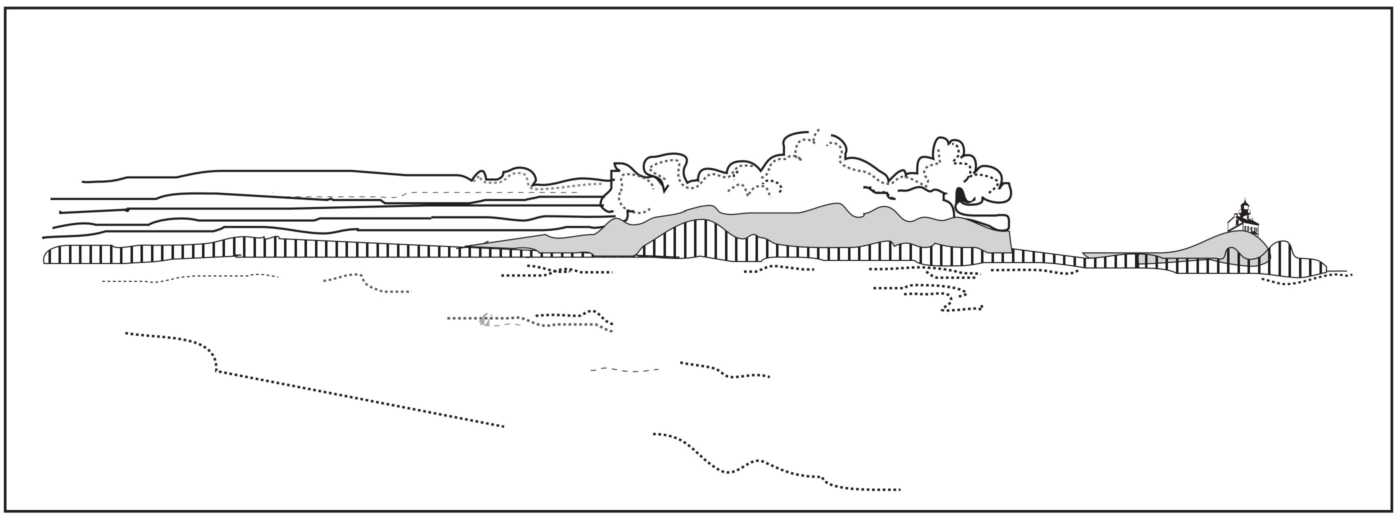
International Boundary and Water Commission

Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (2001)



Prepared by:

City of San Diego
Ocean Monitoring Program
Metropolitan Wastewater Department
Environmental Monitoring and Technical Services Division

June 2002

International Boundary and Water Commission

Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall

(2001)

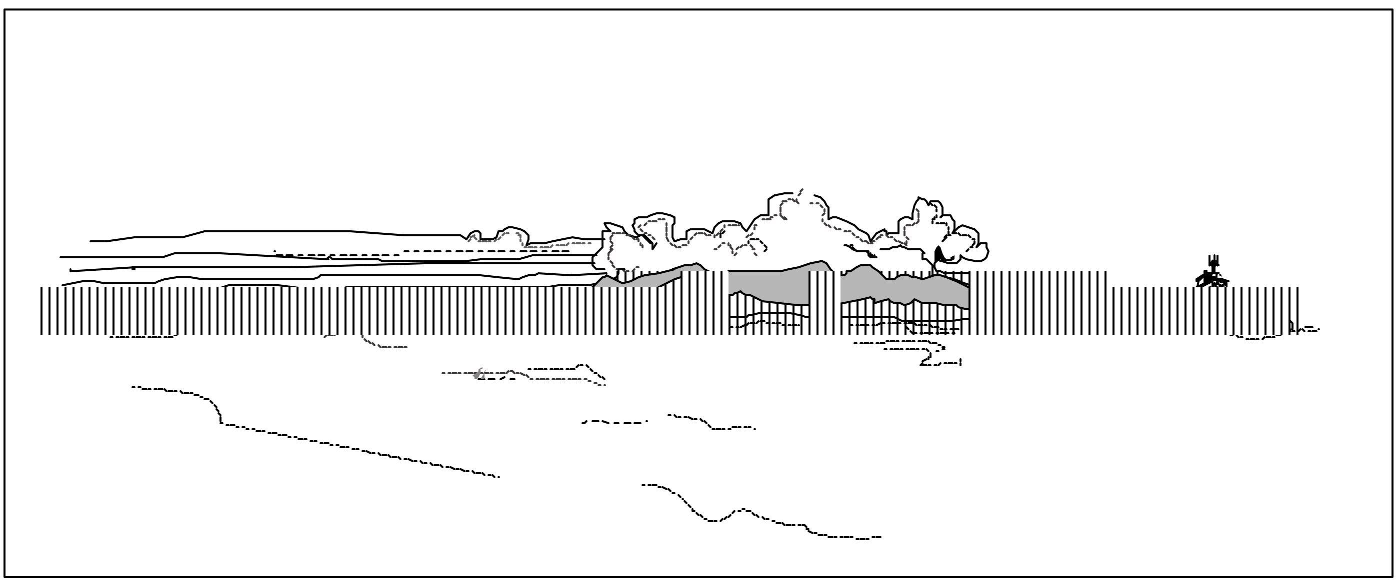


Table of Contents

Credits and Acknowledgments

Technical Editor
Dean Pasko

Production Editor
John Byrne

Graphics
John Byrne Diane O'Donohue Judes Brooks

Executive Summary
Dean Pasko

Chapter 1. General Introduction
Dean Pasko

Chapter 2. Water Quality
Diane O'Donohue

Chapter 3. Sediment Characteristics
Daniel Ituarte

Chapter 4. Benthic Infauna
Eric Nestler John Byrne

Chapter 5. Demersal Fishes & Megabenthic Invertebrates
Ami Groce Robin Gartman

Chapter 6. Bioaccumulation of Contaminants in Fish Tissues
Ami Groce

Acknowledgments: We are grateful to the personnel of the City's Marine Biology Laboratory for their assistance in the collection and processing of all samples and for discussions of the results. The completion of this report would not have been possible without their continued efforts and contributions. We would also like to acknowledge the City's Microbiology and Chemistry laboratories for providing the bacteriological and chemistry data analyzed herein. Reviews of the various chapters were provided by R. Duggan, A. Feit, R. Gartman, A. Groce, D. Ituarte, D. James, M. Lilly, E. Nester, D. Pasko, T. Stebbins, and R. Velarde.

CITY OF SAN DIEGO OCEAN MONITORING PROGRAM

Alan C. Langworthy
Deputy Metropolitan Wastewater Director
Environmental Monitoring and Technical Services Division

Marine Biology & Ocean Operations

Timothy Stebbins
Senior Marine Biologist

Kelvin Barwick
John Byrne
Robin Gartman
Daniel Ituarte
Kathy Langan-Cranford
Ricardo Martinez-Lara
Diane O'Donohue
Rick Rowe
Wendy Storms

Calvin Baugh
Ross Duggan
Ami Groce
David James
Megan Lilly
Ronda Nesby
Dawn Olson
Jack Russell
Lan Wiborg

Judes Brooks
Adriano Feit
David Gutoff
Michael Kelly
Richard Mange
Eric Nestler
Dean Pasko
Ron Velarde

Marine Microbiology / Vector Management

Ric Amador
Senior Biologist

Arnold Adamos
Roxanne Davis
Sonji Romero

George Alphonso
Andre Macedo
David Straup

Toby Brown
Laila Othman
Zakee Shabazz

Executive Summary

Compliance monitoring for the South Bay Ocean Outfall (SBOO) is performed by the City of San Diego in accordance with a Memorandum of Understanding between the City and the United States International Boundary and Water Commission (IBWC). The study area extends from the tip of Point Loma southward to Punta Bandera, Baja California, Mexico, and from the shoreline seaward to a depth of about 200 ft. Prior to the initiation of discharge on 13 January 1999, the City also conducted a 3½ year baseline monitoring program that was designed to characterize background environmental conditions surrounding the outfall and provide information against which post-discharge data may be compared. The City has also conducted regionwide surveys off the San Diego coast during the summers of 1994 through 2001. Such regional monitoring helps to evaluate patterns and trends over a larger geographic area, thus providing additional information that may help to identify and distinguish reference areas from sites impacted by wastewater and stormwater discharge.

The present report focuses on the SBOO monitoring results and conclusions from January through December 2001 and also discusses general differences with previous years. Sampling included monthly seawater measurements of physical, chemical and bacteriological parameters in order to document water quality conditions in the region. Sediment samples were collected semiannually to monitor changes in sediment quality and benthic infaunal community structure. Trawl surveys were performed quarterly to characterize communities of bottom-dwelling fish and large invertebrates in the region (i.e., demersal fishes and megabenthic invertebrates). Chemical analyses of selected fish tissues were also performed in order to quantify and document contaminant levels that may have ecological or human health implications. Finally, results of the July 2001 random sample survey of regional benthic sediment and infauna conditions are included in Appendices D and E, respectively.

WATER QUALITY

Water quality conditions in the vicinity of the South Bay Ocean Outfall are influenced by both natural and anthropogenic factors. During 2001, changes in most of the physical and chemical water quality parameters coincided with seasonal patterns in oceanographic conditions. For example, winter storms at the beginning of the year resulted in a water column that was well-mixed with very little thermal stratification. This period was followed by an increase in stratification from the spring through early fall. The lowest water temperatures occurred from April to June, particularly at deeper depths. This cool water mass was characterized by relatively high salinity and slightly reduced dissolved oxygen and pH and was accompanied by coastal upwelling. An expansive red tide followed in July. Stratification broke down by the end of the year, leaving an almost homogenous water column throughout the region.

Storm activity, land and riverine runoff, wastewater discharge, and other anthropogenic inputs were the likely factors influencing densities of coliform bacteria in the region. For example, shoreline and nearshore waters in the area were characterized by low transmissivity and high concentrations of bacteria during the first few months of the year when storm activity was prevalent. This was most evident near the Tijuana River and at the southernmost U.S. shore stations. Stormwater inputs and Mexican sewage spills in January and April contributed to the contamination in the river at these times. Additionally, wastewater discharge from the sewage treatment plant located near Canyon San Antonio de los Buenos in Mexico likely impacted the southernmost monitoring stations at various times. Coliform densities along the shore were lower during the summer months than during the rest of the year. These patterns were similar to those seen prior to discharge and during the first two years of compliance monitoring.

The wastewater plume from the South Bay outfall generally remained offshore and beneath the surface layers, limited by stratification of the water column throughout most of the year. In contrast, the absence of a stratified water column in March and December allowed the plume to surface near the point of discharge; however the monitoring data did not indicate that the waste field moved onshore.

The numerous anthropogenic inputs in the South Bay area make it difficult to distinguish effects associated with the outfall from those caused by other sources. Shoreline sources clearly radiate into nearshore waters and tend to impact surface conditions. In contrast, discharge from the outfall usually remains offshore and near the bottom. However, plumes from the various sources may merge under certain oceanographic conditions (e.g., winter storms coincident with an unstratified water column), creating a less definitive picture of cause and effect.

SEDIMENT QUALITY

The physical structure and overall quality of bottom sediments near the South Bay Ocean Outfall were similar in 2001 to those observed during previous years, with the sediments at most sites being composed of primarily fine sands. Although there were differences in particle size composition between surveys also occurred at some sites, this may be partly attributed to patches of sediments associated with multiple geologic origins (e.g., relict red sands, other detrital material). In general, sediment grain size increased with depth. Sediments were coarsest at sites along the 120 and 180-ft depth contours where large deposits of Pleistocene sediments occur. Finer materials, present in shallower water, were probably due to sediment deposition from the Tijuana River or, to a lesser extent, San Diego Bay.

Little evidence of anthropogenic influence was observed in terms of organic enrichment or the various sediment chemistry parameters. Concentrations of organic indicators and trace metals were generally low in SBOO sediments compared to other coastal areas off southern California. Similar to many other studies, the highest organic indicator and metal concentrations were associated with finer sediments. Two derivatives of the chlorinated pesticide DDT (p,p-DDE and p,p-DDT) were detected in only three of the SBOO sediment samples collected in 2001, all during the July survey. The p,p-DDE derivative was detected at station I-29 and p,p-DDT was detected at stations I-35 and I-14. This study found no evidence that the occurrence of these pesticides is related to input from the SBOO. Stations I-29 and I-35 are located at least 7.3 km north of the outfall, while station I-14 is located near the end of the northern diffuser leg, a section of the outfall that receives no discharge (see Chapter 1). Furthermore, these pesticides were already known to occur at these sites prior to construction of the outfall (see

City of San Diego 1999). Polychlorinated biphenyls (PCBs) were detected rarely in sediment samples, while polycylic aromatic hydrocarbons (PAHs) went undetected. Two PCB congeners (PCB 138 and PCB 153/68) were detected off shore of the outfall pipe at station I-13, however, these measurements were well below the MDLs and are considered unreliable.

BENTHIC COMMUNITIES

Benthic communities in the SBOO region consist of infaunal assemblages that vary according to differences in sediment structure (e.g., grain size) and depth (e.g., shallow vs. mid-depth waters). The sandy sediments at most sites in 2001 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. This assemblage was dominated by the polychaetes *Chloeia pinnata* and *Pista* sp B, and the ophiuroid *Amphiodia urtica*, 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 distribution and abundance varied with depth and sediment type in the region. However, there were no clear patterns with respect to the South Bay outfall. The range of values for most parameters in 2001 was similar to that seen in previous years. In addition, values for community parameters such as the infaunal trophic index (ITI) remained characteristic of undisturbed sediments, ranging from 68 to 95 over all sites. Finally, changes in benthic community structure near the SBOO are similar in magnitude to those that have occurred elsewhere in southern California. Such changes often correspond to large-scale oceanographic events or other natural events. Overall, benthic assemblages in the region are still similar to those observed prior to discharge and to natural indigenous communities characteristic of similar habitats on the southern California continental shelf. Consequently, there is no observed evidence from the present monitoring efforts that wastewater discharge has resulted in any degradation of the benthos in the area.

DEMERSAL FISH & MEGABENTHIC INVERTEBRATE COMMUNITIES

Speckled sanddabs dominated fish assemblages surrounding the South Bay Ocean Outfall in 2001, except in January when white croaker and the northern anchovy were collected in very high numbers. The overall dominance of speckled sanddabs was similar to that seen in previous years; these fish occurred at all stations and accounted for 36% of the total catch. 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 hornyhead turbot, California lizardfish, longfin sanddab, spotted turbot, California halibut and California scorpionfish. Most of these common fishes were relatively small, averaging less than 20 cm in length. Larger species included California halibut, specklefin midshipman, diamond turbot, California skate and round stingray. With the exception of California halibut, these fishes were collected infrequently.

As in previous years, fish assemblage structure varied among stations. Differences in the total fish catch per trawl reflected fluctuations in the abundance of several of the more common species (e.g., white croaker, speckled and longfin sanddab). The high abundance and biomass at some sites reflected the occasional capture of large populations of species such as white croaker and northern anchovy. Although megabenthic community structure also varied between sites, these assemblages were generally characterized by low values for species richness, abundance, biomass and diversity.

Overall, no evidence has been observed that the discharge of waste water has affected either the fish or megabenthic invertebrate communities in the SBOO region. Despite variability in both communities, patterns of abundance, biomass and number of species were similar at stations near the outfall and further away. In addition, no changes in these communities were found near the outfall that correspond to the initiation of the discharge. The absences of fin rot or any other physical abnormalities on local fishes suggest that populations in the area continue to be healthy.

TISSUE CONTAMINANTS IN FISHES

There were no clear spatial patterns between the SBOO trawl stations in terms of fish tissue contaminants in 2001. On the other hand, while DDT and PCBs were detected in rig fishing samples from both outfall and reference stations, concentrations were higher at the outfall station (RF3). Tin, HCB, and trans Nonachlor were also reported in muscle samples from RF3 only. Caution should be exercised in the interpretation of these data, however, because California scorpionfish are known to move between large geographical areas (Hartmann 1987, Love et al. 1987), so that the origin of any contamination is uncertain. Although contaminants were present in liver and muscle tissue samples, concentrations were generally within the range of values reported previously for other fish assemblages in the Southern California Bight. In addition, concentrations of most contaminants were not substantially different from those reported in the area prior to discharge.

The frequent occurrence of both metals and chlorinated hydrocarbons in SBOO fish tissues 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 in a highly contaminated area and then move into one 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.

Similar to the results described for the demersal fish community, no evidence has been observed based on the bioaccumulation data that fish collected during 2001 were affected by the discharge of waste water from the South Bay Ocean Outfall. Muscle samples from sport fish in the area were found to be within FDA human consumption limits for both mercury and DDT.

Chapter 1

General Introduction

Treated effluent from the International Wastewater Treatment Plant is discharged into the ocean via the South Bay Ocean Outfall (SBOO) 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. The NPDES permit defines the requirements for monitoring receiving waters around the SBOO, including the sampling plan, compliance criteria, laboratory analyses, statistical analyses and reporting guidelines. These receiving waters requirements went into effect upon initiation of discharge on January 13, 1999.

Compliance monitoring for the SBOO is performed by the City of San Diego in accordance with a Memorandum of Understanding between the City and the United States International Boundary and Water Commission (IBWC). Prior to discharge, the City also conducted a 3½ year baseline monitoring program in order to characterize background environmental conditions surrounding the SBOO (City of San Diego 2000a). The results of this baseline study provide background information against which the compliance data may be compared. In addition, the City has conducted annual region-wide surveys off the San Diego coast since 1994 (e.g., 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 and storm water discharge.

This report presents the results of the third year of post-discharge monitoring at fixed sites around the SBOO from January through December 2001. 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). Each major component of the monitoring program is covered in a separate chapter: (1) Water Quality; (2) Sediment Characteristics; (3) Benthic Infauna; (4) Demersal Fishes and Megabenthic Invertebrates; (5) Bioaccumulation of Contaminants in Fish Tissues. In addition, the results of the July 2001 random sample survey of benthic sediments and organisms for the San Diego region are included in Appendices D and E, respectively. 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 2002). 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 (90 ft). Unlike other southern California discharge pipes 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 treated effluent to a pipeline buried just beneath the surface of the seabed. This seabed pipeline splits into a Y-shaped multiport diffuser system, with the two diffuser legs extending and 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 outfall diffuser wye and 82 others spaced along each of the outfall legs. However, low flow during the first three 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 were necessary to maintain sufficient back pressure within the drop shaft so that the outfall could operate in accordance with the theoretical model. Consequently, discharge during 2001 and previous years was generally limited to the distal end of the south outfall leg, with the exception of a few intermediate points at or near the diffuser wye.

The SBOO sampling area extends from the tip of Point Loma southward to Punta Bandera, Baja California, Mexico, and from the shoreline seaward to a depth of about 61 m (200 ft). The offshore monitoring sites are arranged in a grid spanning the terminus of the outfall, and are monitored in accordance with a prescribed sampling schedule. 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 infaunal communities and sediment conditions. Trawl surveys are performed quarterly to describe communities of demersal fish and large, bottom-dwelling invertebrates in the region. Additionally, analyses of fish tissues are performed semiannually to document levels of chemical constituents that may have ecological or human health implications.

RANDOM SAMPLE REGIONAL SURVEYS

The City of San Diego has conducted regional benthic monitoring surveys off the San Diego coast since 1994. During the summers of 1994 and 1998, the City participated with other major municipal wastewater dischargers in large-scale surveys of the entire Southern California Bight, the Southern California Bight 1994 Pilot Project (SCBPP) and the 1998 Southern California Bight Monitoring Survey (Bight'98). Results of the SCBPP benthic survey are available in Bergen et al. (1998, 2001), while those for the Bight'98 project have not yet been completed (see Bight’98 Steering Committee 1998). Subsequent to the SCBPP, the City of San Diego continued to conduct similar but less extensive surveys of the San Diego region as part of monitoring efforts for the South Bay Ocean Outfall.

The 2001 survey of randomly selected sites off San Diego covered an area from Solana Beach south to the United States/Mexico border and extending offshore to depths up to about 201 m (660 ft). All sampling was conducted during the month of July**.** This survey, along with previous regional surveys, used the USEPA probability-based EMAP sampling design in which a hexagonal grid was randomly placed over a map of the region. One sample site was then randomly selected from within each grid cell. This randomization helps to ensure an unbiased estimate of ecological condition (SCBPP 1994), and serves as an alternative to the fixed site design that is widely used in other compliance monitoring programs. Although 40 sites were initially selected for the 2001 survey, only 38 were successfully sampled for benthic infauna and sediments. Sampling at two sites was unsuccessful due to the presence of incompatible substrates (i.e., rocky reefs), which made it impossible to collect samples.

LITERATURE CITED

Bergen, M., S.B. Weisberg, D. Cadien, A. Dalkey, D. Montagne, R.W. Smith, J.K. Stull, and R.G. Velarde. (1998). Southern California Bight 1994 Pilot Project: IV. Benthic Infauna. Southern California Coastal Water Research Project, Westminster, CA.

Bergen, M., S.B. Weisberg, R.W. Smith, D.B. Cadien, A. Dalkey, D.E. Montagne, J.K. Stull, R.G. Velarde, and J.A. Ranasinghe. (2001). Relationship between depth, sediment, latitude, and the structure of benthic infaunal assemblages on the mainland shelf of southern California. Mar. Biol., 138: 637-647

Bight'98 Steering Committee. (1998). Southern California Bight 1998 Regional Marine Monitoring Survey (Bight'98) Coastal Ecology Workplan. Prepared for Southern California Coastal Water Research Project, Westminster, CA., accessible via Southern California Coastal Water Research Project homepage on the WWW (ftp://ftp.sccwrp.org/pub/download/PDFs/bight98cewkpln.pdf)

City of San Diego. (1999). San Diego Regional Monitoring Report for 1994 - 1997. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

City of San Diego. (2000a). International Wastewater Treatment Plant Final Baseline Ocean Monitoring Report for the South Bay Ocean Outfall (1995-1998). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

City of San Diego. (2000b). Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (1999). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

City of San Diego. (2001). Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (2000). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division, San Diego, CA.

City of San Diego. (2002). 2001 Quality Assurance Manual. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division. San Diego, CA.

SCBPP (Southern California Bight Pilot Project). (1994). Workplan for the Southern California Bight Pilot Project. Southern California Coastal Water Research Project, Westminster, CA.

Chapter 2

Water Quality

INTRODUCTION

The City of San Diego was contracted by the International Boundary and Water Commission to monitor various water quality parameters around the South Bay Ocean Outfall (SBOO) as required by the NPDES permit for the International Wastewater Treatment Plant (see Chapter 1). This monitoring includes sampling along the shoreline and in adjacent offshore waters to track the movement and dispersion of waste water discharged through the outfall, detect the presence of bacterial indicators of fecal contamination in the area, and monitor the physical/chemical parameters that may be affected by the discharge. Additionally, changes in bacterial concentrations, salinity, density, water temperature and transmissivity (water clarity) may help identify the effects of existing point and non-point sources in the area. Concentrations of coliform bacteria present at different depths and locations can provide valuable information on the dispersion and movement of the wastewater field (Pickard and Emery 1990). Monitoring changes in physical parameters may yield information on oceanographic conditions such as water column stratification, upwelling, plankton blooms, El Niño and La Niña events.

This chapter presents summaries, statistical analyses and discussions of water quality monitoring data collected during 2001 in the vicinity of the SBOO. The program consists of monitoring conditions at fixed stations along the shore, in the kelp beds and offshore waters. Raw data are compiled in monthly monitoring reports that are submitted to the Regional Water Quality Control Board.

MATERIALS & METHODS

Field Sampling

Water quality samples were collected at a total of 51 stations ranging from the shoreline to approximately 5 km offshore and encompassing an area of approximately 480 km^2 (Figure 2.1).

Eleven shore stations were located along the shore from Punta Bandera, Mexico to Coronado, USA. These stations include eight that were originally selected to match existing sampling sites used by monitoring agencies in Mexico and the United States (stations S1-S6, S8, S9) . Three other shore stations (S10 - S12) were added in October 1996 to further characterize the area near the Tijuana River. Seawater samples were collected weekly from the surf zone in sterile 250 mL bottles to monitor bacteria levels in near shore waters. The samples were transported on ice to the laboratory for bacterial analyses (i.e, total and fecal coliforms and enterococci). Visual observations of weather conditions, human and animal activity and materials of sewage origin are recorded at each station.

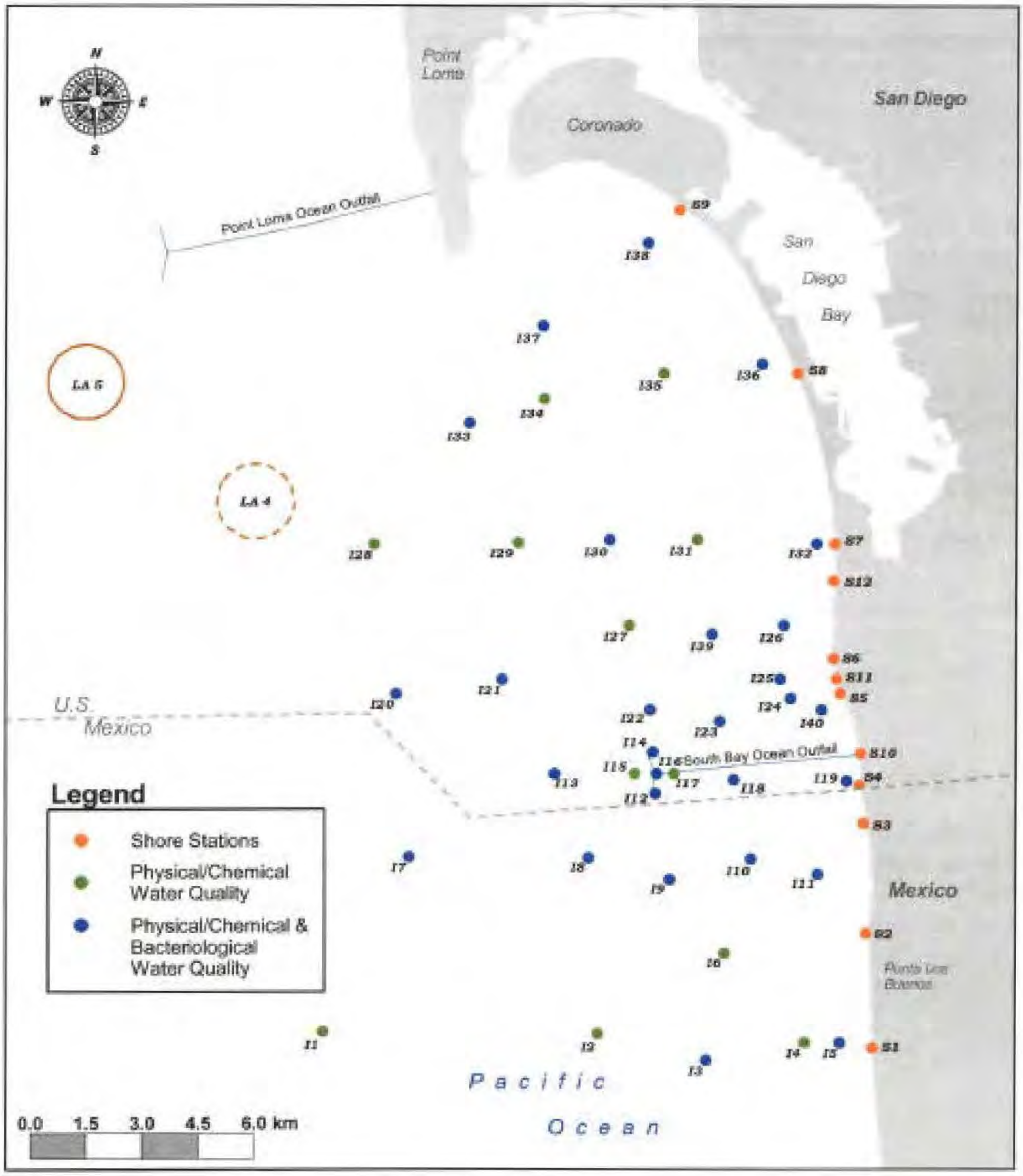


Figure 2.1

Water quality station locations, South Bay Ocean Outfall Monitoring Program.

The 40 offshore stations (I-1 through I-40) are arranged in a grid surrounding the discharge site, and are generally located along the 30, 60, 90, 120, and 180-ft depth contours. Three of these sites are subject to water contact standards set forth in the California Ocean Plan because of their proximity to suitable substrates for the Imperial Beach kelp bed. These stations include I-25, I-26 and I-39, and are subsequently referred to as kelp bed sites. However, this kelp bed has been historically transient and inconsistent in terms of size and density. Thus, these three stations are only occasionally located within an area where kelp is actually found.

Water quality monitoring was performed monthly at all of the offshore stations, usually within three days. The three kelp bed sites were sampled an additional four times each month in order to meet the sampling frequency requirements for assessing compliance with state water contact standards. A Sea-Bird conductivity, temperature and depth instrument (CTD) was used to obtain water column profiles for a suite of physical and chemical parameters at all sites. The CTD instrumentation is fully described in the City's Quality Assurance Manual (City of San Diego 2002). Water column profiles of temperature, salinity, density, dissolved oxygen, pH, chlorophyll *a* and transmissivity were taken at each station. Visual observations of weather and water conditions were also recorded at these stations. In addition, water samples were collected from three discrete depths at 28 of the stations for analysis of bacteria (total coliforms, fecal coliforms, enterococci), suspended solids, and oil and grease concentrations (see Figure 2.1). Water samples were collected using either a series of Van Dorn bottles or a rosette sampler fitted with Niskin bottles. Aliquots for each parameter were drawn into appropriate sample containers. The bacterial samples were returned to the City's Marine Microbiology Laboratory for processing, while the samples for oil and grease, and suspended solids were returned to the City's Wastewater Chemistry Laboratory for analysis. Sampling during the four additional visits to the kelp bed sites included collection of water samples for bacterial analysis and CTD profiles of temperature and transmissivity only.

Laboratory Analyses

All bacteriological analyses were run within six hours of sample collection and conformed to the membrane filtration techniques outlined in the City's Quality Assurance Manual (City of San Diego 2002). The Marine Microbiology Laboratory follows guidelines issued by the EPA Water Quality Office, Water Hygiene Division and the California State Department of Health Services, 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 that fall outside permissible counting limits were given ">", "<", or "e" (estimated) qualifiers. However, these counts were treated as discrete values in subsequent analyses.

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. The results of these procedures were reported in the Quality Assurance Manual (City of San Diego 2002).

Table 2.1

Monthly mean values of temperature (Temp), density (Dens), salinity (Sal), dissolved oxygen (DO), pH, transmissivity (XMS), chlorophyll *a* (Chlor), total suspended solids (TSS) and total coliform values at all SBOO kelp and offshore stations during 2001.

Month	Temp	Dens	Sal	DO	pH	XMS	Chlor	TSS	Total coliforms (CFU/100 mL)	
	(°C)	(ð)	(ppt)	(mg/L)		(%)	(µg/L)	(mg/L)	Kelp	Offshore
Jan	14.4	25.00	33.58	7.9	8.0	86	6.71	4.9	3230	5
Feb	13.3	25.20	33.55	7.9	8.0	80	10.71	4.7	7670	300
Mar	13.8	25.06	33.48	7.7	8.0	83	6.40	7.1	3610	2400
Apr	12.4	25.40	33.59	6.6	7.9	85	9.27	4.6	550	1540
May	12.8	25.32	33.59	7.0	8.1	88	7.57	4.2	10	300
Jun	12.5	25.40	33.64	7.3	7.9	84	8.96	4.0	600	60
Jul	14.8	24.89	33.58	7.9	8.1	82	13.35	11.0	170	270
Aug	13.3	25.21	33.59	7.1	8.1	88	6.82	4.8	6	570
Sep	13.6	25.12	33.54	7.6	8.0	85	9.66	5.4	6	320
Oct	15.1	24.78	33.53	8.0	8.0	88	7.44	5.2	2	200
Nov	14.4	25.00	33.53	7.7	8.0	85	8.49	4.8	20	1670
Dec	13.9	25.09	33.56	7.7	8.1	81	8.90	9.9	260	840

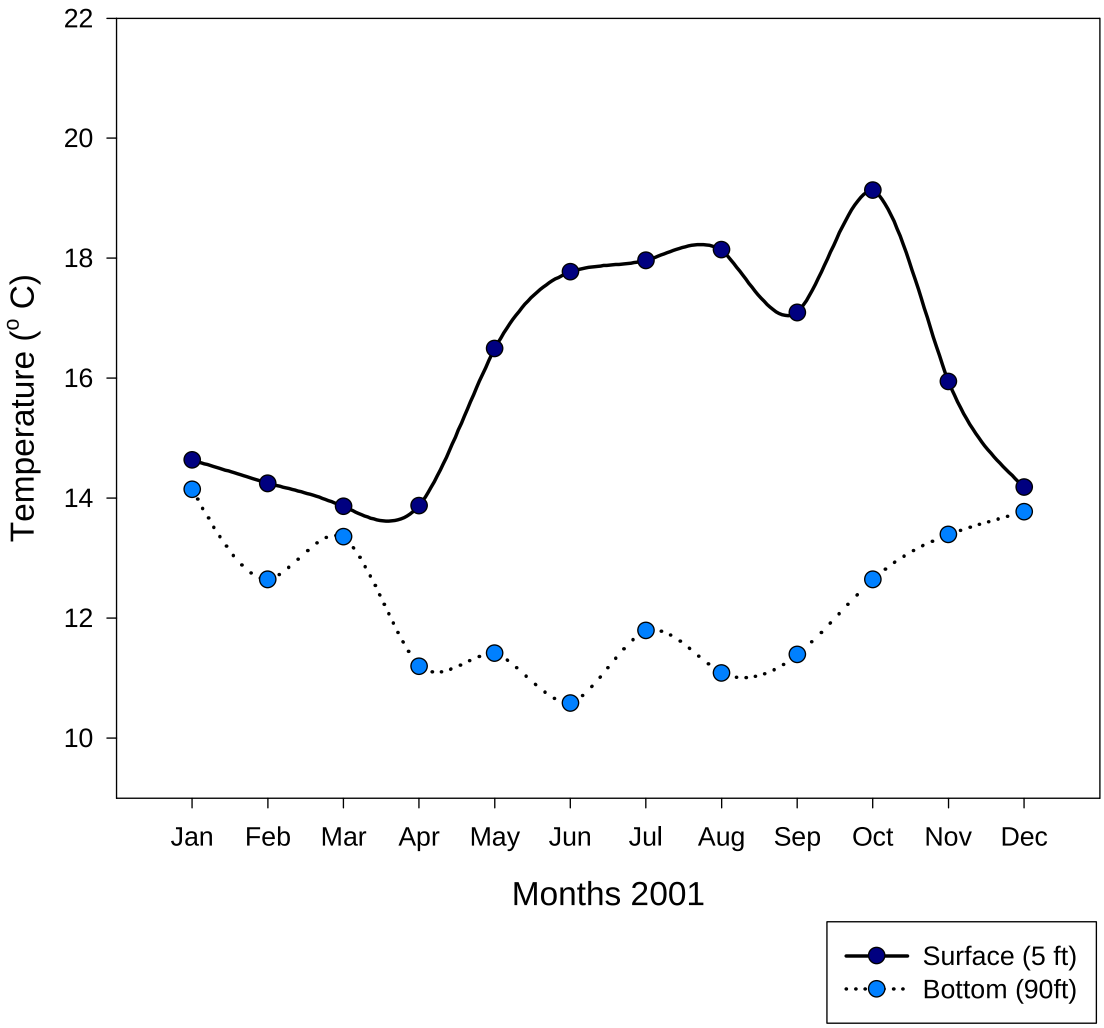


Figure 2.2
Mean monthly temperatures (°C) for surface and bottom waters at the 90 ft depth contour. Means are calculated from CTD profiles for 13 SBOO stations.

