionfish	Liver	Lipids		31.9	%wt	0.005
SD21	1	Ca. scorpionfish	Liver	Manganese		0.387	mg/kg	0.007
SD21	1	Ca. scorpionfish	Liver	Mercury		0.073	mg/kg	0.03
SD21	1	Ca. scorpionfish	Liver	Nickel		0.24	mg/kg	0.094
SD21	1	Ca. scorpionfish	Liver	o,p-DDE	E	10	ug/kg	
SD21	1	Ca. scorpionfish	Liver	p,p-DDD		18	ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	p,p-DDE		880	ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	p,p-DDT	E	4.6	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 101	E	12	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 105	E	8.1	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 110	E	11	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 118		27	ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 123	E	3.5	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 128	E	7.3	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 138		30	ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 149	E	9.2	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 151	E	4.5	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 153/168		58	ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 156	E	3.5	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 158	E	2.8	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 167	E	1.6	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 177	E	5.5	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 180		24	ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 183	E	6.4	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 187		24	ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 206	E	3.5	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 52	E	4.1	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 66	E	6.2	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 87	E	2.9	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 99	E	13	ug/kg	
SD21	1	Ca. scorpionfish	Liver	Selenium		0.66	mg/kg	0.06
SD21	1	Ca. scorpionfish	Liver	Silver		0.25	mg/kg	0.057
SD21	1	Ca. scorpionfish	Liver	Tin		1.5	mg/kg	0.24
SD21	1	Ca. scorpionfish	Liver	Total Solids		51.4	%wt	0.4
SD21	1	Ca. scorpionfish	Liver	Zinc		67.9	mg/kg	0.049

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD21	2	Ca. scorpionfish	Liver	Aluminum		8.4	mg/kg	0.583
SD21	2	Ca. scorpionfish	Liver	Arsenic		1.1	mg/kg	0.375
SD21	2	Ca. scorpionfish	Liver	Barium		0.114	mg/kg	0.007
SD21	2	Ca. scorpionfish	Liver	Beryllium		0.004	mg/kg	0.003
SD21	2	Ca. scorpionfish	Liver	Cadmium		0.803	mg/kg	0.029
SD21	2	Ca. scorpionfish	Liver	Chromium		0.272	mg/kg	0.08
SD21	2	Ca. scorpionfish	Liver	Copper		13.3	mg/kg	0.068
SD21	2	Ca. scorpionfish	Liver	Hexachlorobenzene	E	4.2	ug/kg	
SD21	2	Ca. scorpionfish	Liver	Iron		97.3	mg/kg	0.096
SD21	2	Ca. scorpionfish	Liver	Lipids		22	%wt	0.005
SD21	2	Ca. scorpionfish	Liver	Manganese		0.402	mg/kg	0.007
SD21	2	Ca. scorpionfish	Liver	Mercury		0.103	mg/kg	0.03
SD21	2	Ca. scorpionfish	Liver	Nickel		0.126	mg/kg	0.094
SD21	2	Ca. scorpionfish	Liver	o,p-DDE	E	13	ug/kg	
SD21	2	Ca. scorpionfish	Liver	p,p-DDD		23	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	p,p-DDE		1100	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	p,p-DDT	E	7.7	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 101		18	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 105	E	11	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 110		14	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 118		43	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 123	E	4.1	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 128	E	13	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 138		47	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 149	E	12	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 151	E	6.5	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 153/168		98	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 156	E	3.9	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 158	E	5.2	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 167	E	2.6	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 170		15	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 177	E	8.6	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 180		37	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 183	E	12	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 187		44	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 194	E	10	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 201	E	13	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 206	E	5	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 49	E	3.6	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 52	E	5.1	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 66	E	6.1	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 74	E	2.8	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 87	E	4.3	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 99		19	ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	Selenium		0.694	mg/kg	0.06
SD21	2	Ca. scorpionfish	Liver	Silver		0.247	mg/kg	0.057
SD21	2	Ca. scorpionfish	Liver	Tin		1.33	mg/kg	0.24
SD21	2	Ca. scorpionfish	Liver	Total Solids		44.5	%wt	0.4

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Station	Rep	Species	Tissue	Parameter		Value	Units	MDL
SD21	2	Ca. scorpionfish	Liver	Trans Nonachlor	E	11	ug/kg	
SD21	2	Ca. scorpionfish	Liver	Zinc		67.3	mg/kg	0.049
SD21	3	Ca. scorpionfish	Liver	Aluminum		9.7	mg/kg	0.583
SD21	3	Ca. scorpionfish	Liver	Arsenic		1.21	mg/kg	0.375
SD21	3	Ca. scorpionfish	Liver	Barium		0.114	mg/kg	0.007
SD21	3	Ca. scorpionfish	Liver	Beryllium		0.005	mg/kg	0.003
SD21	3	Ca. scorpionfish	Liver	Cadmium		1.12	mg/kg	0.029
SD21	3	Ca. scorpionfish	Liver	Chromium		0.284	mg/kg	0.08
SD21	3	Ca. scorpionfish	Liver	Copper		13.8	mg/kg	0.068
SD21	3	Ca. scorpionfish	Liver	Hexachlorobenzene	E	2.2	ug/kg	
SD21	3	Ca. scorpionfish	Liver	Iron		102	mg/kg	0.096
SD21	3	Ca. scorpionfish	Liver	Lipids		20.7	%wt	0.005
SD21	3	Ca. scorpionfish	Liver	Manganese		0.414	mg/kg	0.007
SD21	3	Ca. scorpionfish	Liver	Mercury		0.099	mg/kg	0.03
SD21	3	Ca. scorpionfish	Liver	Nickel		0.181	mg/kg	0.094
SD21	3	Ca. scorpionfish	Liver	o,p-DDT	E	9.05	ug/kg	
SD21	3	Ca. scorpionfish	Liver	p,p-DDD		33	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	p,p-DDE		555	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	p,p-DDT		24	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 101	E	9.85	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 105	E	6.55	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 110	E	9.55	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 118		26	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 128	E	8.1	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 138		30	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 149	E	5.65	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 151	E	5.4	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 153/168		63	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 156	E	3.35	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 158	E	2.45	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 170	E	8.45	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 177	E	4.9	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 180		24	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 183	E	6.85	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 187		25	ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 201	E	6.8	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 66	E	2.95	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 99	E	11	ug/kg	
SD21	3	Ca. scorpionfish	Liver	Selenium		0.73	mg/kg	0.06
SD21	3	Ca. scorpionfish	Liver	Silver		0.149	mg/kg	0.057
SD21	3	Ca. scorpionfish	Liver	Tin		1.39	mg/kg	0.24
SD21	3	Ca. scorpionfish	Liver	Total Solids		50	%wt	0.4
SD21	3	Ca. scorpionfish	Liver	Zinc		65.3	mg/kg	0.049