RESULTS & DISCUSSION

Physical and Chemical Parameters

Data for water temperature, salinity, density, pH, transmissivity, dissolved oxygen (DO), chlorophyll *a* and suspended solids are presented in Table 2.1. Oil and grease are not presented because values were generally below the detection limit of 2.0 mg/L. The data were examined for spatial and temporal trends that may be related to the South Bay Ocean Outfall. Preliminary analyses of CTD profiles indicated that differences in these parameters for 2001 could be summarized by data for the months of March, April, June and December .

During 2001, changes in most of the physical and chemical parameters reflected seasonal patterns in oceanographic conditions (see Figures 2.2 - 2.6). Typical winter conditions existed throughout the area from

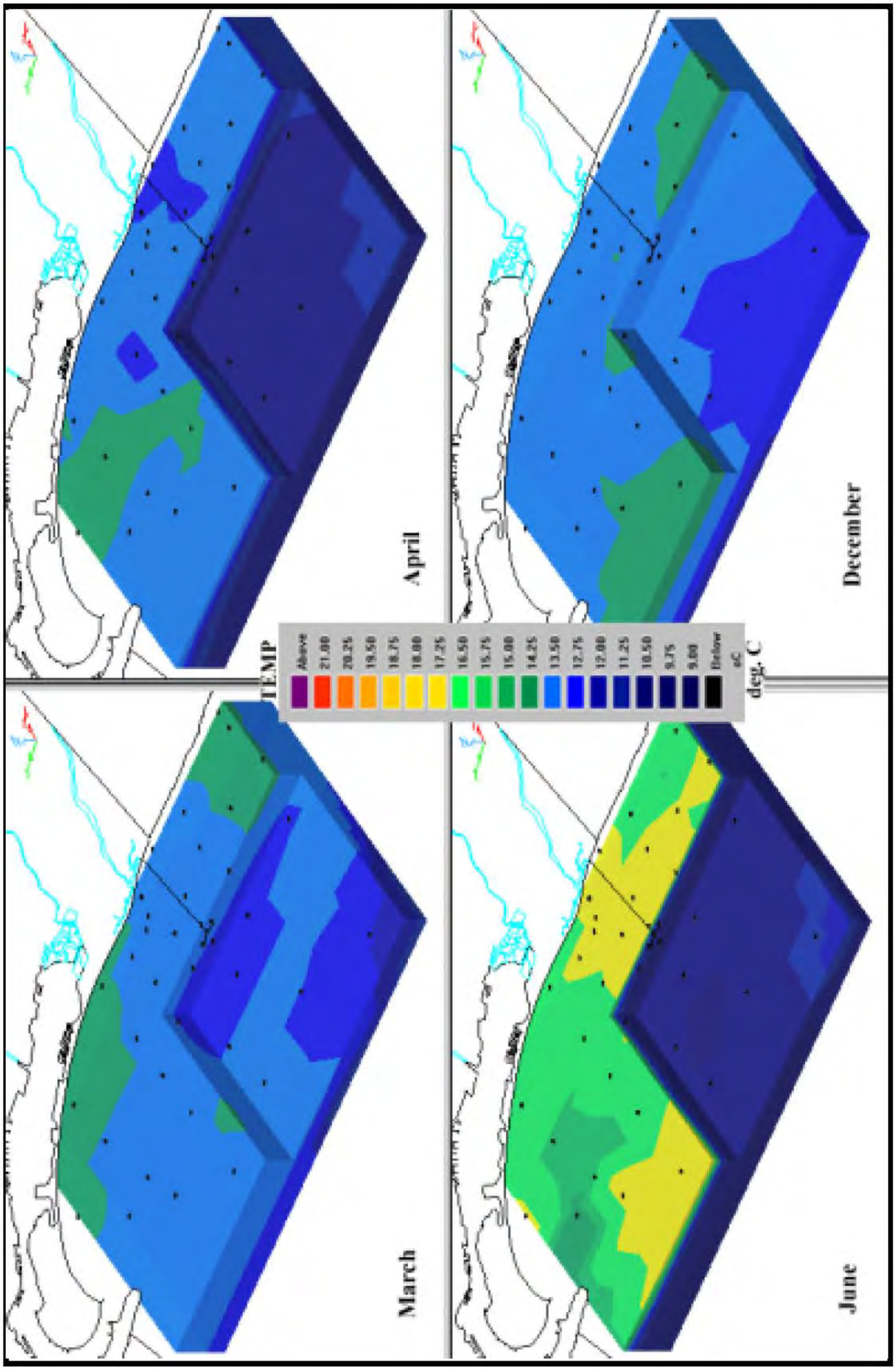


Figure 2.3

Three-dimensional plot of temperature (°C) profile data for the SBOO region during March, April, June and December 2001. The values between sampling sites were interpolated using the Metric method.

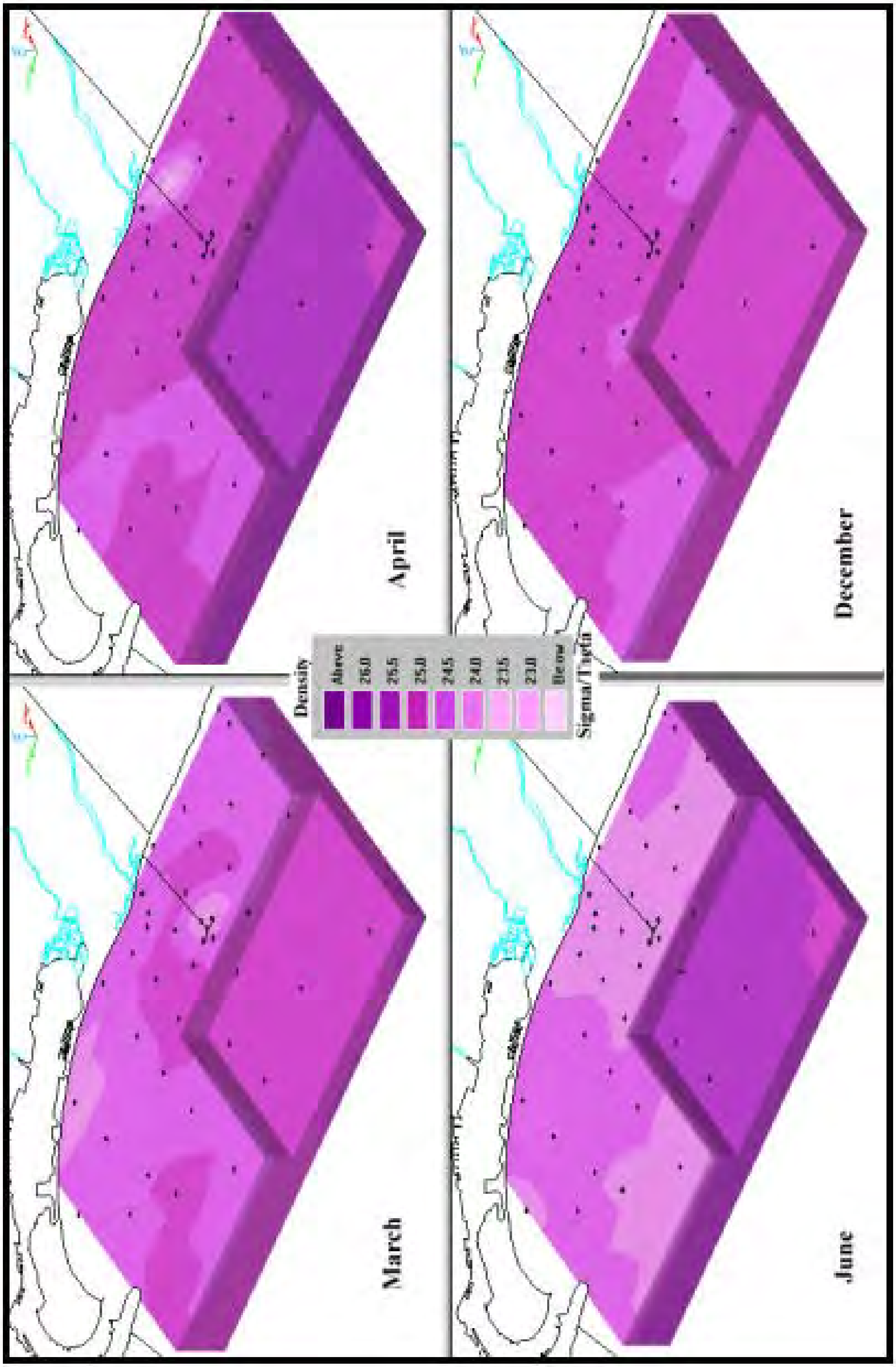


Figure 2.4

Three-dimensional plot of density (δ/theta) profile data for the SBOO region during March, April, June and December 2001. The values between sampling sites were interpolated using the Metric method.

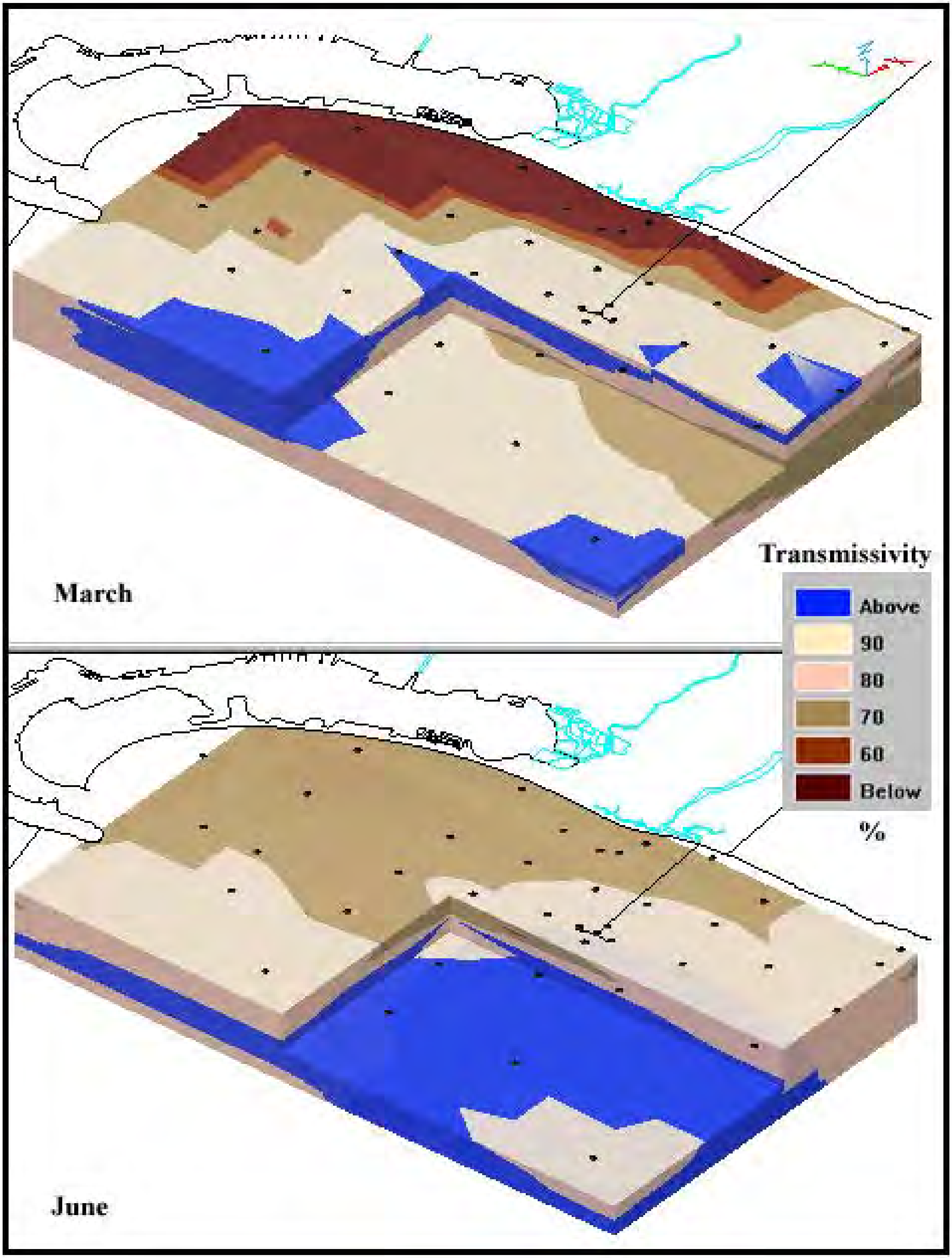


Figure 2.5
Three-dimensional plot of transmissivity (%) profile data for the SBOO region during March and June 2001. The values between sampling sites were interpolated using the Metric method.

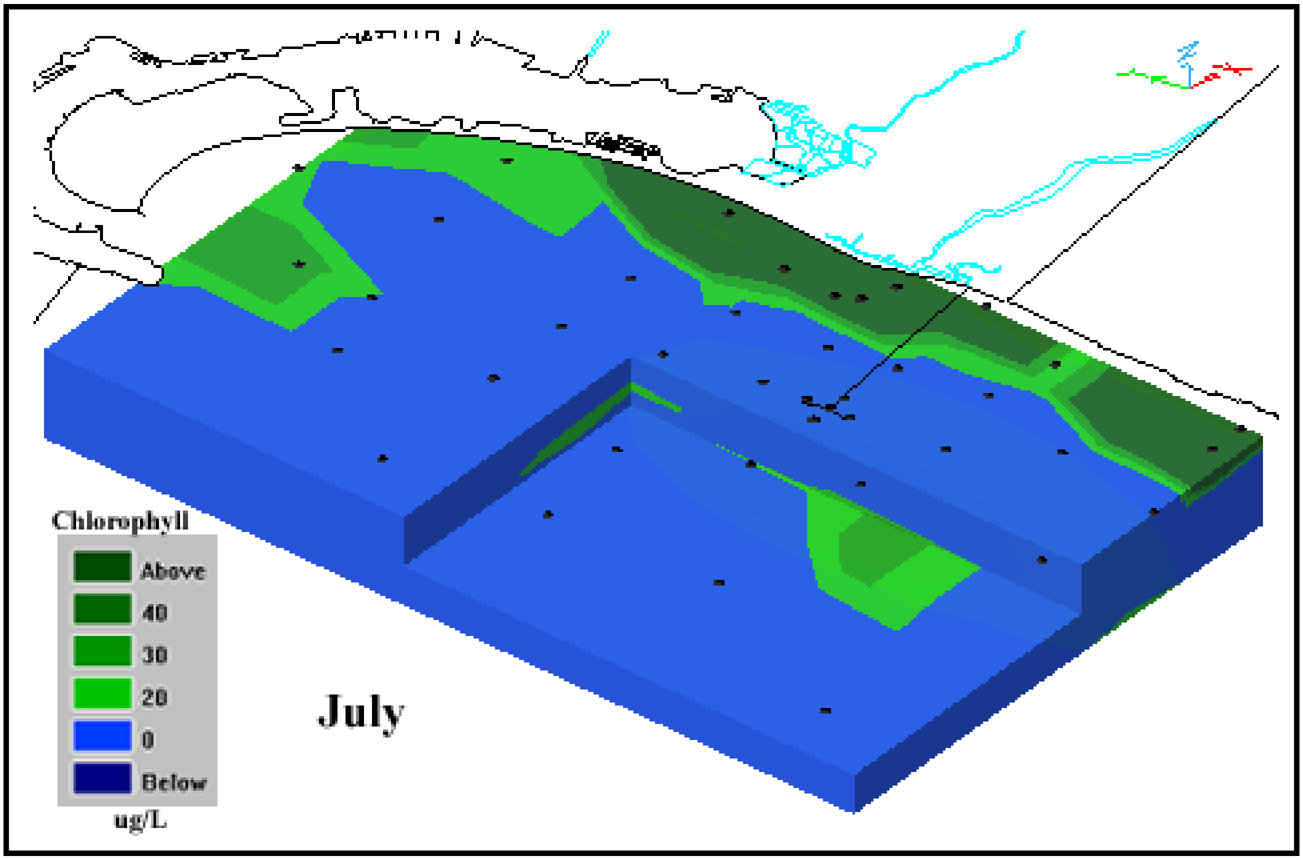


Figure 2.6

Three-dimensional plot of chlorophyll *a* (µg/L) profile data for the SBOO region during July 2001. The values between sampling sites were interpolated using the Metric method.

January through March and in December. Increased surf and wind conditions resulted in a mixed water column with little thermal stratification (i.e., a temperature difference of approximately 0.5 °C between the surface and 90-ft depth). Stormwater runoff and high surf conditions were probably responsible for increased suspended solids and reduced near-shore transmissivity during this period. These conditions were evident during March, for example, when low transmissivity and density values were recorded close to shore (Figures 2.4 and 2.5), and elevated concentrations of suspended solids (>10.5 mg/L) occurred at many inshore stations (I-10, I-23, I-24, I-25, I-26, I-32, I-36 and I-40).

Conditions began to change in April with an intrusion of cold water, followed by a warming of surface waters (see Figure 2.2). The water column became well stratified and was characterized by warm surface waters (approximately 17°C), cold bottom temperatures (approximately 10°C at 90 ft), low DO (3.5 mg/L) and increased offshore transmissivity (see Figures 2.2, 2.3 and 2.5). These conditions, accompanied by offshore winds, lead to the coastal upwelling apparent at some near-shore stations in April (Figure 2.3). A shallow, seasonal thermocline was present throughout summer and fall. The thermocline, marked also by differences in water density, was most pronounced between 13 and 30 ft and at its strongest in June (see Figures 2.3 and 2.4). A substantial increase in chlorophyll *a* and suspended solids occurred in July (see Figure 2.6 and Table 2.1) when field observations indicated a massive red tide. Thermal stratification broke down completely by December, leaving an almost homogenous water column.

Bacteriology

Monthly bacterial levels along the shore averaged from a low of 2 CFU/100 mL under summer conditions, to a high of >16,000 CFU/100 mL in the winter season (Table 2.2). Generally, elevated bacterial counts appeared to be associated with shore-based sources and winter storms. For example, the impacts of the discharge from the Canyon San Antonio de los Buenos Creek outlet in Mexico are likely responsible for the elevated bacterial values seen at the southernmost shore station (S1) throughout most of the year. Shore stations were also impacted by runoff from the Tijuana River. For example, station S5 and those stations immediately to the north and south (S4, S6, S10 and S11) had some of the highest average total coliform densities (annual means ranging from 3,020 - 5,150). In contrast, the three northernmost shore stations along northern Imperial Beach and Coronado Island (S8, S9 and S12) had much lower densities (annual means < 1,870). As had been observed in previous years, this pattern was present during both the wet and dry seasons (see Figure 2.7). The only exception to this pattern occurred in 1998 during an El Niño event (City of San Diego 2000a). Generally, the highest levels of contamination coincided with periods of stormwater runoff during the rainy season. For example 31 of the 44 monthly station means from January through April exceeded 5,000 CFU/100 mL, while only six exceeded this density over the remainder of the entire year (88 monthly station means from May through December). In addition to storm events, sewage spills from Mexico which empty into the Tijuana River may impact nearby shore stations. For example, an April sewage spill may have accounted for the elevated bacterial densities at stations S5, S6 and S11 during the month (Table 2.2). In contrast, there was no indication that the waste field from the SBOO reached the shoreline.

Similar to the pattern observed at the shore stations, bacterial concentrations at the three kelp stations were highest from January through March (Table 2.1). However, plots of the bacterial data indicate that at least some of this contamination may have resulted from stormwater runoff from the Tijuana River (see Figure 2.8).

Total coliform concentrations were highly variable at the offshore water quality stations in 2001, with average values ranging between 6 and 4,070 CFU/100 mL (Table 2.2). The highest values occurred in March, April and November, and most frequently at station I-12 nearest the point of discharge (see Figure 2.8). However, the waste field was primarily limited to the deeper, offshore waters (i.e., >90 ft). The thermal stratification present from May through November (Figure 2.3) probably prevented mixing of the warm surface and cold deep waters, thus acting as a barrier to the upward movement of the waste field. For example, the only evidence that the wastewater plume surfaced above the point of discharge was when there was very little stratification in March and December (see Figures 2.3 and 2.8).

Compliance with California Ocean Plan Standards

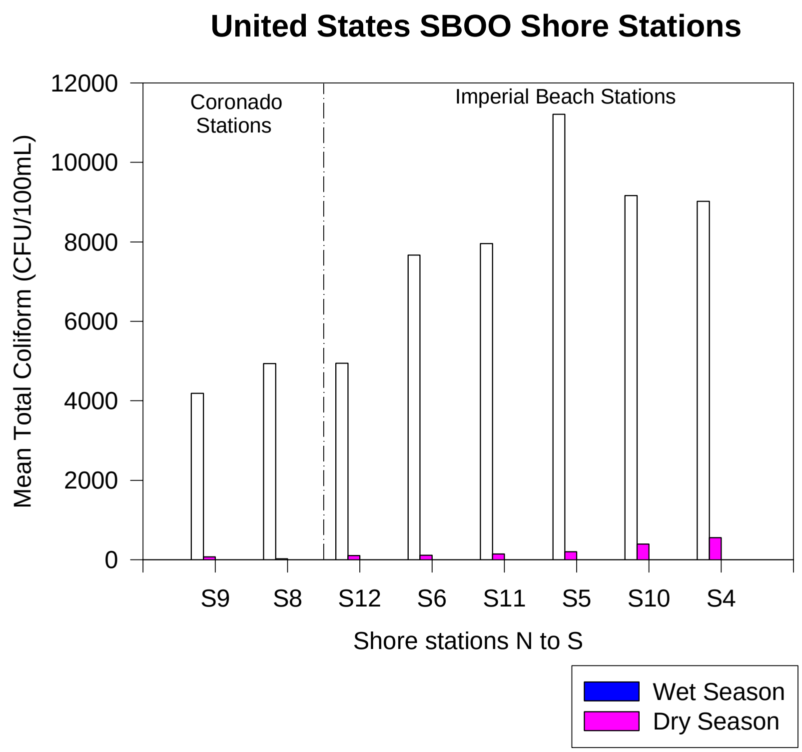
The California Ocean Plan (COP) standards for water contact apply only to the shoreline and kelp bed stations. The COP sets forth four standards for bacterial compliance as described in Box 2.1. Compliance calculations as

Table 2.2

Annual, monthly and all stations means of total coliform densities (CFU/100 mL) for SBOO shore stations, and monthly rainfall (inches) during 2001. Rainfall was measured at Lindberg Field, San Diego, CA. Shore stations are listed left to right from North to South. "n"= total number of samples for each station.

		Shore Stations											
	rainfall (in)	S9 (n=55)	S8 (n=55)	S12 (n=55)	S6 (n=57)	S11 (n=58)	S5 (n=62)	S10 (n=57)	S4 (n=58)	S3 (n=51)	S2 (n=50)	S1 (n=48)	All Stations Mean
Month													
January	3.3	20	10	120	5350	5410	9370	16000	13720	11120	10060	4950	7240
February	2.4	9700	11090	12100	11340	11690	13940	8190	8160	5340	5090	6380	9950
March	0.6	5090	6410	1110	6590	6580	13190	9100	8480	8150	5410	5480	7370
April	0.8	30	20	4170	7140	7160	7220	2280	2470	5170	4400	4340	4240
May	0.2	20	10	10	10	50	200	10	20	10	40	280	60
June	0.0	120	30	40	30	60	80	40	150	50	30	1570	200
July	trace	160	40	380	400	530	660	1050	850	820	710	500	560
August	0.0	90	50	60	30	30	60	20	150	2	30	10	50
September	0.0	30	10	90	170	180	90	1250	2350	5340	5020	5160	1540
October	0.0	30	10	20	10	10	20	10	20	50	90	4540	440
November	1.0	30	40	50	100	190	4510	2750	7450	6800	1050	5580	2700
December	0.5	70	60	300	50	20	100	50	180	1240	70	180	20
Annual Mean		1560	1810	1870	3020	3230	5150	3810	4180	3590	2570	3130	

A



B

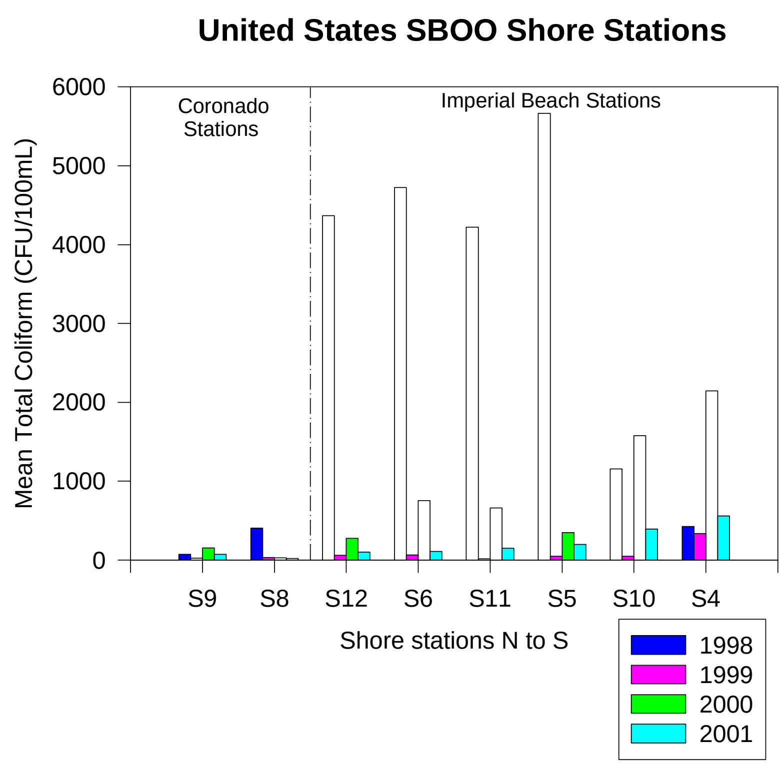


Figure 2.7
Mean total coliform values for the Coronado and Imperial Beach SBOO shore stations during (A) the wet (January through April) and dry (May through October) seasons for 2001, and (B) during the dry season from 1998-2001.

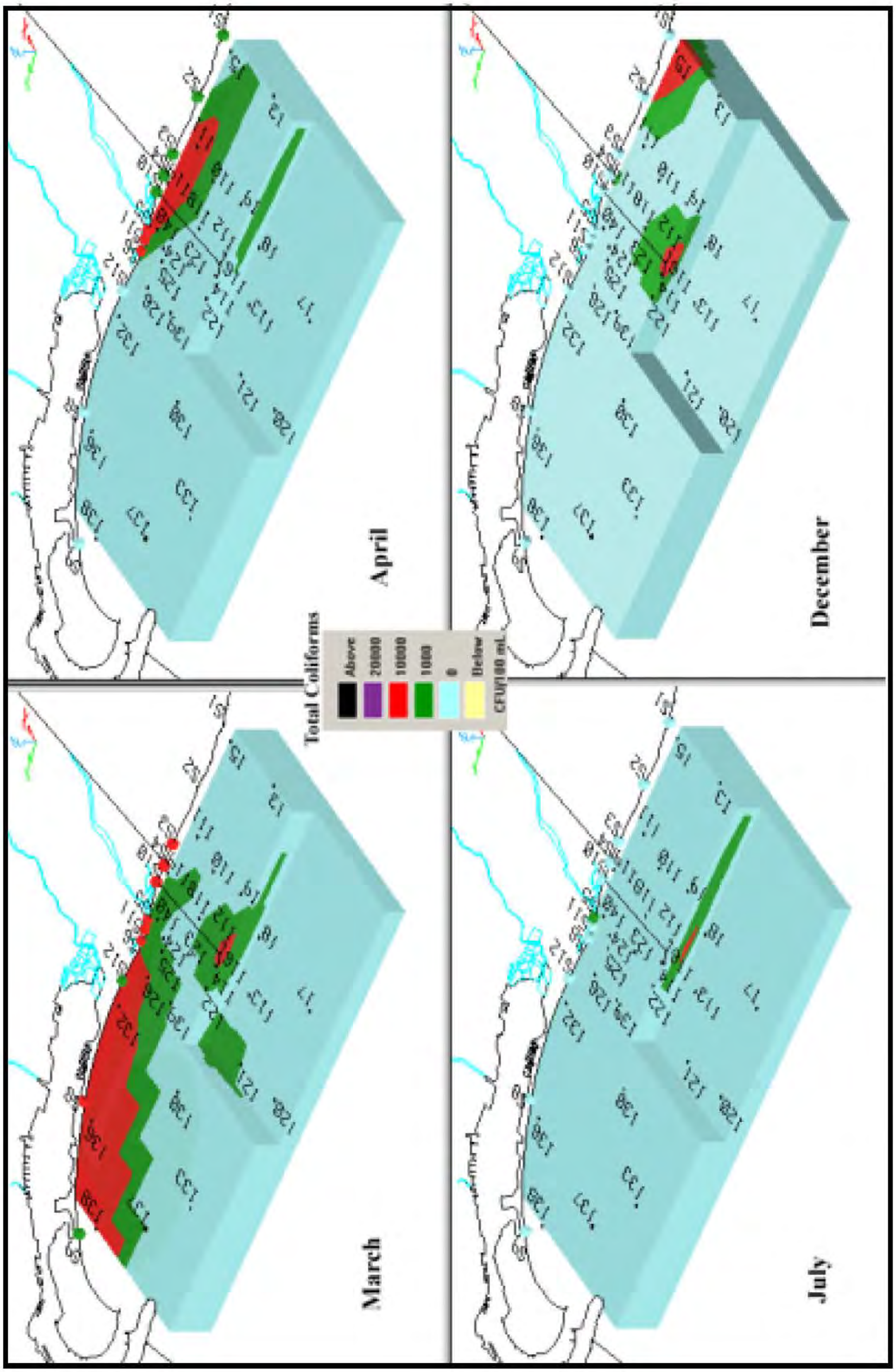


Figure 2.8
Three-dimensional plot of total coliform (CFU/100 mL) data for the SBOO region during March, April, July and December 2001. The values between sampling sites were interpolated using the Metric method.

reported herein were made for both total and fecal coliform values at all stations located north of the US/Mexico border.

In general, evidence of shoreline contamination associated with discharge from the South Bay Ocean Outfall was not apparent in 2001. Exceedence of the various standards was most prominent during the rainy season when elevated bacterial levels along the shore appeared to be related to input from the Tijuana River and to the northward movement of sewage originating from the Canyon San Antonio de los Buenos Creek outlet (see Table 2.3). The shoreline stations located near the Tijuana River (S4, S5, S6, S10 and S11) exceeded the 30-day total and 60-day fecal coliform limits most often, with annual compliance ranging from 49-70% and 35-62% respectively. In contrast, the northernmost stations (S8, S9 and S12) were in compliance much more frequently, ranging from 67-86% for both standards. The 10,000 total coliform and the geometric mean standards were met 98% and 96% of the time at the three northern sites. The stations surrounding the Tijuana River also met these two standards frequently with 92% and 86% compliance, respectively.

The three kelp bed stations appeared to be impacted primarily by storm waters. These stations were in compliance with all water contact standards during most of the year (Table 2.3). Exceptions occurred for the 30-day total, 60-day fecal, and 10,000 total coliform standards in February through April and for the geometric mean standard in early March. These exceedences were associated with heavy flows from the Tijuana River which likely increased bacterial concentrations in the nearshore environment. The running average method of calculation prolonged the high compliance values until well after the elevated coliform levels had subsided.

SUMMARY & CONCLUSIONS

Water quality in the vicinity of the South Bay Ocean Outfall (SBOO) was largely influenced by a number of oceanographic events along with some input from point and non-point anthropogenic sources. Physical and chemical parameters were mostly affected by changes in oceanographic conditions and stormwater inputs.

Box 2.1

Bacteriological compliance standards for water contact areas, 1997 California Ocean Plan. CFU = colony forming units.

(1) *30 day total coliform* — no more than 20% of the samples at a given station in any 30-day period may exceed a concentration of 1000 CFU per 100 ml.

(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 per 100 ml.

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

(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 per 100 ml, based on no fewer than 5 samples.

Table 2.3

Summary of compliance with California Ocean Plan water contact standards for SBOO shore and kelp stations during 2001. The values reflect the number of days that each station exceeded the 30-day total and 60-day fecal coliform standars. Shore stations are listed left to right from north to south.

30-Day Total Coliform Standard

Month	# of possible sampling days	Shore Stations S9	S8	S12	S6	S11	S5	S10	S4	Kelp Stations I-25	I-26	I-39
January	31	0	0	0	8	8	19	16	16	3	7	0
February	28	15	15	15	28	28	28	28	28	28	28	0
March	31	31	31	31	31	31	31	31	31	31	31	0
April	30	4	4	8	24	24	30	30	30	5	10	0
May	31	0	0	23	19	19	19	19	7	0	0	0
June	30	0	0	0	0	0	0	0	0	0	0	0
July	31	0	0	0	0	20	5	20	20	0	0	0
August	31	0	0	0	0	0	15	0	0	0	0	0
September	30	0	0	0	0	0	0	9	9	0	0	0
October	31	0	0	0	0	0	0	0	11	11	0	0
November	30	0	0	0	0	0	3	4	24	0	0	0
December	31	0	0	19	0	0	26	19	6	0	0	0
Percent compliance 2001		86	86	74	70	64	52	49	50	82	79	100

60-Day Fecal Coliform Standard

Month	# of possible sampling days	Shore Stations S9	S8	S12	S6	S11	S5	S10	S4	Kelp Stations I-25	I-26	I-39
January	31	0	0	0	31	9	9	16	16	0	0	0
February	28	16	16	16	28	28	28	28	28	15	2	0
March	31	31	31	31	31	31	31	31	31	31	31	0
April	30	15	29	25	30	30	30	30	30	27	28	0
May	31	1	1	12	31	31	31	4	4	0	1	0
June	30	0	0	9	9	9	9	0	5	0	0	0
July	31	0	0	0	0	0	0	29	31	0	0	0
August	31	0	0	0	0	0	0	30	31	0	0	0
September	30	0	0	0	0	0	0	0	30	0	0	0
October	31	0	0	0	0	0	0	0	19	0	0	0
November	30	0	0	0	0	0	1	11	11	0	0	0
December	31	0	0	28	0	0	15	15	0	0	0	0
Percent compliance 2001		83	79	67	56	62	58	47	35	80	83	100

Typical winter conditions existed throughout the SBOO region from January through March and in December. Local waters were mixed, and there was little evidence of thermal stratification. Conditions began to change in April with an intrusion of cold water, followed by a warming of surface waters. The water column became well stratified and a shallow, seasonal thermocline was present throughout summer and fall. A cooling trend began in November and reduced water column stratification became evident towards the end of the year.

Although coliform bacteria occur naturally in marine environments, high counts are often indicative of anthropogenic contamination in heavily populated coastal areas. Elevated levels of bacteria can indicate the presence of microscopic disease-causing organisms from human or animal wastes. These wastes typically enter coastal waters from combined sewer overflows, sewage spills, overflows from sewage-treatment plants and sanitary sewers, and stormwater runoff from urban, suburban and rural areas (Chasis and Dorfman 1999). Sources of bacterial contamination along the shoreline in the SBOO area include the Mexican sewage treatment plant discharge at the Canyon San Antonio de los Buenos Creek outlet, input via the Tijuana River, and various coastal storm drain outlets. All of these sources appeared to have significant effects on bacterial concentrations along the region's shoreline. The impacts of the discharge from the Canyon San Antonio de los Buenos Creek outlet were seen at the southernmost monitoring station in December, while stations S4, S5, S6, S10 and S11 further to the north, were impacted by flows from the Tijuana River. These river flows were contaminated by inputs from stormwater runoff in addition to several large Mexican sewage spills in January and April that emptied into the Tijuana River valley during 2001. Similar patterns were observed during both the baseline monitoring period and the past two years of discharge (City of San Diego 2000a, 2001).

The SBOO waste field generally remained offshore and at depth. The stratification present for most of the year kept the plume below the surface. In March and December, however, the lack of stratification allowed the plume to surface at the point of discharge, approximately 5.6 km offshore.

The numerous anthropogenic inputs in the South Bay area make it difficult to clearly distinguish water quality impacts associated with the outfall from those impacts caused by other sources. Shoreline sources tend to impact surface waters and clearly radiate from the source into nearshore waters. In contrast, the discharge from the outfall usually remains near the bottom for most of the year. When oceanographic conditions change, however, plumes from various sources can merge and create a less definitive picture of cause and effect. For example, it is clear that discharge from the Mexican sewage treatment plant, as well as flows from the Tijuana River and other shoreline sources are impacting water quality along the shore and in shallow nearshore waters. In contrast, there is no evidence based on the monitoring results for 2001 which suggests that discharge from the SBOO is reaching the shoreline.

LITERATURE CITED

Bordner, R., J. Winter, and P. Scarpino (eds.). (1978). Microbiological Methods for Monitoring the Environment: Water and Wastes, EPA Research and Development, EPA-600/8-78-017. 337 pp.

Chasis, S., and M. Dorfman (eds.). (1999). Testing the Waters 1999: A Guide to Water Quality at Vacation Beaches. Natural Resources Defense Council.

City of San Diego. (2000a). Final Baseline Monitoring Report for the South Bay Ocean Outfall (1995-1998). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2000b). Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (1999). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2001). Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (2000). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2002). 2001 Quality Assurance Manual. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

Greenberg A.E., L.S. Clesceri, and A.D. Eaton eds. (1992). Standard Methods for the Examination of Water and Wastewater, 18th edition. American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1391 pp.

Pickard, G.L., and W.J. Emery. (1990). Descriptive Physical Oceanography. Pergammon Press, New York, 320 pp.

Chapter 3

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 invertebrate prey (Cross and Allen, 1993). Important factors affecting the distribution and composition of sediments 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). For example, 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. Thus, temporal comparisons of these parameters are useful in determining the overall sediment stability and the degree of seasonal import and export of particles associated with storm activity, runoff, upwelling and other sources.

Ocean outfalls are one of many anthropogenic factors that can directly influence the composition and distribution of ocean sediments. This may be due to the discharge and subsequent deposition of a wide variety of organic and inorganic compounds (Anderson et al. 1993), and to the physical structure of the outfall altering the hydrodynamic regime of an area. Among the most common compounds discharged via outfalls are trace metals, pesticides and various organic compounds (e.g., total organic carbon, total nitrogen, sulfides). Nitrogen and sulfide concentrations are often positively correlated with finer particle sizes that provide greater surface area for bacterial growth and adsorption. On the other hand, total organic carbon measurement is considered a more direct indicator of carbon imported as fine particulate matter (Anderson et al. 1993).

This chapter presents summaries and analyses of sediment grain size and chemistry data collected during 2001 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; (2) to determine the presence or absence of sedimentary and chemical footprints near the discharge site.

MATERIALS & METHODS

Field Sampling

Sediment samples were collected during January and July of 2001 at 27 stations surrounding the South Bay Ocean Outfall (Figure 3.1). These stations are located along the 60, 90, 120 and 180-ft depth contours (~18–55 m) and form a grid surrounding the terminus of the outfall. All samples were obtained with a 0.1 m^2 chain-rigged Van Veen grab. These samples were taken from the top 2 cm of the sediment surface and handled according to EPA guidelines (USEPA 1987).

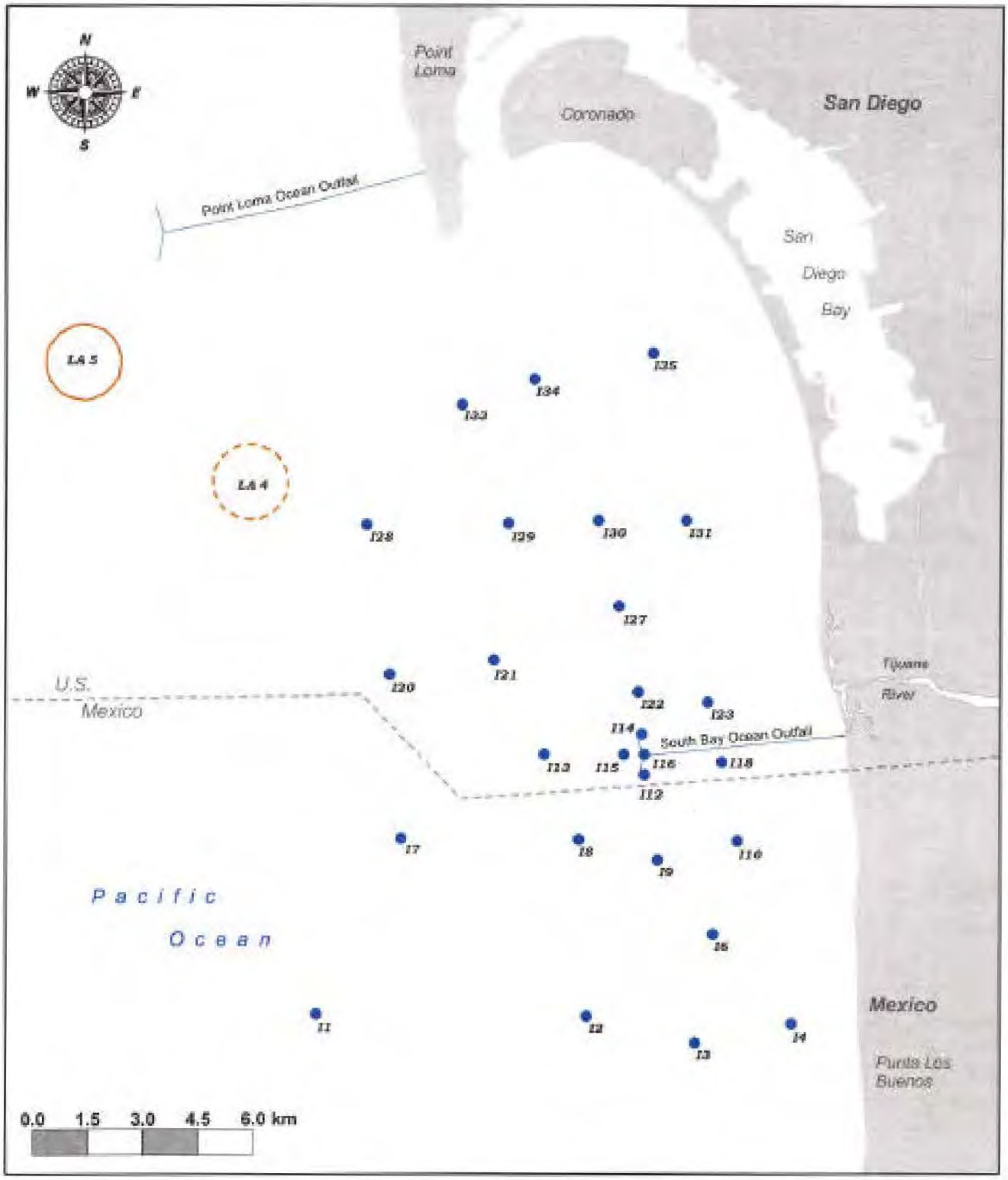


Figure 3.1
Sediment chemistry station locations, South Bay Ocean Outfall Monitoring Program.

Laboratory Analyses

All sediment analyses were performed at the City of San Diego's Wastewater Chemistry Laboratory. Particle size analyses were performed using a Horiba LA-900 laser analyzer, which measures particles ranging in size from 0 to 10 phi (i.e., sand, silt and clay fractions). The fraction of coarser sediments (e.g., very coarse sand, gravel, shell hash) in each sample was determined by measuring the weight of particles retained on a 1.0 mm mesh sieve (i.e., 0 phi), and are expressed as the percent weight of the total sample sieved. This coarse fraction is represented as percent "Coarse" in Table 3.1 and Appendix A.

Data Analyses

A number of particle size parameters were calculated using a normal probability scale (see Folk 1968). These include median and mean phi size, sorting coefficient (standard deviation), skewness, kurtosis and percent sediment type (i.e., coarse particles > 1.0 mm in diameter, sand, silt, clay). Sediment chemical parameters that were analyzed include total organic carbon (TOC), total nitrogen, total sulfides, trace metals, chlorinated pesticides, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyl compounds (PCBs). Prior to analysis, the data were generally limited to values above method detection limits (MDLs). Some parameters 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. Null values (i.e, values below the MDL without an estimate) were eliminated from the dataset and are not intended to represent the absence of a particular parameter.

The 2001 data for the various trace metals, TOC, nitrogen and the DDT were examined in relation to the 50% cumulative distribution functions (CDF) levels for these parameters in southern California. These CDFs were established using data from the 1994 Southern California Bight Pilot Project (see Schiff and Gossett 1998), and allow the comparison of sediment chemistry conditions off San Diego with those for the entire southern California region.

RESULTS & DISCUSSION

Particle Size Distribution

The overall composition of sediments at sites surrounding the South Bay Ocean Outfall in 2001 consisted of fine to medium sands, similar to that observed during the previous six years of sampling (Figure 3.2, Appendix A.1). However, there has been a slight decrease in mean phi size for the region, which indicates an increase in coarse particles. For example, particle sizes averaged 2.3 phi for the region in 2001 compared to 2.5 phi over the 1999 - 2000 post-discharge period and 2.6 phi over the 1995–1998 pre-discharge period (Table 3.1, Figure 3.2). Additionally, the sediments at stations I-15 and I-16 have become more coarse since the construction of the outfall diffusers proximal to these stations. This may be partially attributed to the sand ballast placed over the diffusers, and to the disturbance of sediments during the construction period.

Although most sites were dominated by fine sands, sediment composition was patchy overall. The coarsest sediments were found along the 120 and 180-ft contours (see Figure 3.3) where phi size averaged 1.8 and 1.7 phi,

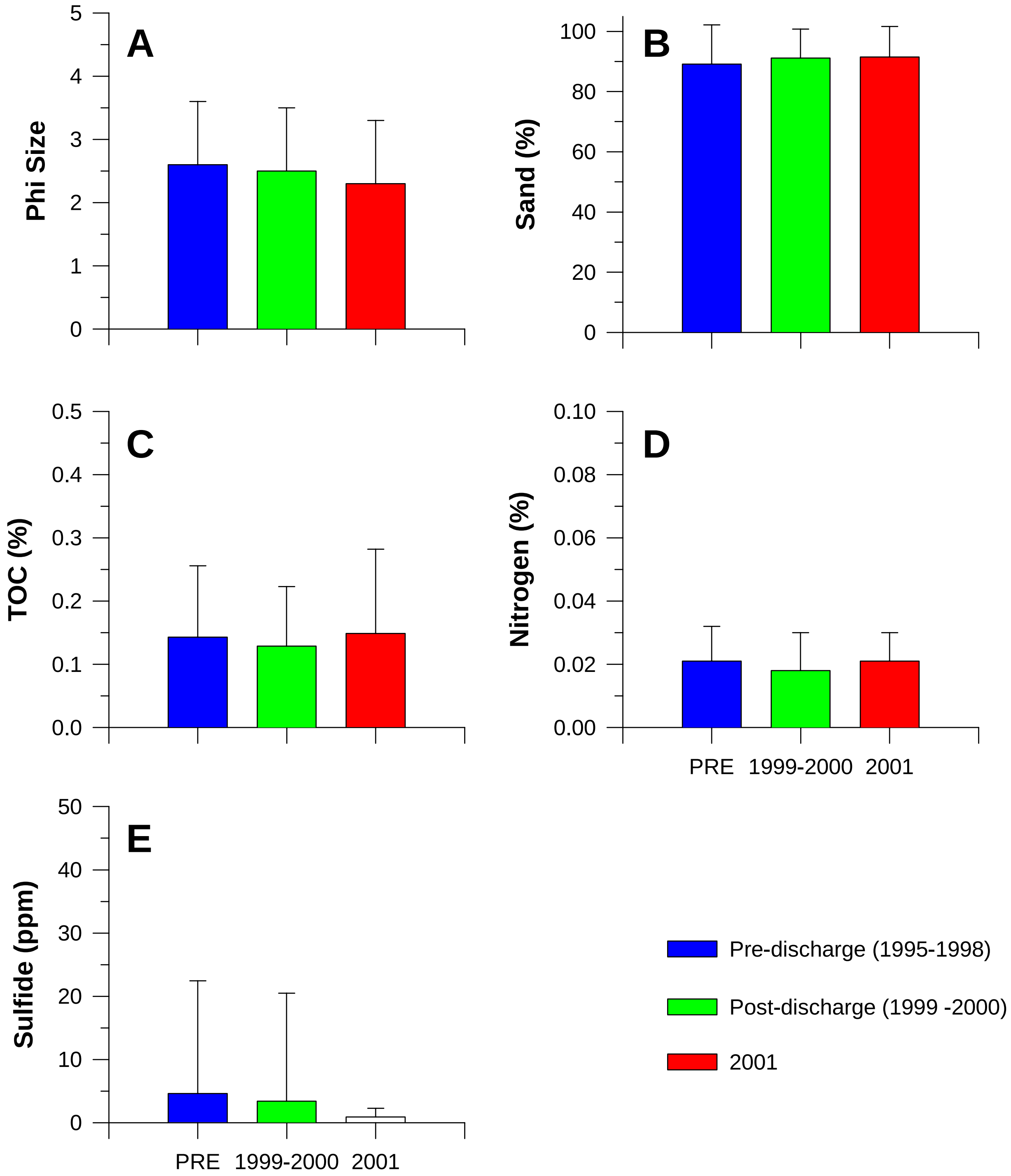


Figure 3.2

Comparison of values for several sediment quality parameters surrounding the SBOO in 2001 with values during the first two years of post-discharge monitoring (1999-2000) and the pre-discharge period (1995-1998): (A) Mean phi size; (B) percent coarse particles and 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 3.1

Summary of sediment particle size parameters and organic compounds for SBOO sediment chemistry stations during 2001, pre-discharge (1995-1998) and post discharge (1999-2000) surveys. Particle size data were determined from a probability curve and are expressed as annual means for: (1) phi size; (2) standard deviation (SD); (3) coarse particles > 1.0 mm; (4) percent sand; (5) percent silt; (6) percent clay. The organic compounds include: (1) sulfides (ppm); (2) total nitrogen (wt%); total organic carbon (wt%). Also included are method detection limits, area means and the 50% CDF value for the Southern California Bight (Schiff and Gosset 1998).

	Mean Phi	SD Phi	% Coarse	% Sand	% Silt	% Clay	Sulfides ppm	TN WT%	TOC WT%	Sediment Notes
50%CDF							na	0.051	0.748	
MDL							0.05	0.001	0.009	
60 ft stations										
I-35	3.7	1.4	6.5	57.3	34.1	2.0	4.8	0.031	0.342	
I-34	1.7	0.6	0.6	99.2	0.2	0.0	3.8	0.008	0.050	coarse sand/red relict sand/shell hash
I-31	3.2	0.6	0.0	91.8	7.3	0.8	0.1	0.011	0.095	
I-23	2.1	0.7	0.6	93.3	5.6	0.3	0.6	0.013	0.127	shell hash
I-18	3.1	0.7	0.0	91.0	8.2	0.7	1.4	0.011	0.102	
I-10	3.0	0.7	0.0	90.8	8.4	0.7	1.0	0.013	0.118	
I-4	2.8	0.8	0.0	92.1	7.6	0.2	1.5	0.017	0.104	fine sand/silt/shell hash
90 ft stations										
I-33	3.0	0.7	0.0	91.3	7.8	0.9	0.5	0.023	0.229	medium sand/shell hash
I-30	3.4	0.9	0.0	81.4	17.1	1.5	1.8	0.019	0.198	medium sand
I-27	3.3	0.7	0.0	86.8	12.0	1.0	1.0	0.016	0.156	
I-22	2.9	0.7	0.0	90.3	9.2	0.5	0.6	0.016	0.161	
I-14	3.1	0.8	0.0	87.9	11.1	0.9	0.4	0.017	0.170	
I-15	1.6	0.7	0.0	99.0	1.0	0.0	0.1	0.008	0.068	sand/silt/shell hash
I-16	1.7	0.7	0.4	98.4	1.2	0.0	1.2	0.010	0.118	hard packed mud/sand/coarse black sand/shell hash
I-12	2.8	0.9	0.0	91.2	8.1	0.6	1.2	0.012	0.117	coarse balck sand/silty sand/shell hash
I-9	3.4	0.8	0.0	83.9	15.3	0.7	1.5	0.016	0.159	organic matter
I-6	1.3	0.6	0.4	99.0	0.5	0.0	0.1	0.010	0.063	red relict sand/shell hash
I-3	1.2	0.6	3.5	96.1	0.3	0.0	0.0	0.009	0.057	sand/red relict sand
120 ft stations										
I-29	3.7	1.1	0.5	68.6	28.6	2.2	1.4	0.033	0.490	medium sand/coarse black sand/shell hash
I-21	1.2	0.7	0.8	99.0	0.3	0.0	0.1	0.009	0.054	red relict sand/shell hash
I-13	1.4	0.5	0.0	99.5	0.4	0.0	0.4	0.011	0.097	red relict sand/shell hash
I-8	1.4	0.6	0.0	98.5	1.3	0.0	1.1	0.009	0.063	
I-2	1.5	0.6	0.0	99.3	0.7	0.0	0.2	0.009	0.061	sand
180 ft stations										
I-28	2.5	1.1	6.5	72.5	17.8	3.1	0.4	0.042	0.538	coarse black sand/sandy silt/clay/shell hash
I-20	0.7	0.7	14.8	85.2	0.0	0.0	0.1	0.008	0.042	coarse sand/red relict sand
I-7	1.0	0.6	5.5	94.3	0.1	0.0	0.1	0.009	0.055	red relict sand
I-1	2.5	1.1	0.0	91.5	6.0	0.8	1.0	0.016	0.182	
Area Means										
2001	2.3	0.8	1.5	90.0	7.8	0.6	0.9	0.015	0.149	
Post-	2.5	0.8	0.9	90.2	8.2	0.6	3.4	0.019	0.129	
Pre-	2.6	1.1	1.4	87.7	9.5	0.8	4.6	0.019	0.143	

respectively. Two exceptions to this pattern included stations I-29 and I-28, which had sediments containing the second and third highest mean concentrations of percent silt and clay (31% and 21%, respectively) (Table 3.1). Most of the finer sediments occurred at the shallower depths (see Figure 3.3) and is probably the result of sediment deposition from the Tijuana River and to a lesser extent from San Diego Bay (see City of San Diego 1988). For example, station I-35 averaged the highest concentrations of percent silt and clay (36%). The sorting coefficients (standard deviation) at most stations were primarily between 0.6 and 0.9 phi (Table 3.1), indicating moderately well sorted particles resulting from strong wave and current activity (Gray 1981).

There were few differences in particle size distribution between the January and July surveys in 2001 (Figure 3.3, Appendix A.2). The stations that exhibited the greatest changes were I-12, I-23, I-28 and I-1. For example, the sediments at station I-28 were highly variable with a mean value of 0.7 phi during January and 4.2 phi during July (Appendix A.2). This station is located near the defunct LA-4 dredged material disposal site and has been highly variable in particle size since monitoring began. Several other stations showed relatively large shifts in the composition of coarse and fine particles without significant changes in mean phi size (i.e., I-20, I-29 and I-35). The random nature of some of these changes may be partially attributed to the patchiness of sediments in the region.

Indicators of Organic Loading

The SBOO area means for total nitrogen and total organic carbon were similar in 2001 to those of the pre-discharge and the first two years of post-discharge surveys (Table 3.1, Figure 3.2). The average values for these indicators were lower than the 50% CDFs for the Southern California Bight. Total nitrogen and total organic carbon were highest at stations I-28, I-29 and I-35 (Table 3.1) but well below the 50% CDF for the region. These stations are located near the mouth of San Diego Bay where the highest concentrations of silt were measured (see Figure 3.3). Such a pattern is expected, since particle size is known to be a factor affecting the concentrations of organic parameters (Emery 1960, Eganhouse and Venkatesan 1993).

Average sulfide concentrations during the year were only slightly higher than the MDL and were considerably lower than pre- and post discharge values (Table 3.1). Mean sulfide concentrations were highest at stations I-35 and I-34 with values of 4.8 and 3.8 ppm, respectively (Table 3.1). This represents a large reduction from a mean value of 91 ppm for station I-35 during the previous year (City of San Diego 2001).

Trace Metals

The concentrations of trace metal in the SBOO sediments was generally low in 2001 compared to the 50% CDFs for southern California (Table 3.2). Of the metals detected at all stations (i.e., aluminum, arsenic, chromium, copper, iron, manganese and zinc), most had their highest concentrations at stations I-29. The exceptions include copper and arsenic which were higher at stations I-28 and I-21, respectively. Silver and tin were not detected while antimony, beryllium, cadmium, lead, mercury, nickel, selenium and thallium were detected infrequently (Table 3.2).

Area wide mean metal concentrations, with the exception of beryllium, were well below 50 % CDFs for southern California (Table 3.2). Levels for cadmium, copper, manganese, lead and nickel had mean values slightly higher

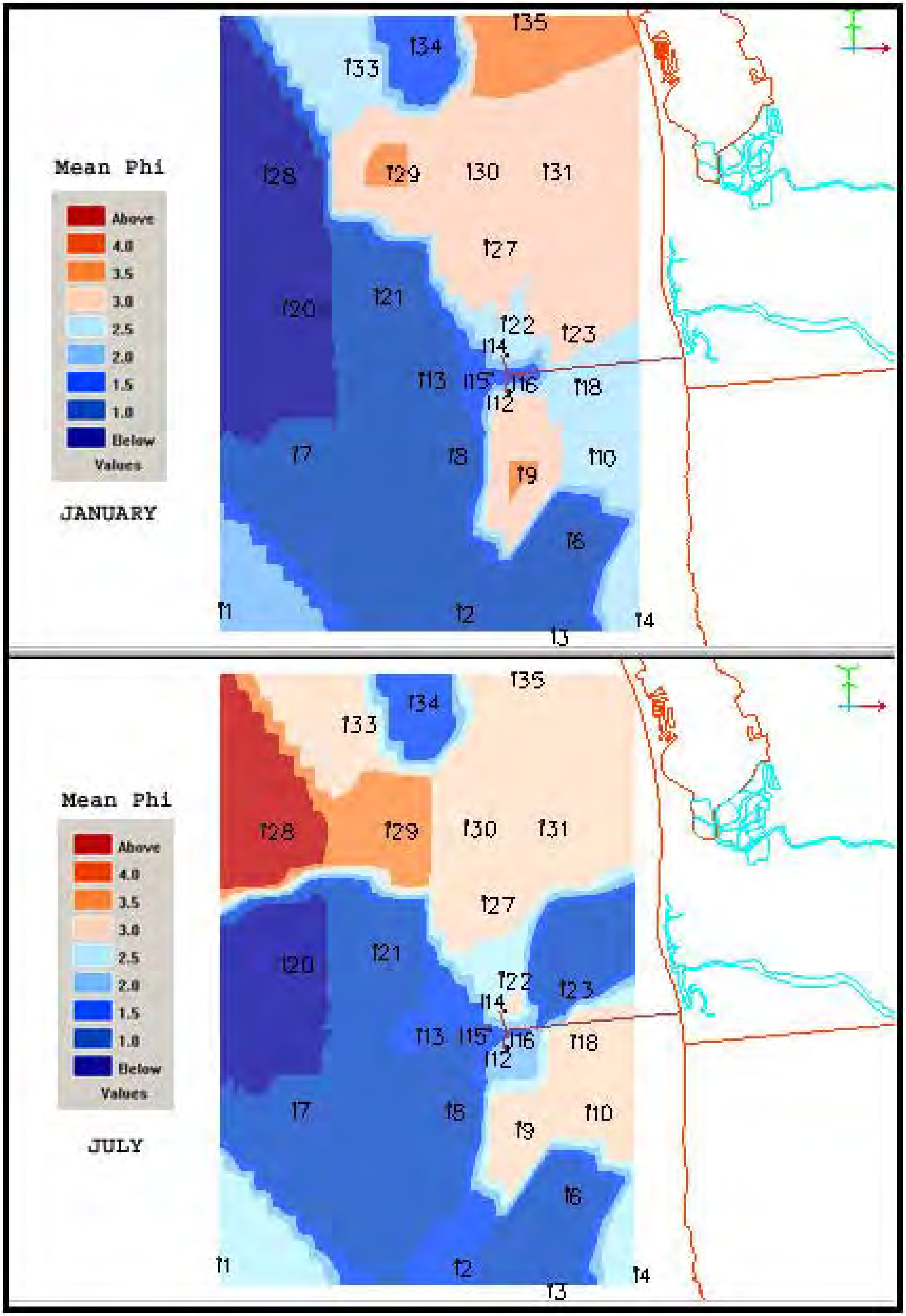


Figure 3.3
Horizontal contour profiles of mean phi size data for the January and July surveys of SBOO sediment chemistry stations during 2001.

Table 3.2

Concentrations of metals (ppm) for each station during 2001, pre-discharge (1995-1998) and post-discharge (1999-2000) surveys. Data for metals include: aluminum (Al); antimony (Sb); arsenic (As); beryllium (Be); cadmium (Cd); chromium (Cr); copper (Cu); iron (Fe); lead (Pb); manganese (Mn); mercury (Hg); nickel (Ni); selenium (Se); thallium (Tl); and zinc (Zn). Values below detection limits are designated by "nd". Also included are area means, method detection limits (MDL), and the 50% CDF value for the Southern California Bight (Schiff and Gosset 1998). Values that exceed the 50% CDF are indicated in bold type. ** = not available

	Al	Sb	As	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Tl	Zn
MDL	5	5.65	0.08	0.20	0.5	3	2	3	5.0	0.5	0.03	3.0	0.11	10	4.0
50% CDF	9400	0.2	4.8	0.26	0.29	34	12	16800	10.2	**	0.04	**	0.29	**	56
60 ft stations															
I-35	**11100**	nd	2.77	**1.54**	**0.85**	15.3	9.6	11650	2.5	122.0	**0.025**	4.6	0.07	nd	28
I-34	2485	nd	1.78	nd	nd	2.1	6.4	3330	nd	32.1	nd	nd	nd	nd	7
I-31	3995	nd	1.17	**0.46**	nd	6.9	8.2	4085	nd	56.3	nd	nd	nd	nd	8
I-23	5640	nd	1.90	**0.95**	nd	9.0	7.9	5780	nd	70.7	nd	nd	nd	nd	12
I-18	5480	nd	1.58	**1.18**	**0.29**	11.9	8.4	7345	nd	86.1	nd	1.9	nd	nd	11
I-10	6185	nd	1.68	**0.68**	nd	5.5	9.2	6750	nd	67.2	nd	nd	nd	nd	14
I-4	5280	nd	1.49	nd	nd	10.3	5.9	6005	nd	69.8	nd	nd	nd	nd	11
90 ft stations															
I-33	4800	nd	1.96	nd	**0.50**	7.8	6.8	5935	nd	66.6	**0.011**	nd	nd	nd	14
I-30	7780	nd	1.65	nd	nd	10.6	9.6	7225	nd	70.7	nd	2.7	nd	nd	17
I-27	5835	nd	2.04	nd	nd	9.6	7.5	6055	nd	63.4	**0.020**	nd	nd	6	13
I-22	4910	nd	1.78	nd	nd	9.0	8.0	5430	nd	61.0	nd	nd	nd	nd	11
I-14	**9655**	nd	1.80	nd	**0.46**	12.2	9.8	8465	nd	93.2	nd	4.1	0.13	nd	19
I-15	2655	nd	2.48	**0.29**	nd	8.3	8.9	4645	nd	30.2	nd	nd	0.06	nd	8
I-16	4010	nd	1.76	nd	**0.31**	6.3	6.4	4770	nd	48.5	nd	nd	nd	nd	11
I-12	5520	nd	1.84	nd	**0.34**	9.4	8.4	6485	nd	61.5	nd	nd	0.05	nd	15
I-9	8685	nd	1.59	nd	nd	11.7	8.8	8060	nd	84.9	nd	4.1	0.05	nd	18
I-6	1430	nd	**5.39**	**0.39**	nd	7.7	6.2	3890	nd	16.6	nd	nd	nd	nd	nd
I-3	847	nd	1.05	nd	nd	5.1	11.8	1395	nd	11.2	nd	nd	0.06	nd	nd
120 ft stations															
I-29	**11555**	nd	2.95	**2.51**	**0.30**	16.9	11.4	12590	nd	122.3	**0.011**	7.3	0.10	nd	29
I-21	1300	nd	**9.61**	nd	0.26	11.0	6.8	8240	nd	16.8	nd	nd	nd	nd	6
I-13	1555	nd	4.91	nd	nd	8.7	4.6	4470	nd	18.6	nd	nd	0.05	nd	3
I-8	1815	nd	2.29	0.22	nd	8.4	7.4	4125	nd	19.9	nd	nd	nd	nd	6
I-2	1310	nd	0.73	0.11	nd	5.2	9.1	1220	nd	9.6	nd	nd	nd	nd	nd
180 ft stations															
I-28	8180	**2.6**	2.55	nd	nd	12.5	**12.5**	9455	3.1	76.1	nd	3.4	0.16	nd	20
I-20	1500	nd	2.46	nd	nd	4.2	4.1	4610	nd	20.3	nd	nd	nd	nd	6
I-7	1340	nd	4.40	nd	nd	8.6	7.1	6825	nd	27.6	nd	nd	nd	nd	6
I-1	3315	nd	1.29	nd	nd	7.0	6.6	3995	nd	46.2	nd	nd	0.11	nd	7
Area Means															
2001	4747	0.10	2.48	**0.31**	0.12	8.9	8.1	6031	0.21	54.4	0.003	1.0	0.03	0.2	11.1
Post-	4839	**0.21**	2.48	0.12	0.06	8.6	2.6	6086	0.16	56.9	0.001	1.5	0.02	0.8	15.0
Pre-	5164	0.08	2.47	0.12	0.00	10.2	2.6	6568	0.09	47.4	0.003	0.2	0.07	0.2	12.5

than those of the pre-discharge surveys (Table 3.2). However, except for manganese, average concentrations of these metals were near or below method detection levels (MDL) at all stations. Concentrations must be at least five times the MDL to be considered reliable (Clesceri et al. 1998).

Pesticides

Pesticides were detected in only three of the SBOO sediment samples collected in 2001, all during the July survey. These included two derivatives of the chlorinated pesticide DDT (p,p-DDE and p,p-DDT). The p,p-DDE derivative was detected at a concentration of 3,500 ppt in a single sample from station I-29. This value is considerably higher than the 50% CDF of 1,250 for this pesticide. Two occurrences of p,p-DDT were detected, one at a concentration of 2,500 ppt at station I-35 and the other at a concentration of 3,100 ppt at station I-14. Both of these values are well below the 50% CDF of 10,000 ppt for p,p-DDT. There is no evidence that the occurrence of these pesticides is related to input from the SBOO, especially since wastewater discharge from the outfall has been limited to the southern diffuser leg since operation began (see Chapter 1). For example, stations I-29 and I-35 are located at least 7.3 km north of the outfall, while station I-14 is located near the end of the northern diffuser leg. Furthermore, these pesticides were already known to occur at these sites prior to construction of the outfall (see City of San Diego 1999).

PAHs and PCBs

During the July survey, PCB 138 and PCB 153/68 were found at station I-13, located just west of the outfall wye, with concentrations of 500 parts per trillion (ppt) and 700 ppt, respectively. However, these values are considered unreliable since they are well below the MDLs of 3,000 ppt for PCB 138, and 2,600 ppt for PCB 153/68. No polycyclic aromatic hydrocarbons (PAHs) were detected in the region during the 2001 surveys.

SUMMARY & CONCLUSIONS

Sediment conditions surrounding the South Bay Ocean Outfall in 2001 were similar to previous years (see City of San Diego 1999, 2001). The sediments consisted primarily of fine sands with an overall mean particle size of 2.3 phi. However, sediment composition varied between surveys at some stations. This may be partially due to patchy sediment conditions at these stations due to multiple geological origins such as the red relict sands and other detrital sediments (Emery 1960).

Most of the stations that had an average particle size less than 2.0 phi (i.e., coarse to medium sand) were found at the 90, 120 and 180-ft stations where large deposits of Pleistocene sediments are present (see City of San Diego 1988). Sediments composed of very fine sands (i.e, >3.0 phi) were found primarily at stations along the 60 and 90-ft depth contours, and are probably the result of sediment deposition from the Tijuana River and, to a lesser extent, from San Diego Bay (City of San Diego 1988).

Higher concentrations of organic compounds and most trace metals were generally associated with finer sediments. This is consistent with 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). Concentrations of organic indicators and metals were low in the SBOO area compared to data from the entire southern California continental shelf (see Schiff and Gossett 1998). Aluminum, chromium, copper, iron, manganese and zinc were found at all stations and were present in highest concentrations at stations where particle sizes were finest. Arsenic was also found at all stations; however, concentrations of this metal were highest where sediments were generally very coarse.

Other sediment contaminants were rarely detected in the SBOO region in 2001. Two derivatives of the chlorinated pesticide DDT were detected at three stations, while PCB compounds were present at a single station. There were no occurrences of polycyclic aromatic hydrocarbons during the year.

LITERATURE CITED

Anderson, J.W., D.J. Reish, R.B. Spies, M.E. Brady, and E.W. Segelhorst. (1993). Human Impacts. In: Dailey, M.D., D.J. Reish and J.W. Anderson, (eds.). Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berkeley, CA. p. 682-766

City of San Diego. (1988). Tijuana Oceanographic Engineering Study, Vol I: Ocean Measurement Program. Prepared by Engineering Science for the City of San Diego.

City of San Diego. (1999). International Wastewater Treatment Plant: Final Baseline Ocean Monitoring Report for the South Bay Ocean Outfall (1995-1998). City of San Diego Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2001). South Bay Ocean Outfall Annual Report (2000). City of San Diego. Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

Clesceri, L., A. E. Greenberg, and A. D. Eaton. (1998). Standard Methods for the Examination of Water and Wastewater. 20th Edition. American Public Health Association, American Water Works Association, and Water Environment Federation.

Cross, J. N., and L. G. Allen. (1993). Fishes. In: Dailey, M.D., D.J. Reish and J. W. Anderson, (eds.). Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berkeley, CA. p. 459-540.

Eganhouse, R. P., and M.. I. Venkatesan. (1993). Chemical Oceanography and Geochemistry. In: Dailey, M.D., D.J. Reish and J. W. Anderson, (eds.). Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berkeley, California. p. 682-766

Emery, K. O. (1960). The Sea Off Southern California. John Wiley, New York, 366 pp.

Folk, R. L. (1968). Petrology of Sedimentary Rocks. Austin, Texas: Hemphill, 182 pp. http://www.lib.utexas.edu/geo/FolkReady/TitlePage.html

Gray, J. S. (1981). The Ecology of Marine Sediments: An Introduction to the Structure and Function of Benthic Communities. Cambridge University Press, Cambridge, England, 185 pp.

Schiff, K. C., and R. W. Gossett. (1998). Southern California Bight 1994 Pilot Project: Volume III. Sediment Chemistry. Southern California Coastal Water Research Project. Westminister, California.

Snelgrove, P. V. R., and C. A. Butman. (1994). Animal-sediment relationships revisited: cause versus effect. Oceanogr. Mar. Biol. Ann. Rev., 32: 111-177

USEPA (1987). Quality Assurance and Quality Control for 301(h) Monitoring Programs: Guidance on Field and Laboratory Methods. EPA Document 430/9-86-004. Office of Marine and Estuary Protection. 267 p.

Chapter 4

Benthic Infauna

INTRODUCTION

The City of San Diego was contracted by the International Boundary and Water Commission (IBWC) to monitor benthic infaunal communities at fixed locations surrounding the South Bay Ocean Outfall (SBOO). This contractual agreement also included monitoring at a random array of stations ranging from the border between the United States and Mexico to northern San Diego County (see Appendix E).

Assessment of changes in benthic community structure is a major component of many marine monitoring programs, based largely on the premise that such changes may be correlated with the alteration of environmental conditions (Pearson and Rosenberg 1978). The data from such programs are used to document both existing conditions and changes in these conditions over time. However, in order to determine whether changes are related to anthropogenic or natural events, it is necessary to have documentation of background or reference conditions for an area. Such information is available for the SBOO discharge area (City of San Diego 2000a) and the San Diego region in general (e.g., City of San Diego 1999).

This chapter presents analyses and interpretations of the macrofaunal data collected at fixed stations surrounding the SBOO during January and July 2001. Included are descriptions and comparisons of soft-bottom infaunal assemblages in the area, and analysis of benthic community structure.

MATERIALS & METHODS

Collection and Processing of Samples

Benthic infauna samples were collected during January and July 2001 at 27 stations surrounding the SBOO pipe (Figure 4.1). These stations range in depth from 59 to 197 ft (19-60 m) and approximate four depth contours. Stations listed from north to south along each contour include: (1) 60-ft contour, stations I-34, I-35, I-31, I-23, I-18, I-10, I-4; (2) 90-ft contour, stations I-33, I-30, I-27, I-22, I-14, I-15, I-16, I-12, I-9, I-6, I-3; (3) 120-ft contour, stations I-29, I-21, I-13, I-8, I-2; and (4) 180-ft contour, stations I-28, I-20, I-7, I-1.

Samples for benthic community analysis were collected from two replicate 0.1 m^2 van Veen grabs per station during each survey. 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 2002). After a minimum of 72 hours, each sample was rinsed with fresh water and transferred to 70% ethanol.

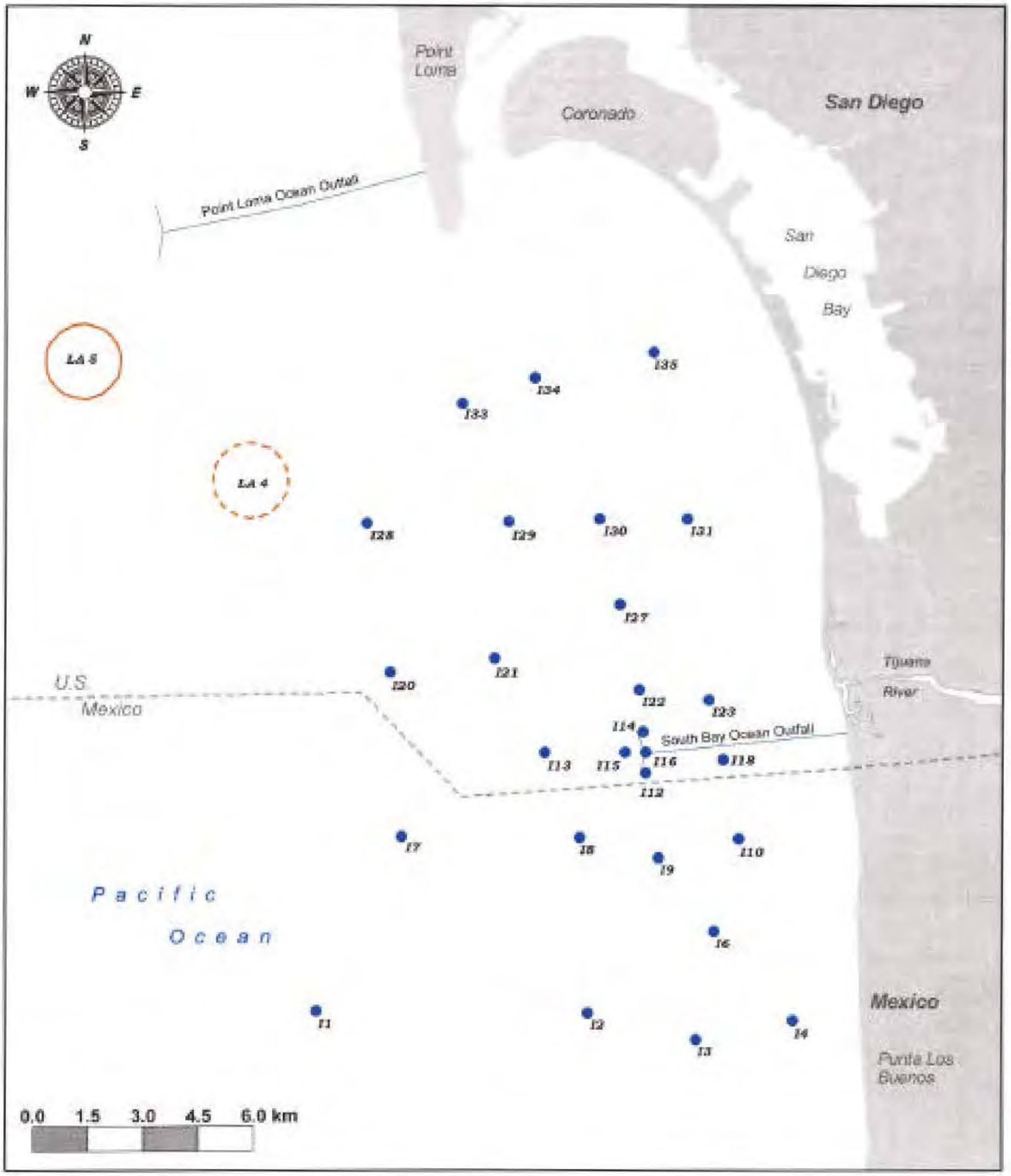


Figure 4.1
Benthic infauna station locations, South Bay Ocean Outfall Monitoring Program.

All organisms were sorted from the debris into major taxonomic groups by a subcontractor (MEC Analytical Systems, Inc., Carlsbad, California). Biomass was measured as the wet weight in grams per sample for each of the following taxonomic categories: Polychaeta (Annelida), Crustacea (Arthropoda), Mollusca, Ophiuroidea (Echinodermata), 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: (1) species richness (number of species per grab); (2) total number of species per station (i.e., cumulative of two replicate samples); (3) abundance (number of individuals per grab); (4) biomass (grams per grab, wet weight); (5) Shannon diversity index (H' per grab); (6) Pielou's evenness index (J' per grab); (7) Swartz dominance (minimum number of species accounting for 75% of the total abundance in each grab); (8) Infaunal Trophic Index (ITI per grab) (see Word 1980).

Ordination (principal coordinates) and classification (hierarchical agglomerative clustering) analyses were performed to examine spatio-temporal patterns in the overall similarity of benthic assemblages in the region. These analyses were performed using Ecological Analysis Package (EAP) software (see Smith 1982, Smith et al. 1988). The macrofaunal abundance data were square-root transformed and standardized by the species mean values greater than zero. Prior to analysis the data set was reduced by excluding any species represented by less than 20 individuals over all samples. The effect of such reductions on the outcome of subsequent analyses is negligible (see Smith et al. 1988).

RESULTS & DISCUSSION

Community Parameters

Number of Species

Species richness varied on both spatial and temporal scales in the SBOO region, with no apparent influence by proximity to the outfall. A total of 692 benthic infaunal taxa was identified in 2001, though only a fraction of these occurred in any single sample. The average number of taxa per 0.1 m^2 grab ranged from 33 at station I-3 to 124 at station I-28 (Table 4.1). This spatial pattern was consistent with previous surveys (see City of San Diego 2001). The wide variation in species richness can probably be attributed to different habitat types. Higher values, for example, are common at stations such as I-28, I-29 and I-9 where the sediments are characterized by relatively greater percentages of silt and clay (see Chapter 3). In addition, species richness varies seasonally in the region, with there typically being higher numbers of species in July than in January (see Figure 4.2A). This seasonal pattern was pronounced in 2001, with average species richness increasing about 32% between the January and July surveys.

Table 4.1

Benthic infaunal community parameters at SBOO stations sampled in 2001. Data are expressed as annual means for: (1) species richness, no. species/0.1 m^2 (SR); (2) total no. species per site (Tot spp); (3) abundance/0.1 m^2 (Abun); (4) biomass, g/0.1 m^2; (5) diversity (H'); (6) evenness (J'); (7) Swartz dominance, no. species comprising 75% of a community by abundance (Dom); (8) infaunal trophic index (ITI). Minimum (Min) and Maximum (Max) values are for individual grabs (two each for January and July surveys) except for total no. of species, which is cumulative per survey.

	SR	Tot spp	Abun	Biomass	H'	J'	Dom	ITI
60 ft stations								
I-34	47	76	181	6.7	3.1	0.8	16	70
I-35	74	104	240	6.3	3.9	0.9	31	76
I-31	48	70	109	2.2	3.5	0.9	23	79
I-23	57	87	141	3.9	3.6	0.9	25	84
I-18	45	69	94	2.7	3.4	0.9	22	82
I-10	51	78	124	3.9	3.5	0.9	21	84
I-4	36	57	99	1.6	3.1	0.9	14	73
90 ft stations								
I-33	83	119	214	3.1	4.0	0.9	36	81
I-30	73	107	195	1.9	4.0	0.9	33	84
I-27	63	96	160	4.4	3.8	0.9	27	82
I-22	62	92	153	1.5	3.7	0.9	26	83
I-14	58	86	156	2.9	3.7	0.9	24	80
I-15	56	92	188	5.5	3.4	0.9	20	77
I-16	55	90	182	4.0	3.4	0.9	19	79
I-12	43	71	114	1.8	3.2	0.9	17	77
I-9	87	125	251	3.1	4.0	0.9	34	84
I-6	50	78	140	7.3	3.3	0.9	19	68
I-3	33	52	117	6.2	2.8	0.8	12	80
120 ft stations								
I-29	95	139	264	4.6	4.1	0.9	39	85
I-21	48	72	177	3.9	3.2	0.8	17	85
I-13	55	90	156	4.1	3.5	0.9	23	86
I-8	41	60	112	4.0	3.1	0.8	16	77
I-2	42	60	154	2.5	3.0	0.8	13	75
180 ft stations								
I-28	124	176	374	5.4	4.3	0.9	49	86
I-20	50	76	181	2.7	3.3	0.8	16	87
I-7	55	80	191	6.9	3.2	0.8	17	95
I-1	59	88	151	4.0	3.4	0.9	23	84
All stations								
Mean	59	88	171	4.0	3.5	0.9	23	81
Min	19	41	47	0.3	2.3	0.7	6	55
Max	149	191	479	19.3	4.5	0.9	57	95

Polychaete worms comprised the greatest proportion of species, accounting for around 31 to 53% of the taxa at various sites during 2001. Crustaceans and pycnogonids comprised 17 to 31% of the species, molluscs from 8 to 25%, echinoderms from 2 to 12%, and all other taxa combined about 6 to 17%. These percentages are generally similar to those observed during previous years, including prior to discharge (e.g., see City of San Diego 2000a, 2001).

Infaunal Abundance

Infaunal abundance during 2001 ranged from a mean of 94 to 374 animals per grab (Table 4.1). The greatest number of animals occurred at stations I-28, I-29, I-9 and I-35, which were the only sites that averaged 240 or more individuals per sample. Stations I-18, I-4 and I-31, along the 60-ft depth contour, had the lowest abundance values. No clear spatial patterns were evident with respect to the outfall. There was a considerable difference in abundance values between the January and July surveys. For example, average abundance was over 40% lower in January 2001 than in July of both 2000 and 2001 (see Figure 4.2B). This reflects a seasonal pattern similar to that described for species richness. Overall, abundance values were well within the range of historical variation.

Similar to past years, polychaetes were the most abundant animals in the region, accounting for 25 to 67% of the different assemblages during 2001. Crustaceans (and pycnogonids) averaged 10 to 41% of the animals at a station, molluscs from 6 to 24%, echinoderms from 1 to 15%, and all remaining taxa about 4 to 16% combined.

Biomass

Total infaunal biomass averaged from 1.5 to 7.3 g per 0.1 m^2 (Table 4.1). The highest biomass values in any one sample can often be attributed to the collection of a small number of large organisms such as sand dollars, sea stars, crabs and clams. For example, a single specimen of the bivalve mollusc *Simomactra planulata* accounted for 65% of the total annual biomass at station I-34. The biomass of this individual was greater than the composite weight of all other organisms collected at I-34 during 2001, and accounted for the highest biomass for any individual grab (19.3 g, Table 4.1). Overall, the biomass at SBOO stations in 2001 was well within the range of historical values (Figure 4.2C). Lower biomass in the January survey corresponded to similar changes in species richness and abundance. Long-term seasonal patterns, however, are less clear and likely confounded by the occasional presence of megabenthic invertebrates.

None of the major taxa consistently dominated in terms of biomass. Polychaetes accounted for 7 to 63% of the biomass at a station, crustaceans 1 to 36%, molluscs 2 to 77%, echinoderms >1 to 90%, and all other taxa combined >1 to 20%. Echinoderms were typically the dominant component at sites where biomass exceeded 5 g per 0.1 m^2 (e.g., stations I-3, I-6, I-7, I-15). The main exceptions to this pattern occurred at a few stations where the biomass was dominated by either polychaetes (I-28, I-35) or molluscs (I-34).

Species Diversity and Dominance

Species diversity (H') varied little during 2001 and was generally similar to background conditions (Figure 4.2D), although it did differ between stations (Table 4.1). Overall values averaged from 2.8 to 4.3. Similar to previous years, diversity was highest (> 4.0) at stations I-28 and I-29 and lowest (2.8) at station I-3.

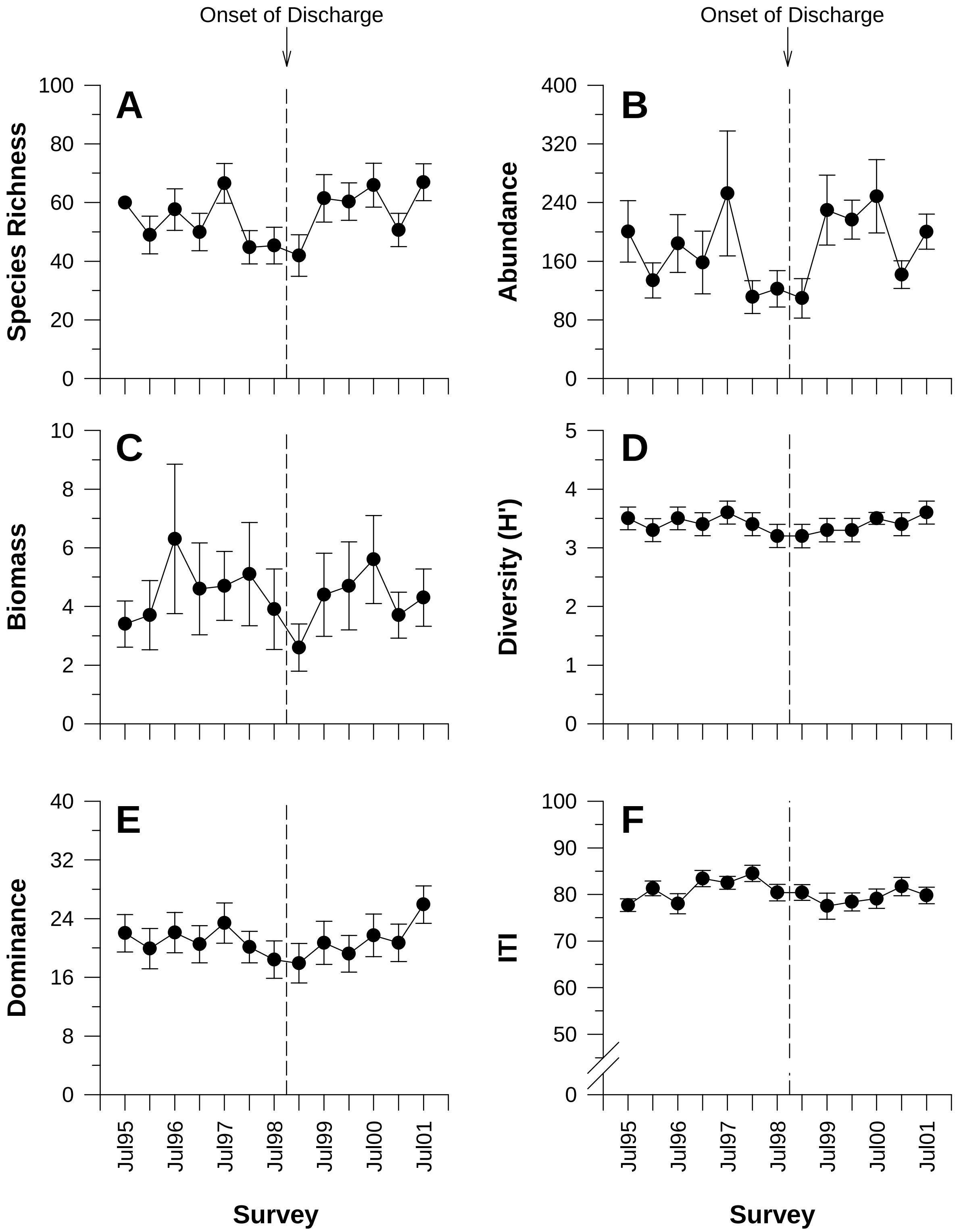


Figure 4.2

Summary of benthic community structure parameters surrounding the South Bay Ocean Outfall (1995 – 2001): (A) species richness = number of species; (B) abundance = number of animals; (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.

Species dominance was measured as the minimum number of species comprising 75% of a community by abundance (see Swartz 1978). Dominance discussed herein is therefore inversely proportional to numerical dominance, such that low values indicate communities dominated by few species. Although most of the SBOO assemblages were characterized by a fairly even distribution of species (i.e., mean J' = 0.8-0.9), dominance values varied widely, averaging from 12 to 49 species per station during the year (Table 4.1). Dominance was 25% higher (lower numerical dominance) in the July survey than in January (Figure 4.2E), consistent with the pattern of seasonal variation noted earlier. No clear patterns relative to the outfall were evident in terms of diversity, evenness, or dominance.

Infaunal Trophic Index (ITI)

ITI values averaged from 68 to 95 at the various sites in 2001 (Table 4.1). 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). Although ITI values averaged over all sites have changed little since monitoring began (see Figure 4.2F), the index has been more variable at the individual stations. For example, three individual grabs at stations I-34, I-4 and I-6 had values in the range of 55 - 60. These values may be indicative of "changed"communities (i.e., ITI between 30 and 60, Bascom et al. 1979), potentially influenced by the proximity of these sites to San Diego Bay (station I-34) or the Canyon San Antonio de los Buenos Creek outlet in Mexico (stations I-4 and I-6).

Dominant Macrofauna

Most assemblages in the SBOO region were dominated by polychaete worms. For example, of the 10 most abundant and the 10 most widely occurring taxa, nine were polychaetes (Table 4.2). The remaining dominant species included four crustaceans and two molluscs. Of the 692 taxa identified during 2001, about 19% represented rare or unidentifiable taxa that were recorded only once.

The spionid polychaete *Spiophanes bombyx* was the most abundant and the most ubiquitous species, averaging about 10 worms per grab and occurring in 98% of the samples. Only six other species were present in at least 70% of the samples. Five of these were also polychaetes, including an orbiniid, *Scoloplos armiger* (likely a species complex), a sigalionid (*Sigalion spinosus*), an onuphid (*Onuphis* sp SD1), and two maldanids (Euclymeninae sp A and unidentified Maldanidae). The other widely distributed species was a bivalve mollusc (*Tellina modesta*). A few additional species occurred in relatively high densities (i.e., ~ 10-14 animals per occurrence), but at more restricted localities (i.e., 11-20% of the samples). These included the polychaetes *Jasmineira* sp B and *Chloeia pinnata*, and the gammarid amphipod *Eohaustorius barnardi*.

Pattern Analysis

Ordination and classification analyses discriminated between six habitat-related benthic assemblages at the SBOO stations during 2001 (see Figures 4.3 and 4.4). The dominant species comprising each group are listed in Table 4.3. Depth and sediment grain size (i.e., fine vs. coarse sediments) appeared to be the major factors affecting the distribution of these assemblages.

Table 4.2

Dominant macroinvertebrates at the SBOO benthic stations sampled during 2001. Included are the 10 most abundant species overall and per occurrence, and the 10 most widely distributed species. Abundance values are summarized over all stations and are expressed as means per 0.1 m^2 over all samples (MS) and per occurrence (MO); PO = percent occurrence.

Species	Higher taxa	MS	MO	PO
Top 10 Species Overall				
1. *Spiophanes bombyx*	Polychaeta: Spionidae	10.3	10.5	98%
2. *Monticellina siblina*	Polychaeta: Cirratulidae	4.3	6.9	63%
3. *Tellina modesta*	Mollusca: Bivalvia	4.0	5.7	70%
4. Eulcymeninae sp A	Polychaeta: Maldanidae	3.3	4.6	72%
5. Maldanidae †	Polychaeta: Maldanidae	2.9	3.9	76%
6. *Jasmineira* sp B	Polychaeta: Sabellidae	2.9	14.4	20%
7. *Rhepoxynius menziesi*	Crustacea: Phoxocephalidae	2.6	4.5	59%
8. *Ampelisca cristata microdentata*	Crustacea: Ampeliscidae	2.5	7.4	33%
9. *Spiophanes duplex*	Polychaeta: Spionidae	2.3	3.6	65%
10. *Caecum crebricinctum*	Mollusca: Gastropoda	2.3	6.5	35%
Top 10 Species per Occurrence				
1. *Jasmineira* sp B	Polychaeta: Sabellidae	2.9	14.4	20%
2. *Chloeia pinnata*	Polychaeta: Amphinomidae	1.3	11.3	11%
3. *Spiophanes bombyx*	Polychaeta: Spionidae	10.3	10.5	98%
4. *Eohaustorius barnardi*	Crustacea: Haustoriidae	1.1	10.2	11%
5. *Nephasoma diaphanes*	Sipuncula: Golfingiidae	0.5	9.3	6%
6. *Polycirrus* sp SD 1	Polychaeta: Terebellidae	0.2	8.0	2%
7. *Ampelisca cristata microdentata*	Crustacea: Ampeliscidae	2.5	7.4	33%
8. *Petaloclymene pacifica*	Polychaeta: Maldanidae	1.0	6.9	15%
9. *Monticellina siblina*	Polychaeta: Cirratulidae	4.3	6.9	63%
10. *Euchone arenae*	Polychaeta: Sabellidae	1.8	6.8	26%
Top 10 Widespread Species				
1. *Spiophanes bombyx*	Polychaeta: Spionidae	10.3	10.5	98%
2. *Scoloplos armiger* (=spp complex)	Polychaeta: Orbiniidae	1.5	1.9	78%
3. Maldanidae †	Polychaeta: Maldanidae	2.9	3.9	76%
4. *Sigalion spinosus*	Polychaeta: Sigalionidae	1.9	2.6	76%
5. Eulcymeninae sp A	Polychaeta: Maldanidae	3.3	4.6	72%
6. *Onuphis* sp SD 1	Polychaeta: Onuphidae	1.7	2.4	72%
7. *Tellina modesta*	Mollusca: Bivalvia	4.0	5.7	70%
8. *Euphilomedes carcharodonta*	Crustacea: Ostracoda	2.2	3.2	69%
9. *Hemilamprops californicus*	Crustacea: Cumacea	1.4	2.1	67%
10. *Spiophanes duplex*	Polychaeta: Spionidae	2.3	3.6	65%

† = unidentified juveniles and/or damaged specimens

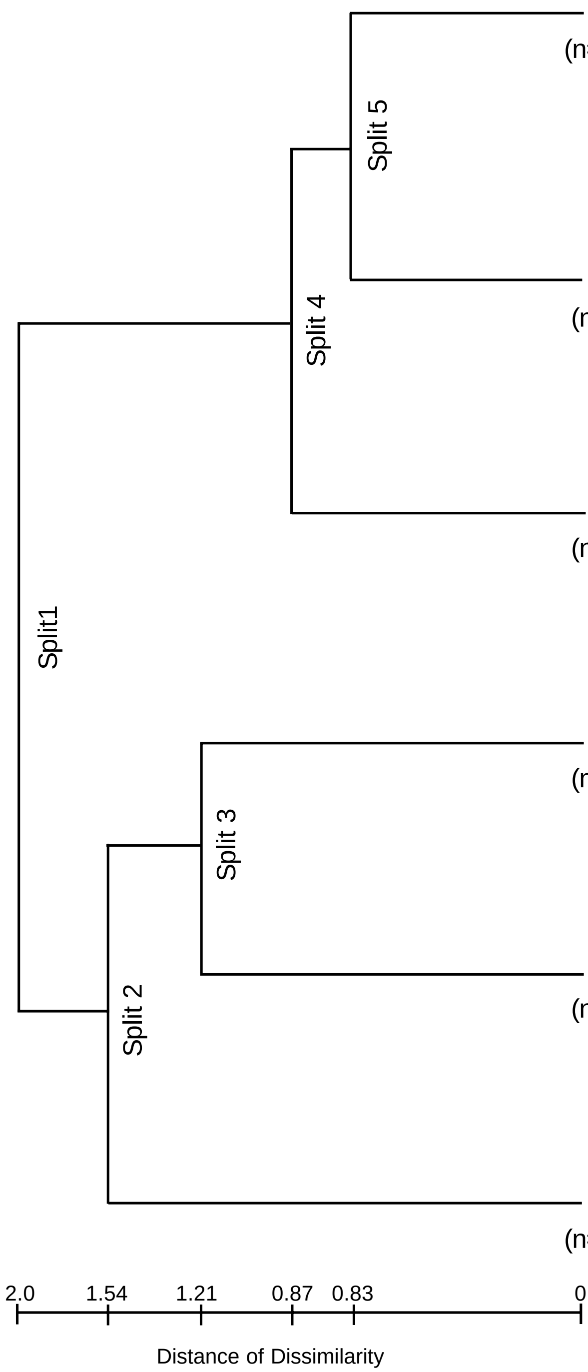
The first split in the dendrogram was associated primarily with depth, and separated the sites into two primary clusters, groups A-C versus groups D-F (see split 1 in Figure 4.3). Groups A-C consisted entirely of stations along the 60 and 90-ft depth contours, accounting for 75% of the SBOO stations at those depths. The remaining shallow stations comprised group F, which were characterized by coarser sediments (average percent fines=1.5) than those in groups A-C (average percent fines >6). This shallow, coarse sediment assemblage was more closely associated with the deeper assemblages of groups D and E.

Groups A, B and C separated primarily by depth and proximity to the outfall (see Figures 4.3 and 4.4). Group A had the second highest average percentage of fine particles (14% fines), and included eight stations along the 90-ft contour and one 60-ft station (I-35). Assemblages at these sites were dominated by the cirratulid polychaete *Monticellina siblina* followed by the bivalve *Tellina modesta* and the spionid polychaete *Spiophanes bombyx* (Table 4.3). Group B contained sites along the 60-ft contour. *Spiophanes bombyx* was the most abundant organism at these shallow stations, followed by the gammarid amphipods *Ampelisca brachycladus* and *Rhepoxynius menziesi*. Group C was restricted to the January surveys of stations I-12 and I-16, the two sites nearest the outfall. The three most abundant species present at these sites were the ophiuroid *Amphiodia urtica*, and the polychaetes *Monticellina siblina* and *Lumbrineris latrielli* (Table 4.3).

Groups D-F represented two deepwater assemblages (i.e., >125 ft) and a coarse sediment assemblage of shallower depths. Groups D and E contained the deepest SBOO stations that separated from each other primarily by the presence or absence of relict red sands (see Table 3.1, Chapter 3). Group D consisted of sites lacking relict red sands, some of which also contained a high percentage of fines (i.e., stations I-28 and I-29). The three most abundant species characterizing this assemblage were the amphinomid polychaete *Chloeia pinnata*, the terebellid polychaete *Pista* sp B, and the ophiuroid *Amphiodia urtica* (Table 4.3). The stations comprising group E had sediments characterized by the presence of coarse relict red sands and very little fines (0.2%). This infaunal assemblage was dominated by the sabellid polychaetes *Jasmineira* sp B and *Euchone arenae*, followed by the gastropod mollusc *Caecum crebricinctum*. Group F contained shallow stations that separated from groups D and E at the second split of the dendrogram (see split 2 in Figure 4.3). This group included stations with a relatively low percentage of fines, and also included some stations with relict red sands. *Spiophanes bombyx*, ubiquitous at the SBOO stations, was the dominant species in this group. Other abundant species included the gammarid amphipod *Rhepoxynius heterocuspidatus* and the the sand dollar *Dendraster terminalis* (Table 4.3).

SUMMARY & CONCLUSIONS

Benthic infaunal communities surrounding the South Bay Ocean Outfall were similar in 2001 to those that occurred prior to discharge and during the first two years of outfall operation (City of San Diego 2000a, 2000b, 2001). 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, several of the assemblages described herein (e.g, groups A, B, F) were dominated by the spionid polychaete *Spiophanes bombyx*, a species characteristic of shallow-water environments in the SCB (see Bergen et al. 2001). These three groups represented sub-assemblages of the shallow SCB benthos that



Cluster Group	Avg. Depth	Avg. % Fines	Stations
A (n=16)	90ft	14.5	I-9, I-14, I-15b, I-16b, I-22, I-27, I-30, I-33, I-35
B (n=9)	64ft	8.0	I-4b, I-10, I-18, I-23, I-31
C (n=2)	92ft	6.1	I-12a, I-16a
D (n=7)	170ft	16.8	I-1, I-20b, I-28, I-29
E (n=6)	154ft	0.2	I-7, I-13a, I-20a, I-21
F (n=14)	93ft	1.5	I-2, I-3, I-4a, I-6, I-8, I-12b, I-13b, I-15a, I-34

Figure 4.3

Cluster results of macrofaunal abundance data for the SBOO benthic stations sampled during January and July 2001. Station designations: a=January survey, b=July survey, no letter designation=both surveys. Fines=silt + clay fraction.

Table 4.3

Summary of the most abundant taxa comprising cluster groups A-F from the 2001 infaunal 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 comprising each cluster group

		Cluster Group					
Species/Taxa	Higher Taxa Code*	A (n=16)	B (n=9)	C (n=2)	D (n=7)	E (n=6)	F (n=14)
Rhepoxynius stenodes	C	3.3	4.1	0.8	0.2	.	0.1
Nereis procera	P	4.6	0.7	.	0.9	.	0.1
Ampelisca brachycladus	C	0.8	7.5	0.5	.	.	0.1
Rhepoxynius menziesi	C	4.3	6.1	5.3	0.4	0.1	0.3
Tellina modesta	M	8.8	5.7	4.8	0.3	.	0.9
Diastylopsis tenuis	C	0.1	2.7	.	.	.	0.3
Ampelisca cristata microdentata	C	7.5	0.1	.	1.9	.	.
Ampelisca brevisimulata	C	4.4	0.6	.	2.9	.	.
Monticellina siblina	P	10.2	0.9	9.0	5.6	.	0.3
Mediomastus sp	P	3.8	0.5	2.8	3.3	.	0.1
Sthenelanella uniformis	P	0.5	.	.	6.4	0.2	.
Spiophanes duplex	P	3.3	3.2	.	6.2	0.2	0.1
Euclymeninae sp A	P	7.4	3.2	.	3.2	1.1	0.2
Sigalion spinosus	P	3.5	3.3	0.3	1.2	1.2	0.3
Euphilomedes carcharodonta	C	3.4	0.7	0.8	1.1	0.3	3.4
Maldanidae, unidentified	P	3.5	1.1	.	4.5	1.9	3.5
Myriochele sp M	P	2.2	0.1	0.8	0.4	6.7	0.1
Foxiphalus obtusidens	C	2.3	0.9	3.3	1.7	1.9	0.6
Amphiodia urtica	E	0.1	.	12.5	6.6	.	0.4
***Pista* sp B**	P	0.6	.	.	8.0	0.2	.
Chloeia pinnata	P	<0.1	.	.	8.9	0.8	.
Chone mollis	P	0.1	.	3.8	0.3	.	0.4
Lumbrineris latreilli	P	0.1	.	8.8	0.1	0.2	0.1
Spiophanes bombyx	P	8.3	9.2	2.0	6.3	5.7	18.4
Scoloplos armiger (=spp complex)	P	1.0	0.3	1.0	0.6	1.3	3.3
Astropecten verrilli	E	0.6	.	7.3	0.6	0.6	0.8
Ampelisca cristata cristata	C	0.7	5.2	0.3	0.1	3.6	1.1
Eohaustorius barnardi	C	0.1	0.1	.	.	.	4.2
Rhepoxynius heterocuspidatus	C	0.2	0.1	0.3	0.1	1.3	5.2
Dendraster terminalis	E	0.1	0.2	0.3	.	2.1	5.1
Protodorvillea gracilis	P	0.1	.	.	.	.	2.8
Ophelia pulchella	P	<0.1	.	.	.	0.1	3.2
Amphiodia sp	E	0.4	0.2	5.3	3.9	0.3	0.9
Apionsoma misakianum	S	0.1	.	3.3	3.9	5.3	0.3
Ophiuroconis bispinosa	E	<0.1	.	.	2.7	6.5	0.5
Euchone arenae	P	<0.1	0.1	.	0.4	12.8	1.0
Caecum crebricinctum	M	.	0.1	.	0.3	8.8	4.9
***Jasmineira* sp B**	P	0.1	.	.	3.6	22.1	.
Mooreonuphis sp SD 1	P	.	.	.	1.8	7.3	0.3
Lirobarleeia kelseyi	M	.	.	.	0.4	6.4	<0.1
Syllis (Typosyllis) sp SD 1	P	.	.	.	.	4.6	0.2

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

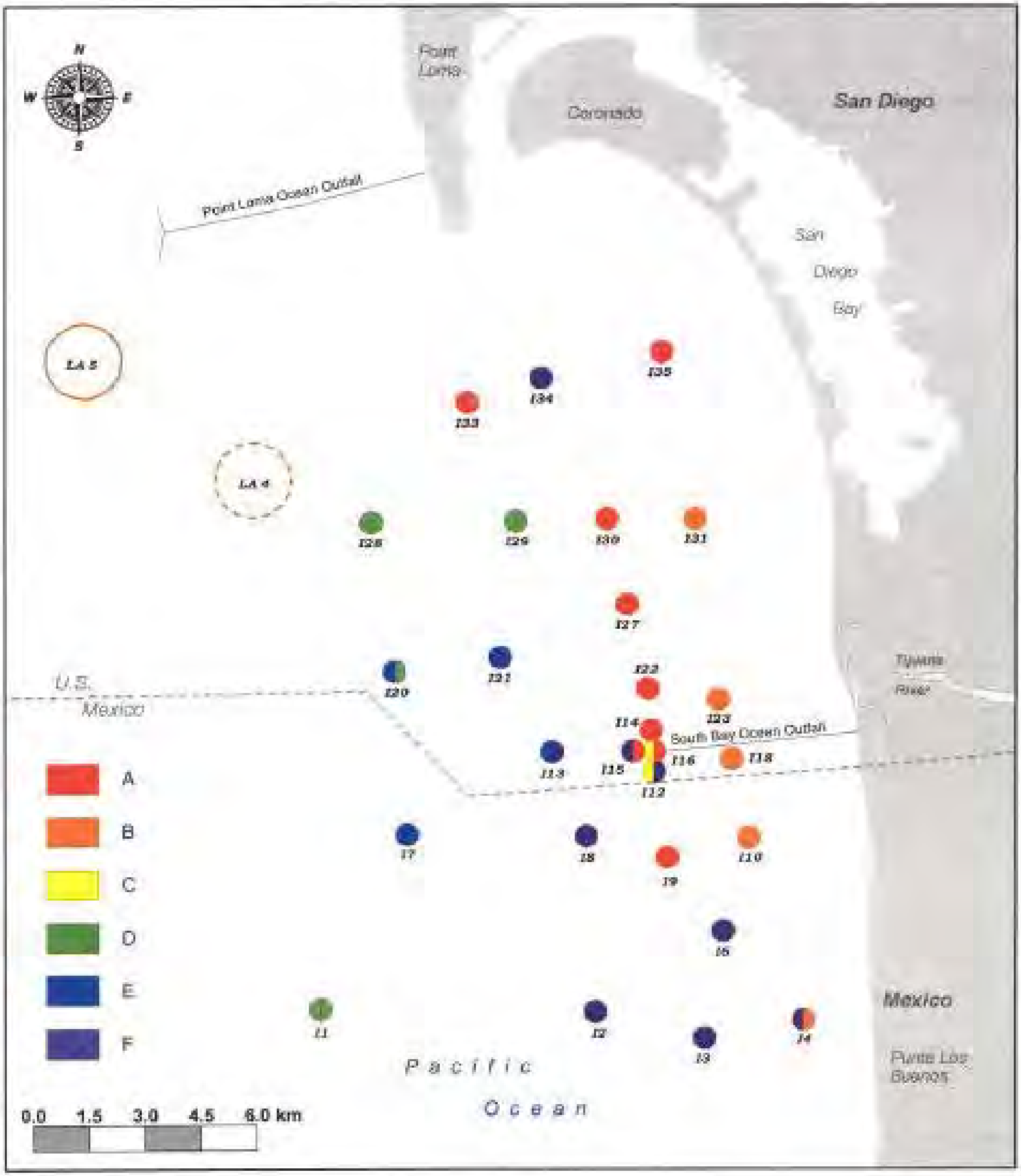


Figure 4.4

SBOO benthic infauna stations sampled during January and July 2001, color-coded to represent affiliation with infaunal cluster groups. Left half of circle represents cluster group affiliation for the January survey, right half represents the July survey.

differred in terms of 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., groups A and B) or coarser sediments, including relict red sands (i.e., group F). In contrast, the deeper group D assemblage in the South Bay area was similar to the mid-depth infaunal community characteristic of much of the SCB mainland shelf (see Barnard and Ziesenhenne 1961, Jones 1969, Fauchald and Jones 1979, Thompson et al. 1987, 1993a, b, EcoAnalysis et al. 1993, Zmarzly et al. 1994, Diener and Fuller 1995, Bergen et al. 2001). The ophiuroid *Amphiodia urtica* and the polychaete *Pista* sp B were the most abundant species in this group. Finally, group E represented a second relict red sand assemblage that occurred in deeper waters than group F. These deeper relict red sands were dominated by sabellid worms and the gastropod *Caecum crebricinctum.*

The separation of stations I-12 and I-16 located nearest the outfall (i.e., January only) into cluster group C might be interpreted as an indication of outfall effects on the infaunal community. An analysis of sediment characteristics, however, fails to support this conclusion. For example, there was no evidence of organic loading or elevated levels of trace metals or sulfides at these two sites (see chapter 3). In addition, two of the most abundant taxa at these sites, the ophiuroid *Amphiodia urtica* and the gammarid amphipod *Rhepoxynius menziesi*, are common indicators of undisturbed sediments. Furthermore, ITI values averaged 77 and 79 respectively for stations I-12 and I-16, which are considered characteristic of "normal" or undisturbed sediments (see Bascom et al. 1979).

Patterns of species distribution and abundance varied with depth and sediment type in the region. In spite of various changes, the overall range of values for the different community parameters in 2001 was similar to that seen in previous years (see City of San Diego 2000a, b, 2001). Intra-annual fluctuations in the infaunal community appear primarily related to seasonal influences. Furthermore, average values for parameters such as the infaunal trophic index (ITI) are still characteristic of undisturbed sediments. Finally, changes in benthic community structure near the SBOO are similar in magnitude to those that have occurred elsewhere in southern California and that often correspond to large-scale oceanographic (e.g., El Niño–La Niña oscillations) or other natural events.

It may be too early to detect specific effects of the SBOO on the marine benthos. Such impacts have spatial and temporal dimensions that can vary depending on a range of biological and physical factors. Furthermore, benthic invertebrate populations exhibit substantial spatial and temporal variability that may mask the effects of any disturbance event (Morrisey et al. 1992a, b, Otway 1995). Although some changes have occurred near the SBOO, values for the different community parameters were within the range of those seen in previous years (see City of San Diego 2000a, 2000b, 2001). 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.

LITERATURE CITED

Barnard, J.L., and F.C. Ziesenhenne. (1961). Ophiuroidea communities of southern Californian coastal bottoms. Pac. Nat., 2: 131-152

Bascom, W., A.J. Mearns, and J.Q. Word. (1979). Establishing boundaries between normal, changed, and degraded areas. In: Southern California Coastal Water Research Project Annual Report, 1978. Long Beach, CA. pp. 81-95

Bergen, M., S.B. Weisberg, R.W. Smith, D.B. Cadien, A. Dalkey, D.E. Montagne, J.K. Stull, R.G. Velarde, and J.A. Ranasinghe. (2001). Relationship between depth, sediment, latitude, and the structure of benthic infaunal assemblages on the mainland shelf of southern California. Mar. Biol., 138: 637-647

City of San Diego. (1999). San Diego Regional Monitoring Report for 1994-1997. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2000a). Final Baseline Monitoring Report for the South Bay Ocean Outfall (1995-1998). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2000b). Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (1999). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2001). Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (2000). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2002). 2001 Quality Assurance Manual. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

Diener, D.R., and S.C. Fuller. (1995). Infaunal patterns in the vicinity of a small coastal wastewater outfall and the lack of infaunal community response to secondary treatment. Bull. Southern Cal. Acad. Sci., 94: 5-20

EcoAnalysis, SCCWRP, and Tetra Tech. (1993). Analyses of ambient monitoring data for the Southern California Bight. Final Report to U.S. EPA, Wetlands, Oceans and Estuaries Branch, Region IX, San Francisco, California.

Fauchald, K., and G.F. Jones. (1979). Variation in community structures on shelf, slope, and basin macrofaunal communities of the Southern California Bight. In: Southern California outer continental shelf environmental baseline study, 1976/1977 (second year) benthic program. Vol. II, Principal Invest. Reps., Ser. 2, Rep. 19. Available from: NTIS, Springfield, Virginia; PB80-16601. Science Applications, Inc., La Jolla.

Jones, G.F. (1969). The benthic macrofauna of the mainland shelf of southern California. Allan Hancock Monogr. Mar. Biol., 4: 1-219

Morrisey, D.J., L. Howitt, A.J. Underwood, and J.S. Stark. (1992a). Spatial variation in soft-sediment benthos. Mar. Ecol. Prog. Ser., 81: 197-204

Morrisey, D.J., A.J. Underwood, L. Howitt, and J.S. Stark. (1992b). Temporal variation in soft-sediment benthos. J. Exp. Mar. Biol. Ecol., 164: 233-245

Otway, N.M. (1995). Assessing impacts of deepwater sewage disposal: a case study from New South Wales, Australia. Mar. Poll. Bull., 31: 347-354

Pearson, T.H., and R. Rosenberg. (1978). Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanogr. Mar. Biol. Ann. Rev., 16: 229-311

Smith, R.W. (1982). Analysis of ecological survey data with SAS and EAP. Proc. 7th Annual SAS Users' Group International, 705 pp. (SUGI). SAS Institute, Inc., Cary, North Carolina, p. 610-615

Smith, R.W., B.B. Bernstein, and R.L. Cimberg. (1988). Community-environmental relationships in the benthos: Applications of multivariate techniques. In: Soule, D.F., and G.S. Kleppel (eds.). Marine Organisms as Indicators. Springer-Verlag, New York, pp. 247-326

Swartz, R.C. (1978). Techniques for sampling and analyzing the marine macrobenthos. U.S. Environmental Protection Agency (EPA), Doc. EPA-600/3-78-030, EPA, Corvallis, Oregon. 27 p.

Thompson, B., J. Dixon, S. Schroeter, and D.J. Reish. (1993a). Chapter 8. Benthic invertebrates. In: Dailey, M.D., D.J. Reish, and J.W. Anderson (eds.). Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berkeley, p. 369-458

Thompson, B.E., J.D. Laughlin, and D.T. Tsukada. (1987). 1985 reference site survey. Tech. Rep. No. 221, Southern California Coastal Water Research Project, Long Beach.

Thompson, B.E., D. Tsukada, and D. O'Donohue. (1993b). 1990 reference site survey. Tech. Rep. No. 269, Southern California Coastal Water Research Project, Long Beach.

USEPA (United States Environmental Protection Agency). (1987). Quality Assurance and Quality Control (QA/QC) for 301(h) Monitoring Programs: Guidance on Field and Laboratory Methods. EPA Document 430/9-86-004. Office of Marine and Estuarine Protection. 267 p.

Word, J.Q. (1980). Classification of benthic invertebrates into infaunal trophic index feeding groups. In: Bascom, W. (ed.). Biennial Report for the Years 1979-1980, Southern California Coastal Water Research Project, Long Beach, p. 103-121

Zmarzly, D.L., T.D. Stebbins, D. Pasko, R.M. Duggan, and K.L. Barwick. (1994). Spatial patterns and temporal succession in soft-bottom macroinvertebrate assemblages surrounding an ocean outfall on the southern San Diego shelf: Relation to anthropogenic and natural events. Mar. Biol., 118: 293-307

Chapter 5

Demersal Fishes and Megabenthic Invertebrates

INTRODUCTION

Demersal fishes and megabenthic invertebrates are conspicuous components of soft-bottom habitats of the mainland shelf and slopes off southern California. More than 100 species of fish inhabit the Southern California Bight (SCB) (Allen 1982, Love et al. 1986, Allen et al. 1998), while the megabenthic invertebrate fauna consists of more than 200 species (Allen et al. 1998). These communities have become an important focus of monitoring programs throughout the world. Fishes of the 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). Although much is known about SCB assemblages in general (see Allen et al. 1998 and references therein), until recently no trawl data existed that described the region encompassing the United States/Mexican border. Studies of this area will be useful in characterizing the marine environment in terms of community structure and stability and may also provide insight into the effects of both anthropogenic and natural inputs.

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. This chapter presents analyses and interpretations of demersal fish and megabenthic invertebrate data collected during 2001.

MATERIALS & METHODS

Field Sampling

Trawl surveys were conducted in January, April, July and October 2001 at seven fixed sites around the South Bay Ocean Outfall (Figure 5.1). These stations, SD15 - SD21, are located along the 90-ft (27-m) isobath, and encompass an area from a point south of Point Loma, California, USA to Punta Bandera, Baja California, Mexico. A single trawl was performed at each station during a survey 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 following 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 2002).

Trawl catches were brought on board for sorting and inspection. All organisms captured were identified to species or to the lowest taxon possible. If an animal could not be identified in the field, it was returned to the laboratory for further identification. The total number of individuals and the total biomass (wet weight, kg) were recorded for each species of fish, and each individual was inspected for the presence of external parasites or physical anomalies

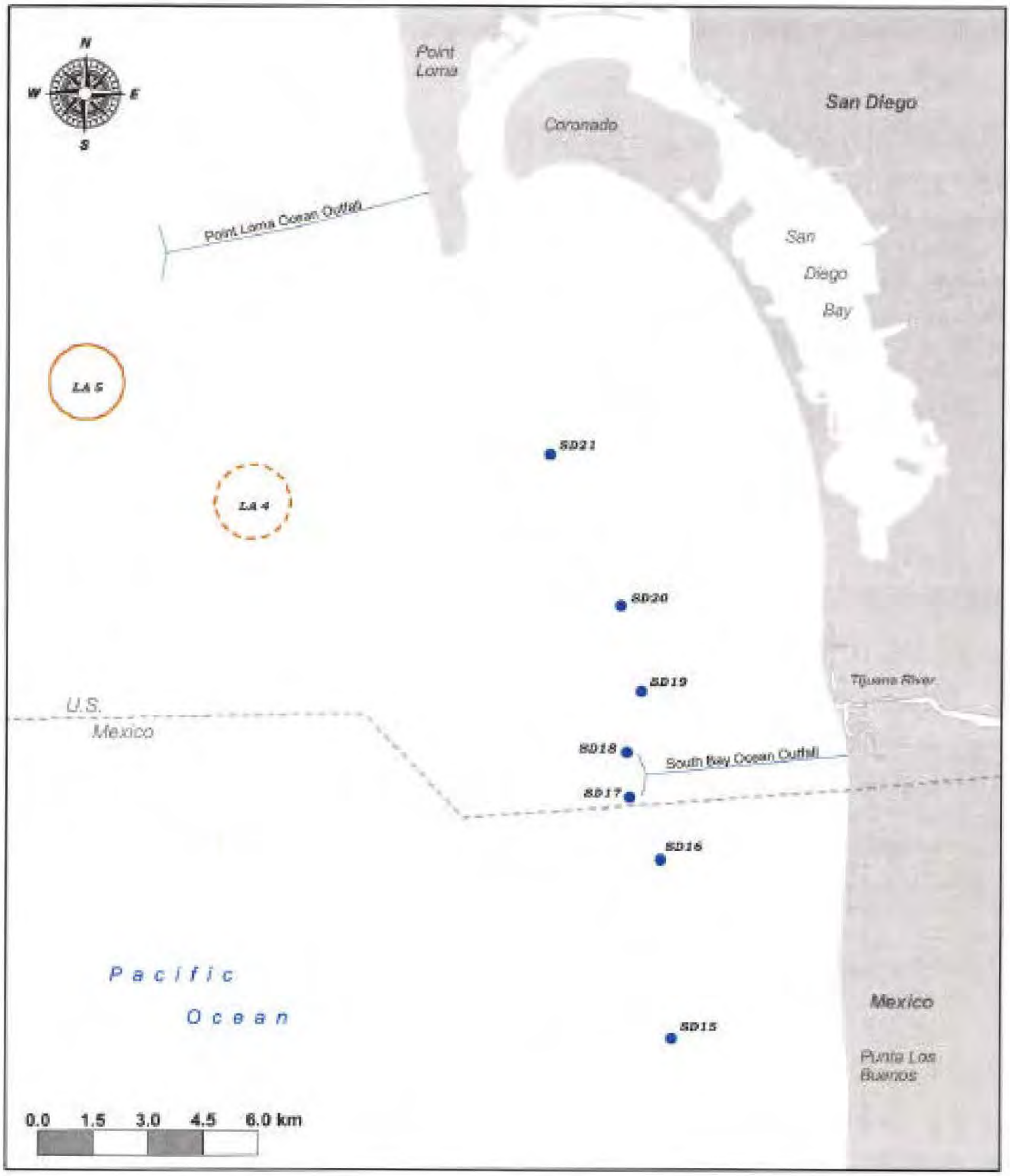


Figure 5.1

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

(e.g., tumors, fin erosion, discoloration). The length of each fish was measured to the nearest centimeter according to protocols described in City of San Diego (2002). Large invertebrate species were weighed separately. However, due to the small size of most organisms, invertebrate biomass was primarily measured as a composite wet weight (kg) of all species combined. When the echinoid *Lytechinus pictus* was collected in large numbers, its abundance was estimated by multiplying the total number of individuals per 1.0 kg subsample by the total urchin biomass.

Data Analyses

Each fish and invertebrate species was summarized in terms of frequency of occurrence (number of occurrences/ total number of trawls x 100), percent abundance (number of individuals/total of all individuals caught x 100), mean abundance per haul (number of individuals/total number of trawls), and 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 (number of individuals); (3) Shannon diversity index (H’); (4) total biomass (wet weight, kg).

Ordination (principal coordinates) and classification (hierarchical agglomerative clustering) analyses were performed to examine spatio-temporal patterns in the similarity of demersal fish assemblages in the region. The total abundance per trawl for each species was used in the analyses, although the data were square-root transformed and standardized by species mean of values greater than zero. All analyses were performed using Ecological Analysis Package (EAP) software (see Smith 1982, Smith et al. 1988).

RESULTS & DISCUSSION

Fish Community

Twenty-seven species of fish were collected in the area surrounding the South Bay Ocean Outfall in 2001 (Table 5.1). The total catch for the year was 1,572 individuals, representing an average of about 56 fish per trawl. The speckled sanddab was the most abundant fish, comprising 36% of the total catch. This species was also the most frequently occurring species, found in 96% of the hauls. Other common fishes present in at least 50% of the trawls included hornyhead turbot, California lizardfish, longfin sanddab, spotted turbot, California halibut and California scorpionfish.

Fishes captured in the region ranged in length from 3 to 49 cm (Appendix B). With the exception of the California halibut, the species mentioned above tended to be relatively small, averaging from 8 to 20 cm in length. California halibut averaged 34 cm. Other large species (i.e., > 20 cm in length) were collected infrequently and included specklefin midshipman, diamond turbot, California skate and round stingray.

Fish species richness averaged from 6 to 11 species of fish per station (Table 5.2). Diversity (H’) averaged from 1.0 to 1.8 per station. Abundance and biomass were more variable, averaging 28 to129 fish and 2.2 to 6.3 kg per

Table 5.1

Demersal fish species collected in 28 trawls in the SBOO region during 2001. Data for each species are expressed as: (1) percent abundance (PA); (2) frequency of occurrence (FO); (3) mean abundance per haul (MAH); (4) mean abundance per occurrence (MAO).

Species	PA	FO	MAH	MAO
Speckled sanddab	36	96	20	21
Northern anchovy	23	7	13	180
Longfin sanddab	9	68	5	7
White croaker	8	25	5	18
Hornyhead turbot	5	89	3	3
California lizardfish	4	68	2	3
California scorpionfish	3	71	2	3
Spotted turbot	2	50	1	3
California halibut	2	75	1	2
Roughback sculpin	1	18	1	4
California tonguefish	1	32	1	2
English sole	1	39	1	1
Fantail sole	1	36	<1	1
California skate	<1	14	<1	1
Curlfin sole	<1	14	<1	1
Plainfin midshipman	<1	14	<1	2
Shiner perch	<1	11	<1	2
Specklefin midshipman	<1	11	<1	1
Yellowchin sculpin	<1	11	<1	2
Bigmouth sole	<1	7	<1	3
Queenfish	<1	7	<1	3
Barred sand bass	<1	7	<1	1
Giant kelpfish	<1	7	<1	1
Round stingray	<1	7	<1	1
Ocean whitefish	<1	4	<1	3
Bay goby	<1	4	<1	1
Diamond turbot	<1	4	<1	1
Unidentified flatfish	<1	4	<1	1

station, respectively. This variability was partly due to the occasional capture of large populations of a single species. For example, the high abundance (> 100 individuals) at station SD16 reflect a large haul of northern anchovies in January.

Fish community structure has varied in the South Bay area since 1996 (Figure 5.2). Although species richness has remained relatively low, abundances have fluctuated substantially, with annual values averaging between 28 and 178 individuals per station. These changes generally reflect different numbers of the common species, especially speckled sanddabs. However, the high abundance at station SD16 in 2001 was due to a large haul of northern anchovies. Fluctuations in the fish community that occurred post discharge were similar between the stations closest to the outfall and those farther away.

Ordination and classification of sites discriminated between four major cluster groups that reflect different numbers of the more common species (Figure 5.3, Table 5.3). Changes in the assemblages during 2001 were evident at stations within station group 1 (SG1) between January and April (Figure5.3). This change was primarily

Table 5.2

Summary of demersal fish community parameters for SBOO stations sampled during 2001. Data are expressed as means and standard deviations (SD) for number of species, abundance, diversity (H') and biomass (kg, wet weight); n = 4.

Parameter	Station	Jan	Apr	Jul	Oct	Mean	SD
No. of Species	SD15	10	4	4	6	6.0	2.8
	SD16	8	9	8	8	8.3	0.5
	SD17	13	9	7	7	9.0	2.8
	SD18	12	11	10	9	10.5	1.3
	SD19	6	7	9	7	7.3	1.3
	SD20	9	5	6	6	6.5	1.7
	SD21	11	8	7	8	8.5	1.7
	Survey Mean	9.9	7.6	7.3	7.3		
	Survey SD	2.4	2.4	2.0	1.1		
Abundance	SD15	57	44	14	33	37.0	162.6
	SD16	372	68	34	42	129.0	162.6
	SD17	35	38	17	23	28.3	9.9
	SD18	60	89	46	40	58.8	21.8
	SD19	29	39	33	78	44.8	22.5
	SD20	25	36	28	46	33.8	9.4
	SD21	104	24	50	68	61.5	33.6
	Survey Mean	97.4	48.3	31.7	47.1		
	Survey SD	124.0	22.4	13.5	19.4		
Diversity (H')	SD15	1.6	0.6	1.0	0.9	1.0	0.4
	SD16	0.3	1.3	1.6	1.6	1.2	0.6
	SD17	2.2	1.7	1.6	1.6	1.8	0.3
	SD18	1.9	1.5	1.3	1.6	1.6	0.2
	SD19	0.9	1.0	1.6	1.2	1.2	0.3
	SD20	1.9	1.0	1.2	1.3	2.7	0.4
	SD21	0.9	1.8	1.1	1.3	1.3	0.4
	Survery Mean	1.4	1.3	1.3	1.4		
	Survey SD	0.7	0.4	0.3	0.3		
Biomass	SD15	7.9	1.3	0.7	2.1	3.0	3.3
	SD16	8.8	3.1	4.3	5.8	5.5	2.5
	SD17	6.1	3.3	1.6	2.7	3.4	1.9
	SD18	5.1	4.6	2.6	4.3	4.2	1.1
	SD19	1.2	1.4	2.4	3.9	2.2	1.2
	SD20	3.3	1.6	2.5	3.3	2.7	0.8
	SD21	14.6	2.6	4.2	3.6	6.3	5.6
	Survey Mean	6.7	2.6	2.6	3.7		
	Survey SD	4.3	1.2	1.3	1.2		

due to different numbers speckled sanddab, longfin sanddab, and white croaker (Table 5.3) The stations in SG1 included relatively large numbers of white croaker, while those in SG2 contained more than twice the number of speckled and longfin sanddabs. Species that comprised SG2 are typical for this area. Populations of several of these common species were reduced at the stations in SG3 and were absent at station SD15 in April (SG4).

Parasitism and Physical Abnormalities

No physical abnormalities were detected on any fish in 2001. A parasite was found on a hornyhead turbot that was collected at station SD21 in July. Other evidence of parasitism was the presence of the ectoparasitic isopod, *Elthusa vulgaris*, in several trawls. However, it is unknown which fish were actually parasitized since the isopods became detached from their hosts while in the trawl net. Although *E. vulgaris* occurs on a wide variety of fish species off of 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 1,485 megabenthic invertebrates (~ 53/trawl) was collected during 2001 at the SBOO stations, representing 47 taxa (Appendix B). The sea star *Astropecten verrilli* was the most abundant and most frequently

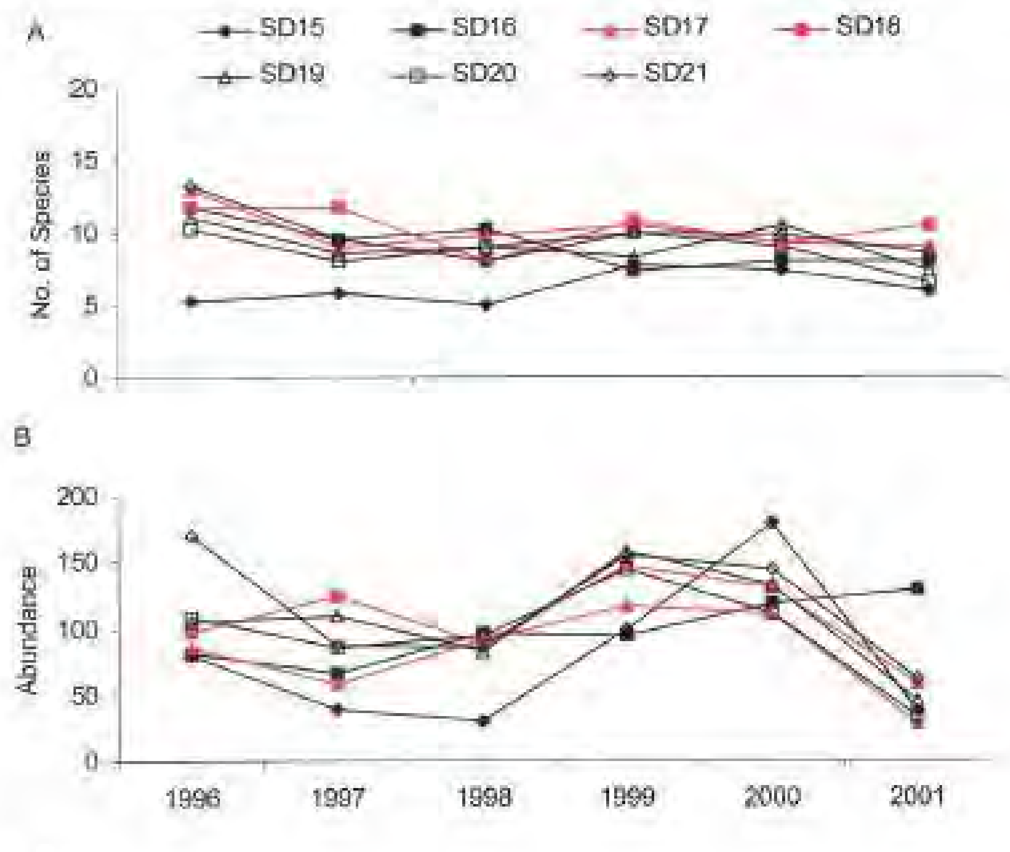


Figure 5.2
Annual mean number of fish species (A) and abundance (B) per station, 1996 through 2001.

captured invertebrate. It accounted for 47% of the total catch and was captured in 96% of the trawls (~ 25/trawl) (Table 5.4). Other relatively common species that occurred in at least 50% of the trawls included the sea urchin *Lytechinus pictus* and the sea star *Pisaster brevispinus*.

As in previous years, the megabenthic invertebrate community was variable in 2001 (Table 5.5, Figure 5.4). In 2001 species richness averaged 5 - 8 species per station. Diveristy (H') values averaged 1 - 1.6 per station (Table 5.5). Abundance averaged from 28 to 88 individuals per station, and biomass averaged from 0.3 to 1.5 kg per station. (Figure 5.4). Fluctuations in the invertebrate community that occurred post discharge were similar between the stations closest to the outfall and those farther away.

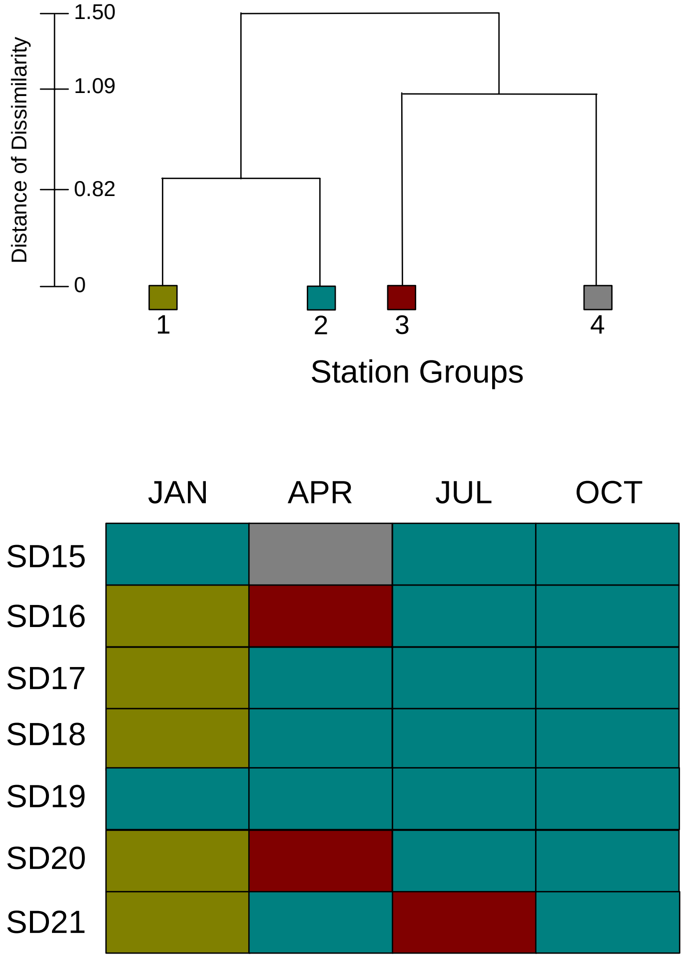


Figure 5.3

Results of classification analysis of demersal fish collected at stations SD15 - SD21 during 2001. Data are presented as a dendrogram of major station groups and a matrix showing distribution over time.

Table 5.3

Ten most abundant and frequently occurring fish species among the four main SBOO station cluster groups.

	SG1	SG2	SG3	SG4
Number of hauls	5	19	3	1
Mean no. of species per haul	11	8	7	4
Mean no. of individuals per haul	119.2	40.9	51.3	44.0
Species	**Mean Abundance**			
Northern Anchovy	71.8	—	—	—
White croaker	20.8	1.2	0.3	—
Speckled sanddab	8.2	22.3	22.7	37.0
California lizardfish	3.8	2.3	—	—
California halibut	2.4	0.9	1.0	—
Hornyhead turbot	2.2	2.4	5.7	—
California tonguefish	1.4	0.5	1.0	—
California scorpionfish	1.4	2.5	—	—
English sole	1.2	0.5	—	—
Longfin sanddab	1.0	4.8	15.0	—
Shiner perch	1.0	—	—	—
Spotted turbot	0.8	1.7	—	—
Plainfin midshipman	0.8	0.1	0.3	—
Fantail sole	0.6	0.3	0.7	—
Specklefin midshipman	0.2	0.1	0.3	—
Roughback sculpin	—	0.4	2.7	5.0
Yellowchin sculpin	—	0.1	1.7	—
Round stingray	—	0.1	—	1.0
Bay goby	—	—	—	1.0

SUMMARY & CONCLUSIONS

Demersal fish and megabenthic invertebrate communities are inherently variable and 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). These factors can impact the migration of adult fish or the recruitment of juveniles into an area (Murawski 1993). Population fluctuations may also be due to the mobile nature of many species (e.g., schools of fish or aggregations of urchins).

Speckled sanddabs dominated fish assemblages surrounding the South Bay Ocean Outfall in 2001. They occurred in most trawls and accounted for 36% of the total catch. This pattern was similar to those seen in previous years. Such results are expected because the relatively shallow depths and coarse sediments in the region represent the typical habitat for the speckled sanddab (Fitch and Lavenberg 1971, 1975). Other characteristic, but less abundant, species included the hornyhead turbot, California lizardfish, longfin sanddab, spotted turbot, California halibut and California scorpionfish. Most of these common fishes were relatively small, averaging less than 20 cm in length.

Larger species included California halibut, specklefin midshipman, diamond turbot, California skate and round stingray. With the exception of California halibut, these fishes were collected infrequently.

As in previous years, the structure of the fish assemblages varied among stations. Differences in the total catch per trawl reflected fluctuations in populations of several of the more common fishes, including speckled and longfin sanddabs. The high abundance and biomass at some sites reflected the occasional capture of large populations of species such as white croaker and northern anchovy. Although megabenthic invertebrate community structure also varied between sites, these assemblages were generally characterized by low species richness, diversity, abundance, and biomass.

Overall, the monitoring data providede no evidence that the discharge of waste water from the South Bay Ocean Outfall in 2001 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 are 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.

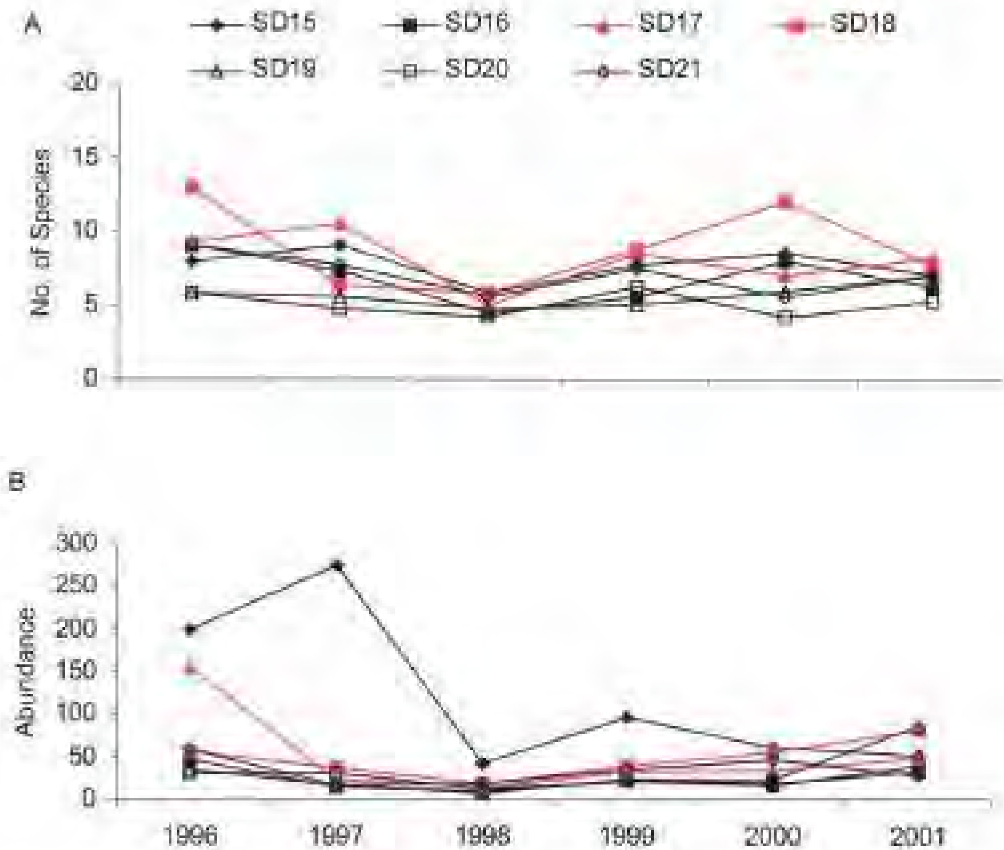


Figure 5.4

Annual mean number of megabenthic invertebrate species (A) and abundance (B) per station, 1996 through 2001.

Table 5.4

Megabenthic invertebrate species collected in 28 trawls in the SBOO region during 2001. Data for each species are expressed as: (1) percent abundance (PA); (2) frequency of occurrence (FO); (3) mean abundance per haul (MAH); (4) mean abundance per occurrence (MAO).

Species	PA	FO	MAH	MAO		PA	FO	MAH	MAO
Astropecten verrilli	47	25	25	99	*Elthusa vulgaris*	<1	4	<1	3
Heterocrypta occidentalis	13	21	7	33	*Kelletia kelletii*	<1	11	<1	1
Lytechinus pictus	10	18	5	30	*Stylatula elongata*	<1	7	<1	2
Loligo opalescens	6	11	3	31	*Astropecten* sp	<1	4	<1	2
Crangon nigromaculata	5	25	3	11	*Cancer antennarius*	<1	4	<1	2
Philine auriformis	3	14	2	12	*Crangon alba*	<1	4	<1	2
Dendraster terminalis	2	11	1	11	*Nassarius perpinguis*	<1	4	<1	2
Pisaster brevispinus	2	18	1	6	*Panulirus interruptus*	<1	7	<1	1
Pyromaia tuberculata	2	18	1	5	Porifera	<1	4	<1	2
Hemisquilla ensigera californiensis	1	21	1	3	*Portunus xantusii*	<1	4	<1	2
Loxorhynchus grandis	1	21	<1	2	*Spirontocaris prionota*	<1	4	<1	2
Luidia armata	1	11	<1	3	*Strongylocentrotus purpuratus*	<1	4	<1	2
Randallia ornata	1	11	<1	3	*Calliostoma turbinum*	<1	4	<1	1
Lovenia cordiformis	<1	11	<1	2	Caridea	<1	4	<1	1
Platymera guadichaudii	<1	11	<1	2	*Euspira lewisii*	<1	4	<1	1
Cancer sp	<1	14	<1	1	*Flabellina iodinea*	<1	4	<1	1
Crangon alaskensis	<1	7	<1	3	*Heptacarpus tenuissimus*	<1	4	<1	1
Acanthodoris brunnea	<1	7	<1	2	*Loxorhynchus* sp	<1	4	<1	1
Cancer anthonyi	<1	7	<1	2	*Megasurcula carpenteriana*	<1	4	<1	1
Heptacarpus stimpsoni	<1	4	<1	4	*Orthopagurus minimus*	<1	4	<1	1
Podochela hemphillii	<1	7	<1	2	*Pagurus spilocarpus*	<1	4	<1	1
Solen sicarius	<1	7	<1	2	*Pugettia dalli*	<1	4	<1	1
Cancer gracilis	<1	7	<1	2	*Pugettia producta*	<1	4	<1	1
Crossata californica	<1	7	<1	2					

Table 5.5

Summary of megabenthic invertebrate community parameters for SBOO stations sampled during 2001. Data are expressed as means and standard deviations for number of species, abundance, diversity (H') and biomass (kg, wet weight); n = 4.

Parameter	Station	Jan	Apr	Jul	Oct	Mean	SD
No. of Species	SD15	8	6	5	9	7.0	1.8
	SD16	7	5	6	7	6.3	1.0
	SD17	8	9	8	8	8.3	5
	SD18	5	9	8	9	7.8	1.9
	SD19	7	6	8	7	7.0	0.8
	SD20	4	6	4	7	5.3	1.5
	SD21	7	5	5	11	7.0	2.8
	Survey Mean	6.6	6.6	6.3	8.3		
	Survey SD	1.5	1.7	1.7	1.5		
Abundance	SD15	26	54	94	30	51.0	31.2
	SD16	12	36	36	46	32.5	14.5
	SD17	21	54	68	58	50.3	20.4
	SD18	34	56	152	88	82.5	51.4
	SD19	26	37	96	192	87.8	76.0
	SD20	30	16	63	50	39.8	20.9
	SD21	24	12	30	44	27.5	13.3
	Survey Mean	24.7	37.9	77.0	72.6		
	Survey SD	7.0	18.3	41.7	55.6		
Diversity (H')	SD15	1.7	1.1	0.4	1.4	1.1	0.5
	SD16	1.7	1.2	0.9	0.9	1.2	0.4
	SD17	1.9	1.1	1.2	1.2	1.3	0.3
	SD18	1.3	1.4	1.3	1.3	1.3	0.0
	SD19	1.5	0.6	1.1	0.9	1.0	0.4
	SD20	1.2	1.3	0.9	1.4	1.2	0.2
	SD21	1.6	1.4	1.4	1.9	1.6	0.2
	Survery Mean	1.6	1.1	1.0	1.3		
	Survey SD	0.2	0.3	0.3	0.3		
Biomass	SD15	0.1	0.3	3.2	0.2	1.0	1.5
	SD16	1.8	1.3	1.7	0.9	1.4	0.4
	SD17	0.1	0.1	0.5	0.4	0.3	0.2
	SD18	0.1	0.2	0.5	3.0	1.0	1.4
	SD19	0.6	0.5	3.4	1.0	1.4	1.4
	SD20	1.2	1.3	0.4	1.5	1.1	0.5
	SD21	0.7	0.8	1.2	3.1	1.5	1.1
	Survey Mean	0.7	0.6	1.6	1.4		
	Survey SD	0.7	0.5	1.3	1.2		

LITERATURE CITED

Allen, M.J. (1982). Functional structure of soft-bottom fish communities of the southern California shelf. Ph.D. dissertation. University of California, San Diego. La Jolla, CA. 577 pp.

Allen, M.J., S.L. Moore, K.C. Schiff, S.B. Weisberg, D. Diener, J.K. Stull, A. Groce, J. Mubarak, C.L. Tang, and R. Gartman. (1998). Southern California Bight 1994 Pilot Project: Chapter V. Demersal Fishes and Megabenthic Invertebrates. Southern California Coastal Water Research Project, Westminister, CA. 324 pp.

Brusca, R.C. (1978). Studies on the cymothoid fish symbionts of the eastern Pacific (Crustacea: Cymothoidae). II. Systematics and biology of *Livoneca vulgaris* Stimpson 1857. Occ. Pap. Allan Hancock Fdn. (New Ser.), 2: 1-19

Brusca, R.C. (1981). A monograph on the Isopoda Cymothoidae (Crustacea) of the eastern Pacific. Zool. J. Linn. Soc., 73: 117-199

City of San Diego. (2000a). International Wastewater Treatment Plant Final Baseline Ocean Monitoring Report for the South Bay Ocean Outfall (1995-1998). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2000b). International Boundary and Water Commission Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (1999). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2002). 2001 Quality Assurance Manual. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

Cross, J.N., and L.G. Allen. (1993). Chapter 9. Fishes. In: Dailey, M.D., D.J. Reish, and J.W. Anderson, eds. Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berkeley, CA. p. 459-540

Cross, J.N., J.N. Roney, and G.S. Kleppel. (1985). Fish food habitats along a pollution gradient. Calif. Fish and Game., 71: 28-39

Fitch, J.E., and R.J. Lavenberg. (1971). Marine Food and Game Fishes of California. University of California Press, Berkeley, CA. 179 pp.

Fitch, J.E., and R.J. Lavenberg. (1975). Tidepool and Nearshore Fishes of California. University of California Press, Berkeley, CA. 157 pp.

Helvey, M., and R.W. Smith. (1985). Influence of habitat structure on the fish assemblages associated with two cooling-water intake structures in southern California. Bull. Mar. Sci., 37: 189-199

Karinen, J.B., B.L. Wing, and R.R. Straty. (1985). Records and sightings of fish and invertebrates in the eastern Gulf of Alaska and oceanic phenomena related to the 1983 El Niño event. In: Wooster, W.S. and D.L. Fluharty, eds. El Niño North: El Niño Effects in the Eastern Subarctic Pacific Ocean. Washington Sea Grant Program. p. 253-267

Love, M.S., J.S. Stephens, Jr., P.A. Morris, and M.M. Singer. (1986). Inshore soft substrata fishes in the Southern California Bight: An overview. CalCOFI, 27: 84-107

Murawski, S.A. (1993). Climate change and marine fish distribution: forecasting from historical analogy. Trans. Amer. Fish. Soc., 122: 647-658

Nelson, J.S. (1994). Fishes of the World - Third Edition. John Wiley & Sons, Inc. New York, NY. 600 pp.

Smith, R.W. (1982). The Analysis of Ecological Survey data with SAS and EAP. Proc. 7th Annual SAS Users' Group International, (SUGI). SAS Institute Inc., Cary, N C. 705 pp.

Smith, R.W., B.B. Bernstein, and R.L. Cimberg. (1988). Community-environmental relationships in the benthos: applications of multivariate techniques. In: Soule, D.F. and G.S. Kleppel, eds. Marine Organisms as Indicators. Springer-Verlag, New York, p. 247-326

Chapter 6

Bioaccumulation of Contaminants in Fish Tissues

INTRODUCTION

Bioaccumulation is the process of biological uptake and retention of chemical contaminants derived from various exposure pathways (Tetra Tech 1985). Because of their proximity to bottom sediments, demersal fish can accumulate pollutants through any of the following three exposure routes: (1) adsorption or absorption of dissolved chemical constituents from the water; (2) ingestion of pollutant-containing suspended particulate matter or sediment particles and subsequent assimilation into body tissues; (3) ingestion and assimilation of pollutants from food sources. Once a contaminant becomes incorporated into a fish's tissues, it may resist normal metabolic excretion and accumulate. The bioaccumulation of contaminants in fish tissues is often used as an indicator of exposure to pollution. In addition, because fish may ingest particle-bound pollutants, contaminant concentrations in fish tissues are often related to those found in the environment (Schiff and Allen 1997), and are therefore useful in biomonitoring programs.

The South Bay Ocean Outfall (SBOO) monitoring program includes the collection of fish to assess the accumulation of contaminants in their tissues. This part of the 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 species are targeted based on their ecological significance (i.e., prevalence in the community). Chemical analyses are performed on livers from these species because contaminants are typically concentrated in this tissue. For example, the high lipid content of liver tissue makes the detection of hydrophobic organochlorines (e.g., pesticides, PCBs) more likely.

In contrast to trawl-caught species, fishes targeted for collection by rig fishing are thought to represent a typical sport fisher's catch, and therefore have recreational and commercial importance. Muscle tissue is analyzed from rig-caught 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 are analyzed for contaminants as specified in the NPDES discharge permit for the SBOO monitoring program. This chapter presents the results of all tissue analyses that were performed during the third year of post-discharge monitoring for the SBOO.

MATERIALS & METHODS

Collection

Fishes were collected during April and October 2001 at seven trawl stations and two rig fishing stations (Figure 6.1). Trawl-caught fishes were collected following established trawling guidelines as described in Chapter 5 of this report. Fishes targeted at the rig fishing sites were collected using rod and reel fishing tackle, and then measured and

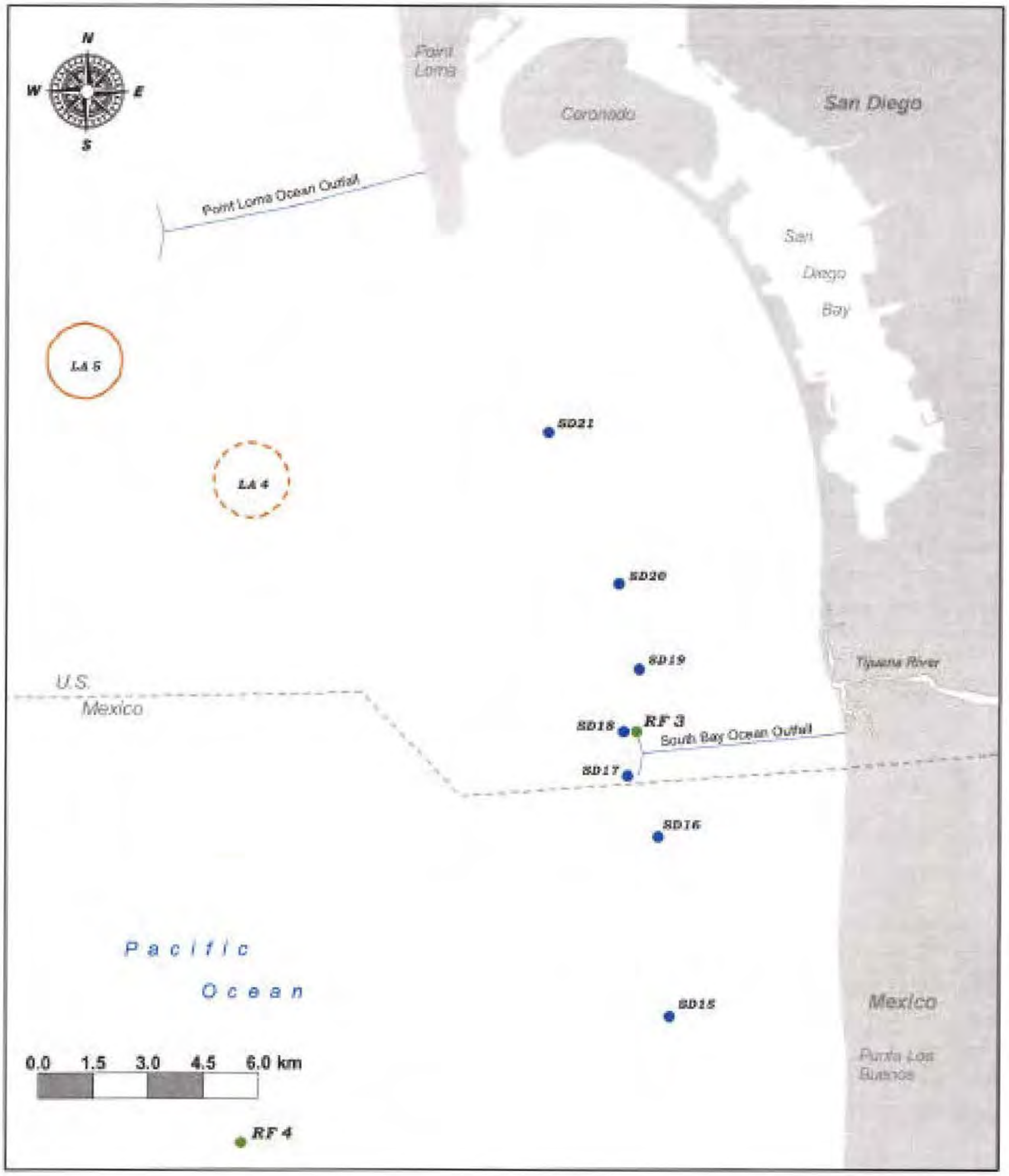


Figure 6.1
Otter trawl and rig fishing station locations, South Bay Ocean Outfall Monitoring Program.

Table 6.1

Species collected at each SBOO trawl and rig fishing station during April and October 2001; ns = samples not collected due to insufficient numbers of fish.

Station	Rep 1	Rep 2	Rep 3
April 2001			
SD15	Hornyhead turbot	ns	ns
SD16	Longfin sanddab	Hornyhead turbot	Hornyhead turbot
SD17	Longfin sanddab	Longfin sanddab	Hornyhead turbot
SD18	Ca. scorpionfish	Longfin sanddab	Hornyhead turbot
SD19	Hornyhead turbot	Longfin sanddab	Hornyhead turbot
SD20	Longfin sanddab	Longfin sanddab	Ca. scorpionfish
SD21	Ca. scorpionfish	Longfin sanddab	Longfin sanddab
RF3	Vermilion rockfish	Ca. scorpionfish	Ca. scorpionfish
RF4	Ca. scorpionfish	Ca. scorpionfish	Ca. scorpionfish
October 2001			
SD15	Ca. scorpionfish	Ca. scorpionfish	Ca. scorpionfish
SD16	Longfin sanddab	Ca. scorpionfish	Ca. scorpionfish
SD17	Hornyhead turbot	Ca. scorpionfish	Ca. scorpionfish
SD18	Hornyhead turbot	Ca. scorpionfish	Ca. scorpionfish
SD19	Longfin sanddab	Longfin sanddab	Ca. scorpionfish
SD20	Longfin sanddab	Ca. scorpionfish	Ca. scorpionfish
SD21	Longfin sanddab	Ca. scorpionfish	Ca. scorpionfish
RF3	Vermilion rockfish	Vermilion rockfish	Ca. scorpionfish
RF4	Ca. scorpionfish	Ca. scorpionfish	Ca. scorpionfish

weighed following standard procedures (City of San Diego 2002). Only fish >11 cm (standard length) were retained for tissue analyses at all stations. After collection, fish were sorted into three composite samples, each containing a minimum of three individuals. They were then wrapped in aluminum 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 6.1.

Dissection and Chemical Analyses

All dissections were performed according to standard techniques for tissue analysis (City of San Diego 2002). 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). Liver tissue was removed from trawl-caught fish and muscle tissue was removed from fish collected by rig fishing. 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 NOAA National Status and Trends chemical constituents specified by the contract under which this sampling was performed. These constituents are listed in Appendix C along with a summary of all those detected at each station during each survey. A detailed description of the analytical protocols may be obtained from the City of San Diego Wastewater Chemistry Laboratory.

Data Treatment

Prior to analysis, the data were generally limited to values above method detection limits (MDLs). Some parameters 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. Null values (i.e, values below the MDL without an estimate) were eliminated from the dataset and are not intended to represent the absence of a particular parameter.

RESULTS & DISCUSSION

Contaminants in Liver Tissues

Distribution among Species

Detection rates were highly variable for the metals that occurred in liver tissues (Table 6.2). Aluminum, cadmium, copper, iron, manganese, mercury, selenium and zinc were reported in more than 90% of the samples and in every species of fish. Other metals were detected infrequently. The majority of all metals found in the liver tissues were also detected in local sediments (see Chapter 3, Appendix D).

DDT was the most frequently reported chlorinated pesticide (Table 6.3). Concentrations of total DDT (the sum of three DDT derivatives and their isomers) averaged from about 229 ppb in hornyhead turbot to 1,944 ppb in longfin sanddab. DDT was detected in the sediments at only three benthic monitoring stations during the year (see Chapter 3) and one station from the randomized regional survey (Appendix D).

Several other pesticides were also detected in fish liver tissues, although they were not present in local sediments (see Chapter 3). These included Chlordane, trans Nonachlor, cis Nonachlor, Mirex and hexachlorobenzene (HCB) (Table 6.3). HCB was the most common of these five pesticides, occurring in 80% of the samples and at concentrations ranging from 0.4 to 11 ppb. Although this 80% detection rate is substantially higher than in previous years (see City of San Diego 2000b, c, 2001b), it does not necessarily represent an actual increase in the prevalence of HCB. Instead, the increase reflects recent changes in the reporting methods for such compounds (i.e., lower MDLs and inclusion of estimated values; see Materials and Methods, Data Treatment section). The pesticide trans Nonachlor occurred in 63% of the liver samples, with concentrations ranging from 3.1 to 60 ppb. Chlordane occurred in fewer samples (20%) as alpha(cis) Chlordane at concentrations ranging from 4.0 to 12 ppb, while Cis Nonachlor and Mirex were each detected in a single longfin sanddab sample.

Total PCB is reported as the sum of all congeners measured in each sample, while concentrations for the individual congeners are listed separately in Appendix C. PCBs occurred in all samples from all three species. Total PCB values ranged from 19 ppb to 1,733 ppb. PCBs were detected in a single sediment sample from the benthic monitoring study during 2001 (see Chapter 3) and none were detected in the regional survey (Appendix D).

Table 6.2

Metals detected in liver samples from fish collected at SBOO trawl stations during 2001. Values are expressed as parts per million (ppm). N = number of detected values, nd = not detected.

	Al	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Zn
Ca. Scorpionfish													
N (out of 17)	17	nd	17	10	17	17	1	17	16	1	17	1	17
Min	4.10	.	0.44	0.37	10.10	111.00	2.80	0.34	0.07	1.04	0.57	0.74	67.20
Max	37.90	.	6.74	4.89	54.10	385.00	2.80	0.95	0.43	1.04	1.13	0.74	159.00
Mean	15.17	.	2.63	2.35	24.28	222.24	2.80	0.53	0.22	1.04	0.80	0.74	101.76
Longfin sanddab													
N (out of 14)	14	10	14	4	14	14	nd	14	12	nd	14	nd	14
Min	2.70	2.00	1.04	0.59	7.57	75.40	.	0.67	0.09	.	0.64	.	14.80
Max	37.60	10.50	3.71	3.56	18.80	209.00	.	2.79	0.26	.	1.93	.	31.00
Mean	19.11	4.88	2.38	1.42	12.69	136.89	.	1.57	0.12	.	1.09	.	25.10
Hornyhead turbot													
N (out of 9)	9	1	9	nd	9	9	nd	9	9	nd	9	nd	9
Min	7.30	5.90	2.85	.	3.40	36.10	.	1.10	0.09	.	0.40	.	34.80
Max	26.40	5.90	8.68	.	20.40	170.00	.	2.60	0.17	.	1.23	.	61.90
Mean	12.81	5.90	6.92	.	10.86	82.51	.	1.65	0.13	.	0.70	.	43.46
ALL SPECIES													
% Dect.	100	28	100	35	100	100	3	100	93	3	100	3	100

Table 6.3

Chlorinated pesticides, PCBs, and lipids detected in liver samples from fish collected at SBOO trawl stations during 2001. 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, nd = not detected.

	Chlorinated Pesticides:							
	Total		Nonachlor		Alpha (cis)		Total	
	DDT	HCB	Trans	Cis	Chlordane	Mirex	PCB	Lipids
Ca. Scorpionfish								
N (out of 17)	17	17	14	nd	3	nd	17	17
Min	206.3	1.1	3.1	.	5.8	.	58.2	6.5
Max	14019.0	4.2	18.0	.	11.0	.	1732.8	28.0
Mean	1370.3	2.4	9.9	.	7.9	.	408.3	15.3
Longfin sanddab								
N (out of 14)	14	12	10	1	4	1	14	14
Min	341.3	1.2	3.2	10.0	4.0	3.1	202.9	5.8
Max	10674.0	11.0	60.0	10.0	12.0	3.1	1022.0	38.2
Mean	1944.3	3.7	12.0	10.0	6.6	3.1	529.2	19.2
Hornyhead turbot								
N (out of 9)	9	3	1	nd	1	nd	9	9
Min	50.0	0.4	5.6	.	4.3	.	18.8	2.7
Max	751.3	0.9	5.6	.	4.3	.	293.4	10.0
Mean	228.7	0.7	5.6	.	4.3	.	78.9	4.1
ALL SPECIES								
% Dect.	100	80	63	3	20	3	100	100

Distribution among Stations

Spatial patterns were assessed for all metals that occurred frequently in fish liver tissue samples (Figure 6.2). The concentrations of these metals varied substantially across all stations. Intraspecific comparisons between the stations closest to the discharge (SD17, SD18) and those farther away (SD15-SD16, SD19-SD21) showed no clear relationship with proximity to the outfall. Further, most concentrations of metals in the tissue samples from the nearfield stations were close to or below the maximum concentrations detected in the same species prior to discharge.

DDT, trans Nonachlor, HCB and PCBs were detected at all stations at concentrations that were variable (Figure 6.3). As with the metals, there was no clear relationship between concentrations of these parameters and proximity to the outfall, and most were close to or below the maximum concentrations detected in the same species prior to discharge.

Contaminants in Muscle Tissues

The United States Food and Drug Administration (FDA) 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

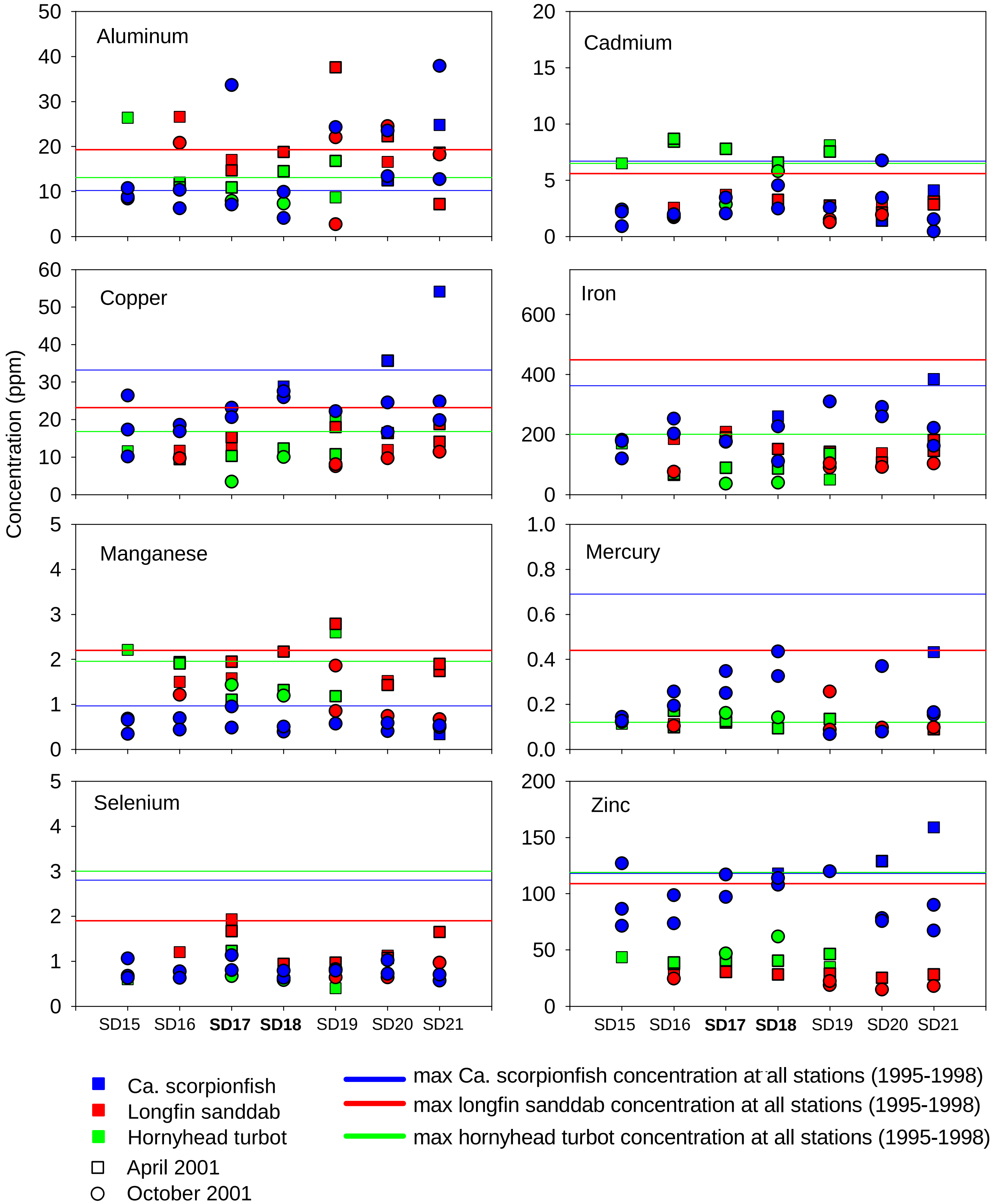


Figure 6.2

Concentrations of frequently detected metals in liver tissues of fish collected from each trawl station during 2001. Note that only four samples were collected at station SD15; otherwise missing data represent concentrations below detection limits. Reference lines are maximum values during the pre-discharge period (1995-1998). Stations closest to the discharge site are labeled in bold.

concentrations of various metals (Mearns et al. 1991). These limits and standards were compared to concentrations of these constituents found in muscle tissue samples from fish captured by hook and line (Table 6.4). While many of these compounds were detected, only arsenic and selenium had concentrations that were higher than international standards. All arsenic values were above the arsenic standard, while the maximum selenium value reported for California scorpionfish was above the selenium standard. A comparison of data from scorpionfish samples collected near the outfall (station RF3) versus farther away (station RF4) revealed that concentrations of most of these constituents were not substantially higher near the outfall (Table 6.5). Exceptions included concentrations of DDT and PCB. Although DDT and PCBs were detected in all samples from both stations, concentrations were higher at station RF3 than RF4. Further, tin, HCB, and trans Nonachlor were reported in muscle samples from RF3 only. Caution should be exercised in the interpretation of this data, however, since California scorpionfish are known to move around between large geographical areas (Hartmann 1987, Love et al. 1987).

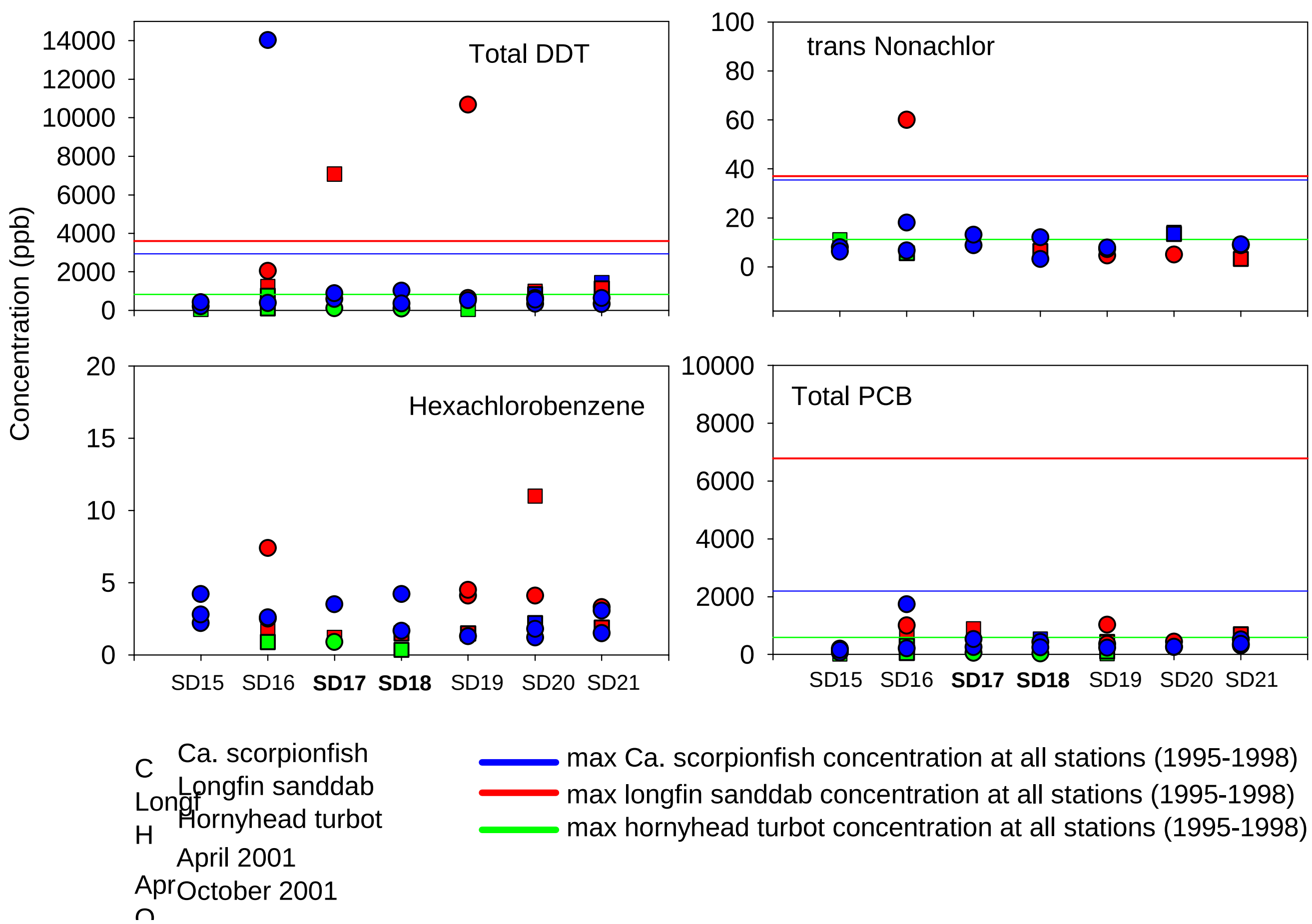


Figure 6.3

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 2001. Note that only four samples were collected at station SD15; otherwise missing data represent concentrations below detection limits. Reference lines are maximum values during the pre-discharge period (1995-1998). Stations closest to the discharge site are labeled in bold.

Table 6.4

Concentrations of various metals and total DDT detected in muscle samples from fish collected at SBOO rig fishing stations during 2001. Values are parts per million (ppm) for all parameters. Also included are US FDA action limits and median international standards. Bolded values exceed standards.

	Ar	Cr	Cu	Hg	Se	Tn	Zinc	tDDT
CA. scorpionfish								
N (out of 9)	4	1	7	8	9	1	9	9
Min	**1.80**	0.48	1.75	0.04	0.13	40.40	2.91	0.04
Max	**12.70**	0.48	11.30	0.31	**0.35**	40.40	5.66	2.59
Mean	**4.88**	0.48	6.23	0.11	0.21	40.40	4.10	0.42
Vermilion rockfish								
N (out of 3)	1	2	3	1	2	nd	3	3
Min	**1.90**	0.49	1.23	0.01	0.17	.	2.99	0.01
Max	**1.90**	0.79	6.36	0.01	0.20	.	3.33	0.04
Mean	**1.90**	0.64	3.72	0.01	0.19	.	3.13	0.03
US FDA Action Limit*				1				5
Median International Standard*	1.40	1.00	20.00	0.50	0.30	175.00	70.00	5.00

*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.

SUMMARY & CONCLUSIONS

Tissue bioaccumulation studies are useful in determining the presence of various contaminants in demersal fishes. It has been well established that various pollutants can affect fish behavior, as well as fecundity and mortality rates (McCain et al. 1978, Gossett et al. 1983, Moller 1985, Thomas 1988, 1989, Hose et al. 1989). However, little information is known about the concentrations at which contaminants must be present in order to precipitate these effects.

Demersal fish collected around the South Bay Ocean Outfall during 2001 were characterized by contaminant values within the range of those reported previously for other fish assemblages in the Southern California Bight (SCB) (see Mearns et al. 1991, City of San Diego 1996 - 2001a, Allen et al. 1998). In addition, concentrations of most contaminants were not substantially different from pre-discharge data (City of San Diego 2000b).

The frequent occurrence of both 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

Table 6.5

Average concentrations of various metals, chlorinated pesticides, and total PCB in muscle tissues from California scorpionfish collected at stations RF3 and FR4 during 2001; nd = not detected.

	Station RF3				Station RF4			
Parameter	**N (out of 3)**	**Min**	**Max**	**Mean**	**N (out of 6)**	**Min**	**Max**	**Mean**
Metals (ppm)								
Aluminum	2	6.40	8.80	7.60	2	3.20	3.90	3.55
Arsenic	2	2.70	12.70	7.70	2	1.80	2.30	2.05
Chromium	nd	—	—	—	1	0.48	0.48	0.48
Copper	3	2.32	8.86	4.88	4	1.75	11.30	7.24
Iron	3	3.45	4.80	3.92	4	4.00	8.00	5.73
Mercury	3	0.08	0.31	0.16	5	0.04	0.13	0.08
Selenium	3	0.22	0.35	0.27	6	0.13	0.25	0.18
Tin	1	40.40	40.40	40.40	nd	—	—	—
Zinc	3	2.91	4.98	3.96	6	3.54	5.66	4.16
Chlorinated Pesticides (ppb)								
Hexachlorobenzene	1	0.20	0.20	0.20	nd	—	—	—
Total DDT	3	10.00	259.20	101.73	6	3.80	25.70	12.19
Trans Nonachlor	1	0.60	0.60	0.60	nd	—	—	—
Total PCB (ppb)	3	17.30	32.00	23.00	6	1.30	5.80	2.82

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 other point and non-point sources that may contribute to contamination in the region. For example, 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.

Overall, there was no evidence that fishes collected in 2001 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 found to be below FDA 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 5).

LITERATURE CITED

Allen, M. J., S.L. Moore, K.C. Schiff, D. Diener, S.B. Weisburg, J.K. Stull, A. Groce, E. Zeng, J. Mubarak, C.L. Tang, R. Gartman, and C.I. Haydock. (1998) Assessment of demersal fish and megabenthic invertebrate assemblages on the mainland shelf of Southern California in 1994. Southern California Coastal Water Research Project, Westminister, CA.

Brown, D. A., R.W. Gossett, G.P. Hershelman, C.G. Word, A.M. Westcott, and J.N. Cross. (1986) Municipal wastewater contamination in the Southern California Bight: Part I-Metal and Organic Contaminants in Sediments and Organisms. Marine Environmental Research. 18: 291-310

City of San Diego. (1996). 1995 Receiving Waters Monitoring Report for the Point Loma Ocean Outfall. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (1997). 1996 Receiving Waters Monitoring Report for the Point Loma Ocean Outfall. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (1998). 1997 Receiving Waters Monitoring Report for the Point Loma Ocean Outfall. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (1999). 1998 Receiving Waters Monitoring Report for the Point Loma Ocean Outfall. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2000a). 1999 Receiving Waters Monitoring Report for the Point Loma Ocean Outfall. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2000b). International Wastewater Treatment Plant Final Baseline Ocean Monitoring Report for the South Bay Ocean Outfall (1995-1998). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2000c). 1999 Receiving Waters Monitoring Report for the South Bay Ocean Outfall. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2001a). 2000 Receiving Waters Monitoring Report for the Point Loma Ocean Outfall. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2001b). 2000 Receiving Waters Monitoring Report for the South Bay Ocean Outfall. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2002). 2001 Quality Assurance Manual. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

Gossett, R.W., D.A. Brown, and D.R. Young. (1983). Predicting the bioaccumulation of organic compounds in marine organisms using octanol/water partition coefficients. Mar. Poll. Bull. 14(10): 387-392

Hartmann, A. R. (1987). Movement of scorpionfishes (Scorpaenidae:*Sebastes* and *Scorpaena*) in the southern California Bight. California Fish and Game 73:68-79

Hose, J.E., J.N. Cross, S.G. Smith, and D. Diehl. (1989). Reproductive impairment in fish inhabiting a contaminated coastal environment off Southern California. Environ. Pollut. 14: 60-65

Love, M. S., B. Axell, P. Morris, R. Collins, and A. Brooks. (1987). Life history and fishery of the Califorina scorpionfish, *Scorpaena guttata*, within the Southern California Bight. Fisheries Bulletin 85:99-116

McCain, B.B., H.O. Hodgins, W.D. Gronlund, J.W. Hawkes, D.W. Brown, M.S. Myers, and J.H. Vandermeulen. (1978). Bioavailability of crude oil from experimentally oiled sediments to English sole (*Parophrys vetulus*), and pathological consequences. J. Fish Res. Bd. Canada 35: 657-664

Mearns, A.J., M. Matta, G. Shigenaka, D. MacDonald, M. Buchman, H. Harris, J. Golas, and G. Lauenstein. (1991). Contaminant Trends in the Southern California Bight: Inventory and Assessment. NOAA Technical Memorandum NOS ORCA 62. Seattle, WA.

Moller, H. (1985). A critical review on the role of pollution as a cause of fish diseases. In: Ellis, A.E. (Eds). Fish and Shellfish Pathology. Academic Press, London. pp. 169-182

Otway, N. (1991). Bioaccumulation studies on fish: choice of species, sampling designs, problems and implications for environmental management. In: Miskiewicz, A. G. (ed). Proceedings of a Bioaccumulation Workshop: Assessment of the Distribution, Impacts, and Bioaccumulation of Contaminants in Aquatic Environments. Australian Marine Science Association, Inc./Water Board. 334 p.

Schiff, K., and M.J. Allen. (1997). Bioaccumulation of chlorinated hydrocarbons in livers of flatfishes from the Southern California Bight. In: S.B. Weisberg, C. Francisco, and D. Hallock (eds.), Southern California

Coastal Water Research Project Annual Report 1995-1996. Southern California Coastal Water Research Project, Westminister, CA.

Tetra Tech. (1985). Commencement Bay Nearshore/Tideflats Remedial Investigation. Final report prepared for the Washington Department of Ecology and the EPA. Tetra Tech, Inc., Bellevue, WA.

Thomas, P. (1988). Reproductive endocrine function in female Atlantic croaker exposed to pollutants. Mar. Environ. Res. 24: 179-183

Thomas, P. (1989). Effects of Aroclor 1254 and cadmium on the reproductive endocrine function and ovarian growth in Atlantic croaker. Mar. Environ. Res. 24: 179-193

Appendix A

Supporting Data

2001 SBOO Stations

Sediment Characteristics

Appendix A.1

Summary of phi size data for SBOO sediment stations from 1995 to 2001. Mean phi size was determined from a probability curve. Data are presented as the mean phi and standard deviation for pre-discharge (1995 - 1998), post-discharge (1999 - 2000), and 2001 surveys for each station. Area means are presented for each survey period. Also included are the sediment type classifications according to Folk, 1968.

	Pre-Discharge 1995 - 1998		Post-Discharge 1999 - 2000		Annual Report 2001		
Station	**Mean phi**	**SD phi**	**Mean phi**	**SD phi**	**Mean phi**	**SD phi**	**Sediment Type (Folk 1968)**
I-35	3.9	0.3	3.7	0.1	3.7	1.4	very fine sand
I-34	1.4	0.7	1.7	0.2	1.7	0.6	medium sand
I-31	3.2	0.0	3.1	0.0	3.2	0.6	very fine sand
I-23	3.1	0.2	3.1	0.1	2.1	0.7	fine & very fine sand
I-18	3.2	0.1	3.2	0.1	3.1	0.7	very fine sand
I-10	3.2	0.0	3.1	0.0	3.0	0.7	very fine sand
I-4	3.0	0.6	2.6	0.9	2.8	0.8	fine & very fine sand
90 ft stations							
I-33	3.1	0.1	3.1	0.1	3.0	0.7	very fine sand
I-30	3.5	0.1	3.5	0.2	3.4	0.9	very fine sand
I-27	3.4	0.1	3.3	0.0	3.3	0.7	very fine sand
I-22	3.1	0.4	3.0	0.7	2.9	0.7	fine & very fine sand
I-14	3.4	0.1	3.3	0.1	3.1	0.8	very fine sand
I-15	2.1	1.0	2.5	1.0	1.6	0.7	medium & fine sand
I-16	2.4	1.2	1.6	0.9	1.7	0.7	medium & fine sand
I-12	2.7	0.9	2.1	1.0	2.8	0.9	fine sand
I-9	3.4	0.1	3.7	0.3	3.4	0.8	very fine sand
I-6	1.7	0.9	1.4	0.2	1.3	0.6	medium sand
I-3	1.4	0.1	1.6	0.1	1.2	0.6	medium sand
120 ft stations							
I-29	3.5	0.6	3.4	0.3	3.7	1.1	very fine sand
I-21	1.5	0.2	1.3	0.2	1.2	0.7	medium sand
I-13	1.3	0.1	1.3	0.1	1.4	0.5	medium sand
I-8	1.5	0.1	1.4	0.1	1.4	0.6	medium sand
I-2	1.7	0.2	1.6	0.1	1.5	0.6	medium sand
180 ft stations							
I-28	3.3	1.1	3.0	0.3	2.5	1.1	fine & very fine sand
I-20	1.3	0.2	1.2	0.3	0.7	0.7	coarse & medium sand
I-7	1.2	0.2	1.2	0.2	1.0	0.6	medium sand
I-1	2.8	0.2	2.4	0.8	2.5	1.1	fine sand
Area Means	2.6	1.0	2.5	1.0	2.3	0.9	

Appendix A.2a

Summary of phi size data for SBOO sediment stations for the January and July quarters, 2001. Mean phi size was determined from a probability curve. Data are presented as the quarterly mean phi: (1) mean phi size; (2) standard deviation (SD); (3) median phi size; (4) skewness; (5) kurtosis; (6) Coarse particles > 1.0 mm; (7) percent sand; (8) percent silt; (9) percent clay. Also included are the sediment type classifications according to Folk, 1968.

January 2001

Station	Mean Phi	SD Phi	Median Phi	Skew-ness	Kurtosis	% Coarse	% Sand	% Silt	% Clay	Sediment Type (Folk 1968)
60 ft stations										
I-35	3.9	1.3	3.7	0.3	1.4	0.0	59.5	38.8	1.7	very fine sand
I-34	1.6	0.6	1.6	0.0	1.1	0.6	99.2	0.2	0.0	medium sand
I-31	3.1	0.6	3.1	0.1	1.3	0.0	92.9	6.6	0.5	very fine sand
I-23	3.1	0.7	3.0	0.5	3.3	0.0	88.9	10.4	0.7	very fine sand
I-18	2.9	0.7	2.8	0.1	0.9	0.0	93.2	6.7	0.1	fine sand
I-10	2.8	0.8	2.8	0.2	1.1	0.0	92.0	7.9	0.1	fine sand
I-4	2.9	0.8	2.9	0.0	1.1	0.0	92.1	7.6	0.3	fine sand
90 ft stations										
I-33	2.8	0.9	2.9	0.1	2.0	0.0	90.3	9.0	0.7	fine sand
I-30	3.4	0.9	3.4	0.3	1.7	0.0	81.9	17.0	1.1	very fine sand
I-27	3.3	0.7	3.3	0.2	1.4	0.0	87.4	11.9	0.6	very fine sand
I-22	3.0	0.7	2.9	0.3	1.4	0.0	90.0	9.6	0.4	very fine sand
I-14	2.9	0.7	2.8	0.4	1.1	0.0	90.6	9.1	0.3	fine sand
I-15	1.6	0.8	1.5	0.4	2.2	0.0	98.6	1.4	0.0	medium sand
I-16	1.4	0.6	1.4	0.1	1.1	0.8	99.0	0.2	0.0	medium sand
I-12	3.2	0.8	3.2	0.2	1.4	0.0	87.9	10.8	1.3	very fine sand
I-9	3.5	0.8	3.5	0.2	1.5	0.0	82.3	16.8	0.9	very fine sand
I-6	1.3	0.6	1.1	0.6	1.6	0.8	98.4	0.8	0.0	medium sand
I-3	1.0	0.7	0.9	0.2	1.7	7.1	92.5	0.4	0.0	medium sand
120 ft stations										
I-29	3.5	1.1	3.4	0.3	1.6	0.0	73.1	25.1	1.8	very fine sand
I-21	1.2	0.7	1.0	0.7	2.9	1.5	98.5	0.0	0.0	medium sand
I-13	1.3	0.4	1.1	0.7	1.2	0.0	99.7	0.3	0.0	medium sand
I-8	1.4	0.5	1.3	0.2	0.9	0.0	99.9	0.0	0.0	medium sand
I-2	1.4	0.6	1.3	0.3	1.2	0.0	98.6	1.4	0.0	medium sand
180 ft stations										
I-28	0.7	0.6	0.7	0.3	4.6	13.0	83.4	3.5	0.1	coarse sand
I-20	0.6	0.8	0.5	0.4	1.7	19.5	80.5	0.0	0.0	coarse sand
I-7	1.0	0.5	1.0	0.1	1.7	3.3	96.4	0.3	0.0	medium sand
I-1	2.1	1.3	1.9	0.5	1.7	0.0	92.6	3.6	0.7	fine sand

Appendix A.2b (Cont...)

July 2001

Station	Mean Phi	SD Phi	Median Phi	Skew-ness	Kurtosis	% Coarse	% Sand	% Silt	% Clay	Sediment Type (Folk 1968)
60 ft stations										
I-35	3.4	1.6	3.5	-0.1	1.6	13.1	55.0	29.4	2.4	very fine sand
I-34	1.8	0.7	1.8	0.0	1.1	0.6	99.2	0.2	0.0	medium sand
I-31	3.2	0.7	3.2	0.2	1.2	0.0	90.8	8.0	1.2	very fine sand
I-23	1.0	0.8	0.7	0.6	3.1	1.3	97.8	0.9	0.0	medium sand
I-18	3.2	0.7	3.2	0.2	1.2	0.0	88.9	9.7	1.4	very fine sand
I-10	3.2	0.7	3.1	0.3	1.6	0.0	89.6	9.0	1.3	very fine sand
I-4	2.7	0.8	2.7	0.2	0.9	0.0	92.1	7.6	0.2	fine sand
90 ft stations										
I-33	3.1	0.6	3.0	0.7	8.7	0.0	92.3	6.5	1.2	very fine sand
I-30	3.4	0.9	3.4	0.2	1.7	0.0	80.9	17.2	1.9	very fine sand
I-27	3.3	0.8	3.3	0.2	1.3	0.0	86.3	12.2	1.5	very fine sand
I-22	2.8	0.8	2.8	0.2	1.2	0.0	90.6	8.8	0.6	fine sand
I-14	3.2	0.9	3.2	0.2	1.3	0.0	85.3	13.1	1.6	very fine sand
I-15	1.5	0.6	1.4	0.1	1.0	0.0	99.4	0.6	0.0	medium sand
I-16	1.9	0.8	1.9	0.1	1.0	0.0	97.8	2.2	0.0	medium sand
I-12	2.3	1.0	2.3	0.0	1.1	0.0	94.6	5.4	0.0	fine sand
I-9	3.2	0.8	3.2	0.3	1.2	0.0	85.5	13.9	0.6	very fine sand
I-6	1.3	0.6	1.1	0.5	1.4	0.0	99.7	0.3	0.0	medium sand
I-3	1.3	0.5	1.2	0.3	1.1	0.0	99.8	0.2	0.0	medium sand
120 ft stations										
I-29	3.8	1.2	3.6	0.3	1.4	1.1	64.1	32.1	2.7	very fine sand
I-21	1.2	0.7	1.1	0.6	1.8	0.0	99.5	0.5	0.0	medium sand
I-13	1.5	0.6	1.5	0.2	1.0	0.0	99.4	0.5	0.0	medium sand
I-8	1.4	0.7	1.4	0.3	1.5	0.0	97.2	2.7	0.0	medium sand
I-2	1.5	0.6	1.4	0.2	1.0	0.0	100.0	0.0	0.0	medium sand
180 ft stations										
I-28	4.2	1.7	3.6	0.6	1.3	0.0	61.6	32.2	6.2	coarse silt
I-20	0.8	0.7	0.8	0.1	1.0	10.1	89.9	0.0	0.0	coarse sand
I-7	1.0	0.8	1.0	0.1	1.6	7.8	92.2	0.0	0.0	medium sand
I-1	2.8	1.0	2.7	0.4	1.9	0.0	90.5	8.5	0.9	fine sand

Appendix B

Supporting Data

2001 SBOO Stations

Demersal Fishes and Megabenthic Invertebrates

Summary of demersal fish species captured during 2001 at SBOO stations. Data are number of fish collected (N) and minimum, maximum, and mean length (cm).

			LENGTH		
Taxon/Species	**Common Name**	**N**	**Min**	**Max**	**Mean**
RAJIFORMES					
Rajidae					
Raja inornata	California skate	4	30	48	38
Urolophidae					
Urolophus halleri	round stingray	2	34	39	37
CLUPEIFORMES					
Engraulidae					
Engraulis mordax	northern anchovy	359	6	12	8
AULOPIFORMES					
Synodontidae					
Synodus lucioceps	California lizardfish	62	8	35	19
BATRACHOIDIFORMES					
Batrachoididae					
Porichthys myriaster	specklefin midshipman	3	21	28	25
Porichthys notatus	plainfin midshipman	6	6	20	10
SCORPAENIFORMES					
Scorpaenidae					
Scorpaena guttata	California scorpionfish	54	13	29	20
Cottidae					
Chitonotus pugetensis	roughback sculpin	21	6	10	9
Icelinus quadriseriatus	yellowchin sculpin	6	6	7	6
PERCIFORMES					
Embiotocidae					
Cymatogaster aggregata	shiner perch	5	10	12	11
Serranidae					
Paralabrax nebulifer	barred sand bass	2	25	30	28
Sciaenidae					
Genyonemus lineatus	white croaker	127	8	26	16
Seriphus politus	queenfish	5	9	17	15
Malacanthidae					
Caulolatilus princeps	ocean whitefish	3	3	5	4
Clinidae					
Heterostichus rostratus	giant kelpfish	2	12	13	13
Gobiidae					
Lepidogobius lepidus	bay goby	1	4	4	4

Taxon/Species	Common Name	N	LENGTH Min	Max	Mean
PLEURONECTIFORMES	(juv. unid. flatfish)	1	3	3	3
Paralichthyidae					
Citharichthys stigmaeus	speckled sanddab	570	3	12	8
Citharichthys xanthostigma	longfin sanddab	141	5	21	14
Hippoglossina stomata	bigmouth sole	5	17	23	19
Paralichthys californicus	California halibut	33	24	49	34
Xystreurys liolepis	fantail sole	10	19	34	23
Pleuronectidae					
Hypsopsetta guttulata	diamond turbot	1	24	24	24
Pleuronectes vetulus	English sole	15	7	26	17
Pleuronichthys decurrens	curlfin sole	5	16	19	18
Pleuronichthys ritteri	spotted turbot	36	11	19	16
Pleuronichthys verticalis	hornyhead turbot	73	5	25	16
Cynoglossidae					
Symphurus atricauda	California tonguefish	20	11	17	14

Taxonomic arrangement from Nelson 1994.

Appendix C

Supporting Data

2001 SBOO Stations

Bioaccumulation of Contaminants in Fish Tissue

Lengths and weights of fishes used in composite samples for April 2001.

STATION	Rep	Species	N	min lnth	max lnth	avg lnth	min wt	max wt	avg wt
RF3	1	Vermilion rockfish	5	18	22	20	164.3	238.5	201.2
RF3	2	Ca. scorpionfish	3	17	30	25	153.4	800.0	567.8
RF3	3	Ca. scorpionfish	3	27	27	27	690.0	750.0	716.7
RF4	1	Ca. scorpionfish	3	20	25	23	247.8	580.2	426.4
RF4	2	Ca. scorpionfish	3	21	28	25	303.9	750.0	551.3
RF4	3	Ca. scorpionfish	3	22	27	25	368.1	625.0	534.4
SD15	1	Hornyhead turbot	7	15	19	17	96.7	196.9	141.0
SD16	1	Longfin sanddab	16	14	17	16	56.4	99.0	73.5
SD16	2	Hornyhead turbot	7	18	20	19	171.5	210.4	181.8
SD16	3	Hornyhead turbot	8	16	24	18	98.7	321.8	152.7
SD17	1	Longfin sanddab	15	12	17	15	39.0	99.7	70.6
SD17	2	Longfin sanddab	19	12	17	14	28.6	88.7	52.6
SD17	3	Hornyhead turbot	6	17	21	19	132.1	335.0	190.0
SD18	1	Ca. scorpionfish	3	16	22	19	138.0	372.0	256.3
SD18	2	Longfin sanddab	10	15	19	17	67.3	138.4	92.4
SD18	3	Hornyhead turbot	7	15	21	18	99.7	268.3	164.6
SD19	1	Hornyhead turbot	4	17	24	20	145.5	318.1	219.0
SD19	2	Longfin sanddab	9	13	17	15	39.3	115.8	65.8
SD19	3	Hornyhead turbot	7	15	19	17	95.1	175.1	124.6
SD20	1	Longfin sanddab	9	15	16	15	55.2	89.1	76.5
SD20	2	Longfin sanddab	11	14	16	15	56.6	83.0	69.7
SD20	3	Ca. scorpionfish	3	21	23	22	249.3	339.0	281.5
SD21	1	Ca. scorpionfish	3	17	25	21	167.1	553.4	382.7
SD21	2	Longfin sanddab	11	14	17	15	54.2	112.7	73.8
SD21	3	Longfin sanddab	18	12	15	14	34.8	72.3	52.5

Lengths and weights of fishes used in composite samples for October 2001.

STATION	Rep	Species	N	min lnth	max lnth	avg lnth	min wt	max wt	avg wt
RF3	1	Vermilion rockfish	3	22	23	22	307.8	326.5	318.5
RF3	2	Vermilion rockfish	3	21	24	22	251.3	370.4	294.6
RF3	3	Ca. scorpionfish	3	25	33	28	479.0	850.0	643.4
RF4	1	Ca. scorpionfish	3	data missing					
RF4	2	Ca. scorpionfish	3	data missing					
RF4	3	Ca. scorpionfish	3	data missing					
SD15	1	Ca. scorpionfish	3	15	22	19	132.5	371.0	262.5
SD15	2	Ca. scorpionfish	3	16	21	19	170.3	346.9	255.9
SD15	3	Ca. scorpionfish	3	15	25	19	98.0	474.1	227.0
SD16	1	Longfin sanddab	4	16	18	17	107.6	167.1	136.5
SD16	2	Ca. scorpionfish	3	17	24	20	230.1	422.2	307.1
SD16	3	Ca. scorpionfish	3	18	22	21	230.3	364.2	309.1
SD17	1	Hornyhead turbot	4	18	19	19	155.4	195.7	176.7
SD17	2	Ca. scorpionfish	3	18	25	21	155.4	507.3	301.7
SD17	3	Ca. scorpionfish	3	20	22	21	245.6	317.0	287.2
SD18	1	Hornyhead turbot	4	18	21	19	184.5	323.8	233.0
SD18	2	Ca. scorpionfish	3	19	22	21	308.0	363.2	342.3
SD18	3	Ca. scorpionfish	3	19	24	22	213.6	532.5	401.1
SD19	1	Longfin sanddab	4	16	18	18	89.1	127.7	111.7
SD19	2	Longfin sanddab	4	17	19	18	92.4	132.5	119.0
SD19	3	Ca. scorpionfish	3	18	24	21	172.4	467.0	305.2
SD20	1	Longfin sanddab	6	14	17	16	65.3	137.2	89.6
SD20	2	Ca. scorpionfish	3	21	24	23	267.3	465.6	373.8
SD20	3	Ca. scorpionfish	3	17	31	22	155.2	610.0	327.9
SD21	1	Longfin sanddab	10	12	16	14	33.9	81.5	57.2
SD21	2	Ca. scorpionfish	3	18	23	20	52.1	368.0	176.7
SD21	3	Ca. scorpionfish	3	16	23	20	128.8	426.7	279.3

Analyzed constituents for fish tissue samples for April and October 2001.

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

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

Metals			
Aluminum	Chromium	Manganese	Silver
Antimony	Copper	Mercury	Thallium
Arsenic	Iron	Nickel	Tin
Beryllium	Lead	Selenium	Zinc
Cadmium			

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

April 2001

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
RF3	1	Vermilion rockfish	Muscle	Aluminum	10.4		mg/kg	2.6
RF3	1	Vermilion rockfish	Muscle	Copper	6.36		mg/kg	0.76
RF3	1	Vermilion rockfish	Muscle	Iron	4.7		mg/kg	1.3
RF3	1	Vermilion rockfish	Muscle	Lipids	0.15		wt%	
RF3	1	Vermilion rockfish	Muscle	Mercury	0.0115		mg/kg	0.012
RF3	1	Vermilion rockfish	Muscle	p,p-DDE	1.4		ug/kg	1.33
RF3	1	Vermilion rockfish	Muscle	PCB 101	0.1	E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 206	0.2	E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	Total Solids	20.3		wt%	0.4
RF3	1	Vermilion rockfish	Muscle	Zinc	3.33		mg/kg	0.58
RF3	2	Ca. scorpionfish	Muscle	Aluminum	8.8		mg/kg	2.6
RF3	2	Ca. scorpionfish	Muscle	Arsenic	12.7		mg/kg	1.4
RF3	2	Ca. scorpionfish	Muscle	Copper	8.86		mg/kg	0.76
RF3	2	Ca. scorpionfish	Muscle	Iron	4.8		mg/kg	1.3
RF3	2	Ca. scorpionfish	Muscle	Lipids	0.38		wt%	
RF3	2	Ca. scorpionfish	Muscle	Mercury	0.0815		mg/kg	0.012
RF3	2	Ca. scorpionfish	Muscle	p,p-DDE	10		ug/kg	1.33
RF3	2	Ca. scorpionfish	Muscle	PCB 101	0.6	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 105	0.6	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 114	0.5	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 118	0.9	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 123	0.5	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 126	0.5	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 128	0.5	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 138	1.1	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 151	0.3	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 153/168	1.8		ug/kg	1.33
RF3	2	Ca. scorpionfish	Muscle	PCB 156	0.5	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 158	0.3	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 167	0.2	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 170	0.6	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 177	0.3	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 180	0.8	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 187	0.5	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 189	0.4	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 194	0.4	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 206	0.5	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 28	0.9	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 37	0.9	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 44	0.2	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 52	0.3	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 66	0.6	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 70	0.6	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 74	0.6	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 77	0.8	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	PCB 99	0.6	E	ug/kg	
RF3	2	Ca. scorpionfish	Muscle	Selenium	0.233		mg/kg	0.17
RF3	2	Ca. scorpionfish	Muscle	Tin	40.4		mg/kg	4.6
RF3	2	Ca. scorpionfish	Muscle	Total Solids	21.9		wt%	0.4

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
RF3	2	Ca. scorpionfish	Muscle	Zinc	4		mg/kg	0.58
RF3	3	Ca. scorpionfish	Muscle	Copper	2.32		mg/kg	0.76
RF3	3	Ca. scorpionfish	Muscle	Iron	3.5		mg/kg	1.3
RF3	3	Ca. scorpionfish	Muscle	Lipids	0.99		wt%	
RF3	3	Ca. scorpionfish	Muscle	Mercury	0.311		mg/kg	0.012
RF3	3	Ca. scorpionfish	Muscle	p,p-DDD	0.7	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	p,p-DDE	35		ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	p,p-DDT	0.3	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 101	1	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 105	0.5	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 110	0.6	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 118	1.8		ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	PCB 128	0.3	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 138	2.3		ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	PCB 149	0.9	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 151	0.4	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 153/168	4.2		ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	PCB 156	0.2	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 170	0.6	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 177	0.5	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 180	1.8		ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	PCB 183	0.6	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 187	1.5		ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	PCB 194	0.4	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 206	0.4	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 66	0.2	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 70	0.1	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 74	0.2	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 87	0.2	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 99	1	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	Selenium	0.22		mg/kg	0.13
RF3	3	Ca. scorpionfish	Muscle	Total Solids	25.2		wt%	0.4
RF3	3	Ca. scorpionfish	Muscle	Zinc	4.98		mg/kg	0.58
RF4	1	Ca. scorpionfish	Muscle	Copper	1.75		mg/kg	0.76
RF4	1	Ca. scorpionfish	Muscle	Iron	8		mg/kg	1.3
RF4	1	Ca. scorpionfish	Muscle	Lipids	0.82		wt%	
RF4	1	Ca. scorpionfish	Muscle	Mercury	0.069		mg/kg	0.012
RF4	1	Ca. scorpionfish	Muscle	p,p-DDD	0.5	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	p,p-DDE	25		ug/kg	1.33
RF4	1	Ca. scorpionfish	Muscle	p,p-DDT	0.2	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 101	0.5	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 105	0.2	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 110	0.2	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 118	0.5	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 138	0.7	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 149	0.4	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 151	0.2	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 153/168	1.4		ug/kg	1.33
RF4	1	Ca. scorpionfish	Muscle	PCB 177	0.2	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 180	0.2	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 187	0.4	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value	Units	MDL
RF4	1	Ca. scorpionfish	Muscle	PCB 206	0.2 E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 52	0.1 E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 66	0.2 E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 74	0.1 E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 99	0.3 E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Selenium	0.14	mg/kg	0.13
RF4	1	Ca. scorpionfish	Muscle	Total Solids	21.6	wt%	0.4
RF4	1	Ca. scorpionfish	Muscle	Zinc	4.12	mg/kg	0.58
RF4	2	Ca. scorpionfish	Muscle	Aluminum	3.2	mg/kg	2.6
RF4	2	Ca. scorpionfish	Muscle	Arsenic	2.3	mg/kg	1.4
RF4	2	Ca. scorpionfish	Muscle	Copper	11.3	mg/kg	0.76
RF4	2	Ca. scorpionfish	Muscle	Lipids	0.32	wt%	
RF4	2	Ca. scorpionfish	Muscle	Mercury	0.079	mg/kg	0.012
RF4	2	Ca. scorpionfish	Muscle	p,p-DDD	0.2 E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	p,p-DDE	11	ug/kg	1.33
RF4	2	Ca. scorpionfish	Muscle	p,p-DDT	0.2 E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 101	0.2 E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 118	0.4 E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 138	0.4 E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 153/168	1 E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 180	0.4 E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 187	0.4 E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 194	0.1 E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 206	0.3 E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Selenium	0.18	mg/kg	0.13
RF4	2	Ca. scorpionfish	Muscle	Total Solids	21.5	wt%	0.4
RF4	2	Ca. scorpionfish	Muscle	Zinc	3.58	mg/kg	0.58
RF4	3	Ca. scorpionfish	Muscle	Aluminum	3.9	mg/kg	2.6
RF4	3	Ca. scorpionfish	Muscle	Copper	10.8	mg/kg	0.76
RF4	3	Ca. scorpionfish	Muscle	Lipids	0.31	wt%	
RF4	3	Ca. scorpionfish	Muscle	Mercury	0.0835	mg/kg	0.012
RF4	3	Ca. scorpionfish	Muscle	p,p-DDD	0.45	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	p,p-DDE	16.5	ug/kg	1.33
RF4	3	Ca. scorpionfish	Muscle	p,p-DDT	0.3	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 101	0.4 E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 105	0.05	ug/kg	1.33
RF4	3	Ca. scorpionfish	Muscle	PCB 110	0.2 E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 118	0.55	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 138	0.35	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 149	0.15	ug/kg	1.33
RF4	3	Ca. scorpionfish	Muscle	PCB 153/168	0.8 E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 180	0.2 E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 187	0.3	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 206	0.2 E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 52	0.05	ug/kg	1.33
RF4	3	Ca. scorpionfish	Muscle	PCB 66	0.1 E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 99	0.35	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Selenium	0.17	mg/kg	0.13
RF4	3	Ca. scorpionfish	Muscle	Total Solids	23	wt%	0.4
RF4	3	Ca. scorpionfish	Muscle	Zinc	3.66	mg/kg	0.58
SD15	1	Hornyhead turbot	Liver	Aluminum	26.4	mg/kg	2.6

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD15	1	Hornyhead turbot	Liver	Cadmium	6.5		mg/kg	0.34
SD15	1	Hornyhead turbot	Liver	Copper	11.6		mg/kg	0.76
SD15	1	Hornyhead turbot	Liver	Iron	170		mg/kg	1.3
SD15	1	Hornyhead turbot	Liver	Lipids	2.76		wt%	
SD15	1	Hornyhead turbot	Liver	Manganese	2.21		mg/kg	0.23
SD15	1	Hornyhead turbot	Liver	Mercury	0.113		mg/kg	0.012
SD15	1	Hornyhead turbot	Liver	p,p-DDE	50		ug/kg	13.3
SD15	1	Hornyhead turbot	Liver	PCB 101	1.4	E	ug/kg	
SD15	1	Hornyhead turbot	Liver	PCB 118	1.3	E	ug/kg	
SD15	1	Hornyhead turbot	Liver	PCB 138	2.5	E	ug/kg	
SD15	1	Hornyhead turbot	Liver	PCB 153/168	5.8	E	ug/kg	
SD15	1	Hornyhead turbot	Liver	PCB 180	2.3	E	ug/kg	
SD15	1	Hornyhead turbot	Liver	PCB 187	3.2	E	ug/kg	
SD15	1	Hornyhead turbot	Liver	PCB 206	2.3	E	ug/kg	
SD15	1	Hornyhead turbot	Liver	Selenium	0.6		mg/kg	0.13
SD15	1	Hornyhead turbot	Liver	Total Solids	22.2		wt%	0.4
SD15	1	Hornyhead turbot	Liver	Zinc	43.5		mg/kg	0.58
SD16	1	Longfin sanddab	Liver	Alpha (cis) Chlordane	5.2	E	ug/kg	
SD16	1	Longfin sanddab	Liver	Aluminum	26.6		mg/kg	2.6
SD16	1	Longfin sanddab	Liver	Cadmium	2.54		mg/kg	0.34
SD16	1	Longfin sanddab	Liver	Copper	11.7		mg/kg	0.76
SD16	1	Longfin sanddab	Liver	Hexachlorobenzene	1.9	E	ug/kg	
SD16	1	Longfin sanddab	Liver	Iron	185		mg/kg	1.3
SD16	1	Longfin sanddab	Liver	Lipids	15.3		wt%	
SD16	1	Longfin sanddab	Liver	Manganese	1.5		mg/kg	0.23
SD16	1	Longfin sanddab	Liver	Mercury	0.112		mg/kg	0.012
SD16	1	Longfin sanddab	Liver	o,p-DDE	13	E	ug/kg	
SD16	1	Longfin sanddab	Liver	p,p-DDD	13	E	ug/kg	
SD16	1	Longfin sanddab	Liver	p,p-DDE	1200		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	p,p-DDT	15		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 101	9.3	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 105	15		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 118	54		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 123	4.5	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 128	11	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 138	110		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 149	7.7	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 151	9.5	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 153/168	160		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 156	8.1	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 158	6.4	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 167	5.5	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 170	32		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 177	8.1	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 180	57		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 183	18		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 187	71		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 194	22		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 201	19		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 206	12	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 66	4.7	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD16	1	Longfin sanddab	Liver	PCB 74	4.3	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 99	28		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	Selenium	1.2		mg/kg	0.17
SD16	1	Longfin sanddab	Liver	Total Solids	40		wt%	0.4
SD16	1	Longfin sanddab	Liver	Trans Nonachlor	11	E	ug/kg	
SD16	1	Longfin sanddab	Liver	Zinc	28.5		mg/kg	0.58
SD16	2	Hornyhead turbot	Liver	Alpha (cis) Chlordane	4.3	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	Aluminum	11.9		mg/kg	2.6
SD16	2	Hornyhead turbot	Liver	Cadmium	8.43		mg/kg	0.34
SD16	2	Hornyhead turbot	Liver	Copper	9.49		mg/kg	0.76
SD16	2	Hornyhead turbot	Liver	Hexachlorobenzene	0.9	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	Iron	65.5		mg/kg	1.3
SD16	2	Hornyhead turbot	Liver	Lipids	2.69		wt%	
SD16	2	Hornyhead turbot	Liver	Manganese	1.94		mg/kg	0.23
SD16	2	Hornyhead turbot	Liver	Mercury	0.172		mg/kg	0.012
SD16	2	Hornyhead turbot	Liver	o,p-DDE	17		ug/kg	13.3
SD16	2	Hornyhead turbot	Liver	p,p-DDD	7.7	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	p,p-DDE	720		ug/kg	13.3
SD16	2	Hornyhead turbot	Liver	p,p-DDT	6.6	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 101	6.6	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 105	4.3	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 118	24		ug/kg	13.3
SD16	2	Hornyhead turbot	Liver	PCB 128	3.6	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 138	46		ug/kg	13.3
SD16	2	Hornyhead turbot	Liver	PCB 149	4.9	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 151	4.1	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 153/168	66		ug/kg	13.3
SD16	2	Hornyhead turbot	Liver	PCB 156	3.7	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 158	3.1	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 170	16		ug/kg	13.3
SD16	2	Hornyhead turbot	Liver	PCB 177	2.4	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 180	24		ug/kg	13.3
SD16	2	Hornyhead turbot	Liver	PCB 183	7.9	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 187	29		ug/kg	13.3
SD16	2	Hornyhead turbot	Liver	PCB 194	9.8	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 201	9.8	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 206	6.8	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 66	2.9	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 70	1	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 74	2.5	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	PCB 99	15		ug/kg	13.3
SD16	2	Hornyhead turbot	Liver	Selenium	0.66		mg/kg	0.13
SD16	2	Hornyhead turbot	Liver	Total Solids	23.1		wt%	0.4
SD16	2	Hornyhead turbot	Liver	Trans Nonachlor	5.6	E	ug/kg	
SD16	2	Hornyhead turbot	Liver	Zinc	37.5		mg/kg	0.58
SD16	3	Hornyhead turbot	Liver	Aluminum	10.9		mg/kg	2.6
SD16	3	Hornyhead turbot	Liver	Cadmium	8.68		mg/kg	0.34
SD16	3	Hornyhead turbot	Liver	Copper	9.43		mg/kg	0.76
SD16	3	Hornyhead turbot	Liver	Iron	69.4		mg/kg	1.3
SD16	3	Hornyhead turbot	Liver	Lipids	2.74		wt%	
SD16	3	Hornyhead turbot	Liver	Manganese	1.91		mg/kg	0.23

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD16	3	Hornyhead turbot	Liver	Mercury	0.099		mg/kg	0.012
SD16	3	Hornyhead turbot	Liver	p,p-DDD	0.6	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	p,p-DDE	91		ug/kg	13.3
SD16	3	Hornyhead turbot	Liver	PCB 101	2.2	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 118	3.7	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 138	6.2	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 153/168	10.2	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 180	5	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 187	3.6	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 194	1.6	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 206	3.7	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 28	1.2	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 66	0.9	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 74	0.9	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	PCB 99	3.2	E	ug/kg	
SD16	3	Hornyhead turbot	Liver	Selenium	0.7		mg/kg	0.13
SD16	3	Hornyhead turbot	Liver	Total Solids	23.2		wt%	0.4
SD16	3	Hornyhead turbot	Liver	Zinc	38.9		mg/kg	0.58
SD17	1	Longfin sanddab	Liver	Aluminum	17		mg/kg	2.6
SD17	1	Longfin sanddab	Liver	Arsenic	3.4		mg/kg	1.4
SD17	1	Longfin sanddab	Liver	Cadmium	3.71		mg/kg	0.34
SD17	1	Longfin sanddab	Liver	Copper	12.9		mg/kg	0.76
SD17	1	Longfin sanddab	Liver	Hexachlorobenzene	1.2	E	ug/kg	
SD17	1	Longfin sanddab	Liver	Iron	209		mg/kg	1.3
SD17	1	Longfin sanddab	Liver	Lipids	9.45		wt%	
SD17	1	Longfin sanddab	Liver	Manganese	1.58		mg/kg	0.23
SD17	1	Longfin sanddab	Liver	Mercury	0.12		mg/kg	0.012
SD17	1	Longfin sanddab	Liver	o,p-DDE	250		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	p,p-DDD	6.8	E	ug/kg	
SD17	1	Longfin sanddab	Liver	p,p-DDE	6790		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	p,p-DDT	26		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 101	13	E	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 105	31		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 118	110		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 123	8.4	E	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 128	17		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 138	150		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 149	5.9	E	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 151	11	E	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 153/168	166		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 156	11	E	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 157	3.2	E	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 158	11	E	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 167	6.4	E	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 170	30		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 177	4.3	E	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 180	64		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 183	18		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 187	66		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 194	27		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 201	16		ug/kg	13.3

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD17	1	Longfin sanddab	Liver	PCB 206	15		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 28	1.8	E	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 66	16		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 74	17		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	PCB 87	1	E	ug/kg	
SD17	1	Longfin sanddab	Liver	PCB 99	59		ug/kg	13.3
SD17	1	Longfin sanddab	Liver	Selenium	1.93		mg/kg	0.43
SD17	1	Longfin sanddab	Liver	Total Solids	36.8		wt%	0.4
SD17	1	Longfin sanddab	Liver	Trans Nonachlor	7.2	E	ug/kg	
SD17	1	Longfin sanddab	Liver	Zinc	31		mg/kg	0.58
SD17	2	Longfin sanddab	Liver	Aluminum	14.7		mg/kg	2.6
SD17	2	Longfin sanddab	Liver	Arsenic	2.4		mg/kg	1.4
SD17	2	Longfin sanddab	Liver	Cadmium	2.75		mg/kg	0.34
SD17	2	Longfin sanddab	Liver	Copper	15.3		mg/kg	0.76
SD17	2	Longfin sanddab	Liver	Iron	190		mg/kg	1.3
SD17	2	Longfin sanddab	Liver	Lipids	5.81		wt%	
SD17	2	Longfin sanddab	Liver	Manganese	1.95		mg/kg	0.23
SD17	2	Longfin sanddab	Liver	Mercury	0.119		mg/kg	0.012
SD17	2	Longfin sanddab	Liver	o,p-DDE	3.9	E	ug/kg	
SD17	2	Longfin sanddab	Liver	p,p-DDD	2.5	E	ug/kg	
SD17	2	Longfin sanddab	Liver	p,p-DDE	330		ug/kg	13.3
SD17	2	Longfin sanddab	Liver	p,p-DDT	4.9	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 101	2.7	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 105	2.4	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 118	17		ug/kg	13.3
SD17	2	Longfin sanddab	Liver	PCB 128	3.3	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 138	31		ug/kg	13.3
SD17	2	Longfin sanddab	Liver	PCB 149	2.5	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 151	3.5	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 153/168	50		ug/kg	13.3
SD17	2	Longfin sanddab	Liver	PCB 156	3.7	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 158	2.1	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 170	7.8	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 177	1.4	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 180	18		ug/kg	13.3
SD17	2	Longfin sanddab	Liver	PCB 183	4.9	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 187	20		ug/kg	13.3
SD17	2	Longfin sanddab	Liver	PCB 194	8.6	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 201	4.8	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 206	7.1	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 66	1.5	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 74	1.2	E	ug/kg	
SD17	2	Longfin sanddab	Liver	PCB 99	9.4	E	ug/kg	
SD17	2	Longfin sanddab	Liver	Selenium	1.67		mg/kg	0.43
SD17	2	Longfin sanddab	Liver	Total Solids	28.5		wt%	0.4
SD17	2	Longfin sanddab	Liver	Zinc	30.5		mg/kg	0.58
SD17	3	Hornyhead turbot	Liver	Aluminum	10.9		mg/kg	2.6
SD17	3	Hornyhead turbot	Liver	Arsenic	5.9		mg/kg	1.4
SD17	3	Hornyhead turbot	Liver	Cadmium	7.8		mg/kg	0.34
SD17	3	Hornyhead turbot	Liver	Copper	10.3		mg/kg	0.76
SD17	3	Hornyhead turbot	Liver	Iron	89.7		mg/kg	1.3

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD17	3	Hornyhead turbot	Liver	Lipids	3.09		wt%	
SD17	3	Hornyhead turbot	Liver	Manganese	1.1		mg/kg	0.23
SD17	3	Hornyhead turbot	Liver	Mercury	0.126		mg/kg	0.012
SD17	3	Hornyhead turbot	Liver	o,p-DDE	1.8	E	ug/kg	
SD17	3	Hornyhead turbot	Liver	p,p-DDD	1.8	E	ug/kg	
SD17	3	Hornyhead turbot	Liver	p,p-DDE	120		ug/kg	13.3
SD17	3	Hornyhead turbot	Liver	PCB 101	2.5	E	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 118	4.8	E	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 138	8.1	E	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 153/168	13.4		ug/kg	13.3
SD17	3	Hornyhead turbot	Liver	PCB 180	5.4	E	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 183	1.2	E	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 206	4.3	E	ug/kg	
SD17	3	Hornyhead turbot	Liver	PCB 99	3.3	E	ug/kg	
SD17	3	Hornyhead turbot	Liver	Selenium	1.23		mg/kg	0.43
SD17	3	Hornyhead turbot	Liver	Total Solids	24.2		wt%	0.4
SD17	3	Hornyhead turbot	Liver	Zinc	40.7		mg/kg	0.58
SD18	1	Ca. scorpionfish	Liver	Aluminum	9.6		mg/kg	2.6
SD18	1	Ca. scorpionfish	Liver	Cadmium	2.74		mg/kg	0.34
SD18	1	Ca. scorpionfish	Liver	Copper	28.8		mg/kg	0.76
SD18	1	Ca. scorpionfish	Liver	Hexachlorobenzene	1.1	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	Iron	261		mg/kg	1.3
SD18	1	Ca. scorpionfish	Liver	Lipids	11.1		wt%	
SD18	1	Ca. scorpionfish	Liver	Manganese	0.47		mg/kg	0.23
SD18	1	Ca. scorpionfish	Liver	Mercury	0.122		mg/kg	0.012
SD18	1	Ca. scorpionfish	Liver	p,p-DDD	9.7	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	p,p-DDE	450		ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	p,p-DDT	4.3	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 101	20		ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 105	11	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 110	12	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 118	59		ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 123	4.9	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 128	15		ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 138	83		ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 149	8.7	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 151	6.6	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 153/168	114		ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 156	6.5	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 158	4.9	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 167	3.3	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 170	18		ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 177	5.1	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 180	38		ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 183	13	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 187	47		ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	PCB 194	11	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 206	7.7	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 66	7.7	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 74	5.4	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	PCB 87	2.2	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD18	1	Ca. scorpionfish	Liver	PCB 99	32		ug/kg	13.3
SD18	1	Ca. scorpionfish	Liver	Selenium	0.86		mg/kg	0.13
SD18	1	Ca. scorpionfish	Liver	Total Solids	29.2		wt%	0.4
SD18	1	Ca. scorpionfish	Liver	Trans Nonachlor	9.3	E	ug/kg	
SD18	1	Ca. scorpionfish	Liver	Zinc	118		mg/kg	0.58
SD18	2	Longfin sanddab	Liver	Aluminum	18.8		mg/kg	2.6
SD18	2	Longfin sanddab	Liver	Arsenic	3.7		mg/kg	1.4
SD18	2	Longfin sanddab	Liver	Cadmium	3.26		mg/kg	0.34
SD18	2	Longfin sanddab	Liver	Copper	12.2		mg/kg	0.76
SD18	2	Longfin sanddab	Liver	Hexachlorobenzene	1.5	E	ug/kg	
SD18	2	Longfin sanddab	Liver	Iron	152		mg/kg	1.3
SD18	2	Longfin sanddab	Liver	Lipids	12.2		wt%	
SD18	2	Longfin sanddab	Liver	Manganese	2.17		mg/kg	0.23
SD18	2	Longfin sanddab	Liver	Mercury	0.095		mg/kg	0.012
SD18	2	Longfin sanddab	Liver	o,p-DDE	9.4	E	ug/kg	
SD18	2	Longfin sanddab	Liver	p,p-DDD	6.9	E	ug/kg	
SD18	2	Longfin sanddab	Liver	p,p-DDE	710		ug/kg	13.3
SD18	2	Longfin sanddab	Liver	p,p-DDT	11	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 101	7.5	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 105	6.6	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 110	5.8	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 118	31		ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 123	2.7	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 128	6.8	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 138	56		ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 149	7	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 151	5.6	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 153/168	78		ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 156	5	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 158	3.9	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 167	2.2	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 170	18		ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 177	4	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 180	28		ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 183	9.8	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 187	39		ug/kg	13.3
SD18	2	Longfin sanddab	Liver	PCB 194	12	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 201	12	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 206	7.5	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 28	2.6	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 37	1.5	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 49	1.8	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 66	4.7	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 70	2.1	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 74	3.2	E	ug/kg	
SD18	2	Longfin sanddab	Liver	PCB 99	17		ug/kg	13.3
SD18	2	Longfin sanddab	Liver	Selenium	0.94		mg/kg	0.13
SD18	2	Longfin sanddab	Liver	Total Solids	30.7		wt%	0.4
SD18	2	Longfin sanddab	Liver	Trans Nonachlor	6.4	E	ug/kg	
SD18	2	Longfin sanddab	Liver	Zinc	28.2		mg/kg	0.58
SD18	3	Hornyhead turbot	Liver	Aluminum	14.5		mg/kg	2.6

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD18	3	Hornyhead turbot	Liver	Cadmium	6.59		mg/kg	0.34
SD18	3	Hornyhead turbot	Liver	Copper	12.3		mg/kg	0.76
SD18	3	Hornyhead turbot	Liver	Hexachlorobenzene	0.35		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	Iron	86.5		mg/kg	1.3
SD18	3	Hornyhead turbot	Liver	Lipids	3.96		wt%	
SD18	3	Hornyhead turbot	Liver	Manganese	1.32		mg/kg	0.23
SD18	3	Hornyhead turbot	Liver	Mercury	0.0935		mg/kg	0.012
SD18	3	Hornyhead turbot	Liver	p,p-DDD	3.55		ug/kg	
SD18	3	Hornyhead turbot	Liver	p,p-DDE	195		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	p,p-DDT	1.5	E	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 101	3.6		ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 105	1.4		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 110	1.35		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 118	6.15		ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 119	1.3		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 128	0.95		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 138	9.9		ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 149	2.15		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 151	0.9		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 153/168	18		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 156	1.55		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 157	1.4		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 158	1.2		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 170	5.85		ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 177	1.25		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 180	11	E	ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 183	3.5		ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 187	8.45		ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 194	4.55		ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 206	5.9		ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 28	1.5		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 37	1.45		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 66	1.85		ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 70	1.2		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 74	1.95		ug/kg	
SD18	3	Hornyhead turbot	Liver	PCB 87	1		ug/kg	13.3
SD18	3	Hornyhead turbot	Liver	PCB 99	4.6		ug/kg	
SD18	3	Hornyhead turbot	Liver	Selenium	0.78		mg/kg	0.13
SD18	3	Hornyhead turbot	Liver	Total Solids	23.2		wt%	0.4
SD18	3	Hornyhead turbot	Liver	Zinc	40.5		mg/kg	0.58
SD19	1	Hornyhead turbot	Liver	Aluminum	8.7		mg/kg	2.6
SD19	1	Hornyhead turbot	Liver	Cadmium	8.1		mg/kg	0.34
SD19	1	Hornyhead turbot	Liver	Copper	20.4		mg/kg	0.76
SD19	1	Hornyhead turbot	Liver	Iron	50.3		mg/kg	1.3
SD19	1	Hornyhead turbot	Liver	Lipids	2.78		wt%	
SD19	1	Hornyhead turbot	Liver	Manganese	2.6		mg/kg	0.23
SD19	1	Hornyhead turbot	Liver	Mercury	0.105		mg/kg	0.012
SD19	1	Hornyhead turbot	Liver	p,p-DDE	59		ug/kg	13.3
SD19	1	Hornyhead turbot	Liver	PCB 101	1.6	E	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 118	2.6	E	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 138	3.2	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD19	1	Hornyhead turbot	Liver	PCB 153/168	6.2	E	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 180	3.4	E	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 183	0.9	E	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 187	3.6	E	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 194	1	E	ug/kg	
SD19	1	Hornyhead turbot	Liver	PCB 206	4.1	E	ug/kg	
SD19	1	Hornyhead turbot	Liver	Selenium	0.4		mg/kg	0.13
SD19	1	Hornyhead turbot	Liver	Total Solids	21.7		wt%	0.4
SD19	1	Hornyhead turbot	Liver	Zinc	34.8		mg/kg	0.58
SD19	2	Longfin sanddab	Liver	Aluminum	37.6		mg/kg	2.6
SD19	2	Longfin sanddab	Liver	Cadmium	2.75		mg/kg	0.34
SD19	2	Longfin sanddab	Liver	Copper	18		mg/kg	0.76
SD19	2	Longfin sanddab	Liver	Hexachlorobenzene	1.5	E	ug/kg	
SD19	2	Longfin sanddab	Liver	Iron	143		mg/kg	1.3
SD19	2	Longfin sanddab	Liver	Lipids	12		wt%	
SD19	2	Longfin sanddab	Liver	Manganese	2.79		mg/kg	0.23
SD19	2	Longfin sanddab	Liver	Mercury	0.113		mg/kg	0.012
SD19	2	Longfin sanddab	Liver	o,p-DDE	7	E	ug/kg	
SD19	2	Longfin sanddab	Liver	p,p-DDD	5.4	E	ug/kg	
SD19	2	Longfin sanddab	Liver	p,p-DDE	490		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	p,p-DDT	6.1	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 101	6.2	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 105	8.8	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 110	5.9	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 118	32		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 128	6.9	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 138	67		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 149	6.1	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 151	6.2	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 153/168	92		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 156	5.7	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 158	4.2	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 167	3.2	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 170	19		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 177	5.7	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 180	43		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 183	13	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 187	45		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 194	19		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 201	11	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 206	12	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 28	0.9	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 66	2.8	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 74	2.7	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 99	17		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	Selenium	0.97		mg/kg	0.13
SD19	2	Longfin sanddab	Liver	Total Solids	32.9		wt%	0.4
SD19	2	Longfin sanddab	Liver	Zinc	28.9		mg/kg	0.58
SD19	3	Hornyhead turbot	Liver	Aluminum	16.8		mg/kg	2.6
SD19	3	Hornyhead turbot	Liver	Cadmium	7.56		mg/kg	0.34
SD19	3	Hornyhead turbot	Liver	Copper	10.8		mg/kg	0.76

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD19	3	Hornyhead turbot	Liver	Iron	136		mg/kg	1.3
SD19	3	Hornyhead turbot	Liver	Lipids	3.32		wt%	
SD19	3	Hornyhead turbot	Liver	Manganese	1.18		mg/kg	0.23
SD19	3	Hornyhead turbot	Liver	Mercury	0.135		mg/kg	0.012
SD19	3	Hornyhead turbot	Liver	o,p-DDE	39		ug/kg	13.3
SD19	3	Hornyhead turbot	Liver	p,p-DDD	12	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	p,p-DDE	540		ug/kg	13.3
SD19	3	Hornyhead turbot	Liver	p,p-DDT	1.9	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 101	7.2	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 105	2.2	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 110	1.5	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 118	11	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 138	13	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 149	5.9	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 151	1.6	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 153/168	24		ug/kg	13.3
SD19	3	Hornyhead turbot	Liver	PCB 158	1	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 180	6.3	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 183	1.7	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 187	8.2	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 194	2.6	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 206	5	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 66	3.2	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 70	1.5	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 74	2.5	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	PCB 99	7.8	E	ug/kg	
SD19	3	Hornyhead turbot	Liver	Selenium	0.68		mg/kg	0.13
SD19	3	Hornyhead turbot	Liver	Total Solids	20.9		wt%	0.4
SD19	3	Hornyhead turbot	Liver	Zinc	46.5		mg/kg	0.58
SD20	1	Longfin sanddab	Liver	Alpha (cis) Chlordane	5	E	ug/kg	
SD20	1	Longfin sanddab	Liver	Aluminum	16.6		mg/kg	2.6
SD20	1	Longfin sanddab	Liver	Arsenic	10.5		mg/kg	1.4
SD20	1	Longfin sanddab	Liver	Cadmium	2.72		mg/kg	0.34
SD20	1	Longfin sanddab	Liver	Copper	11.9		mg/kg	0.76
SD20	1	Longfin sanddab	Liver	Hexachlorobenzene	11	E	ug/kg	
SD20	1	Longfin sanddab	Liver	Iron	138		mg/kg	1.3
SD20	1	Longfin sanddab	Liver	Lipids	10.9		wt%	
SD20	1	Longfin sanddab	Liver	Manganese	1.52		mg/kg	0.23
SD20	1	Longfin sanddab	Liver	o,p-DDE	9.3	E	ug/kg	
SD20	1	Longfin sanddab	Liver	o,p-DDT	1.4	E	ug/kg	
SD20	1	Longfin sanddab	Liver	p,p-DDD	9.1	E	ug/kg	
SD20	1	Longfin sanddab	Liver	p,p-DDE	960		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	p,p-DDT	9.9	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 101	8	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 105	3.1	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 118	29		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 128	6.8	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 138	64		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 149	6.3	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 151	6.4	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 153/168	92		ug/kg	13.3

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD20	1	Longfin sanddab	Liver	PCB 156	4.9	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 158	3.8	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 167	2.8	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 170	17		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 177	5.6	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 180	40		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 183	13	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 187	40		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 194	15		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 201	8.9	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 206	7	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 28	1	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 49	1.3	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 66	2.8	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 70	1.4	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 74	2.2	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 99	16		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	Selenium	1.12		mg/kg	0.17
SD20	1	Longfin sanddab	Liver	Total Solids	34.2		wt%	0.4
SD20	1	Longfin sanddab	Liver	Trans Nonachlor	6.1	E	ug/kg	
SD20	1	Longfin sanddab	Liver	Zinc	25.2		mg/kg	0.58
SD20	2	Longfin sanddab	Liver	Aluminum	22.3		mg/kg	2.6
SD20	2	Longfin sanddab	Liver	Arsenic	2.8		mg/kg	1.4
SD20	2	Longfin sanddab	Liver	Cadmium	2.13		mg/kg	0.34
SD20	2	Longfin sanddab	Liver	Copper	16.4		mg/kg	0.76
SD20	2	Longfin sanddab	Liver	Hexachlorobenzene	1.8	E	ug/kg	
SD20	2	Longfin sanddab	Liver	Iron	107		mg/kg	1.3
SD20	2	Longfin sanddab	Liver	Lipids	6.78		wt%	
SD20	2	Longfin sanddab	Liver	Manganese	1.43		mg/kg	0.23
SD20	2	Longfin sanddab	Liver	o,p-DDE	4.9	E	ug/kg	
SD20	2	Longfin sanddab	Liver	p,p-DDD	3.3	E	ug/kg	
SD20	2	Longfin sanddab	Liver	p,p-DDE	470		ug/kg	13.3
SD20	2	Longfin sanddab	Liver	p,p-DDT	6.2	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 101	5.1	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 105	5.1	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 118	19		ug/kg	13.3
SD20	2	Longfin sanddab	Liver	PCB 128	4.7	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 138	39		ug/kg	13.3
SD20	2	Longfin sanddab	Liver	PCB 149	4.8	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 151	5.4	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 153/168	64		ug/kg	13.3
SD20	2	Longfin sanddab	Liver	PCB 156	3.3	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 158	2.8	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 167	2.2	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 170	12	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 177	4.1	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 180	27		ug/kg	13.3
SD20	2	Longfin sanddab	Liver	PCB 183	8.4	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 187	26		ug/kg	13.3
SD20	2	Longfin sanddab	Liver	PCB 194	8.7	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 201	6.9	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD20	2	Longfin sanddab	Liver	PCB 206	6.1	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 66	1.8	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 74	1.7	E	ug/kg	
SD20	2	Longfin sanddab	Liver	PCB 99	10	E	ug/kg	
SD20	2	Longfin sanddab	Liver	Selenium	1.07		mg/kg	0.13
SD20	2	Longfin sanddab	Liver	Total Solids	34.9		wt%	0.4
SD20	2	Longfin sanddab	Liver	Zinc	25.3		mg/kg	0.58
SD20	3	Ca. scorpionfish	Liver	Alpha (cis) Chlordane	6.85		ug/kg	
SD20	3	Ca. scorpionfish	Liver	Aluminum	12.5		mg/kg	2.6
SD20	3	Ca. scorpionfish	Liver	Cadmium	1.42		mg/kg	0.34
SD20	3	Ca. scorpionfish	Liver	Copper	35.7		mg/kg	0.76
SD20	3	Ca. scorpionfish	Liver	Hexachlorobenzene	2.2		ug/kg	
SD20	3	Ca. scorpionfish	Liver	Iron	260		mg/kg	1.3
SD20	3	Ca. scorpionfish	Liver	Lipids	20.8		wt%	
SD20	3	Ca. scorpionfish	Liver	Manganese	0.5		mg/kg	0.23
SD20	3	Ca. scorpionfish	Liver	o,p-DDE	6.7		ug/kg	
SD20	3	Ca. scorpionfish	Liver	p,p-DDD	12		ug/kg	
SD20	3	Ca. scorpionfish	Liver	p,p-DDE	825		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	p,p-DDT	3.25		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 101	19		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 105	9.15		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 110	11.5		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 118	41.5		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 123	3.95		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 128	5.35		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 138	63.5		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 149	11	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 151	7.95		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 153/168	98		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 156	7.15		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 158	5.15		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 170	17.5		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 177	6.8		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 180	41		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 183	14		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 187	45.5		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 194	11.5		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 206	6.8		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 28	0.5		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 44	0.7		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 52	2.2		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 66	5.85		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 70	2.35		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 74	3.35		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 87	3.1		ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 99	19.5		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	Selenium	0.98		mg/kg	0.18
SD20	3	Ca. scorpionfish	Liver	Total Solids	32.8		wt%	0.4
SD20	3	Ca. scorpionfish	Liver	Trans Nonachlor	13.5		ug/kg	
SD20	3	Ca. scorpionfish	Liver	Zinc	129		mg/kg	0.58
SD21	1	Ca. scorpionfish	Liver	Aluminum	24.8		mg/kg	2.6

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD21	1	Ca. scorpionfish	Liver	Cadmium	4.1		mg/kg	0.34
SD21	1	Ca. scorpionfish	Liver	Copper	54.1		mg/kg	0.76
SD21	1	Ca. scorpionfish	Liver	Hexachlorobenzene	1.7	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	Iron	385		mg/kg	1.3
SD21	1	Ca. scorpionfish	Liver	Lipids	28		wt%	
SD21	1	Ca. scorpionfish	Liver	Manganese	0.335		mg/kg	0.23
SD21	1	Ca. scorpionfish	Liver	Mercury	0.432		mg/kg	0.012
SD21	1	Ca. scorpionfish	Liver	o,p-DDE	5.3	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	p,p-DDD	19		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	p,p-DDE	1400		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	p,p-DDT	6.6	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 101	27		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 105	13	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 110	14		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 118	53		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 123	4.6	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 128	9.8	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 138	79		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 149	15		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 151	9.5	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 153/168	114		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 156	7.5	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 158	5.2	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 167	4.2	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 170	19		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 177	9.8	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 180	44		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 183	14		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 187	52		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 194	14		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	PCB 201	12	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 206	8.6	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 28	2	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 49	4.7	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 52	4.7	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 66	8.7	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 70	3.7	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 74	4.5	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 87	4.3	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	PCB 99	26		ug/kg	13.3
SD21	1	Ca. scorpionfish	Liver	Selenium	0.78		mg/kg	0.13
SD21	1	Ca. scorpionfish	Liver	Total Solids	45.2		wt%	0.4
SD21	1	Ca. scorpionfish	Liver	Trans Nonachlor	14	E	ug/kg	
SD21	1	Ca. scorpionfish	Liver	Zinc	159		mg/kg	0.58
SD21	2	Longfin sanddab	Liver	Aluminum	7.2		mg/kg	2.6
SD21	2	Longfin sanddab	Liver	Arsenic	7.7		mg/kg	1.4
SD21	2	Longfin sanddab	Liver	Cadmium	3.12		mg/kg	0.34
SD21	2	Longfin sanddab	Liver	Copper	18.8		mg/kg	0.76
SD21	2	Longfin sanddab	Liver	Hexachlorobenzene	1.9	E	ug/kg	
SD21	2	Longfin sanddab	Liver	Iron	146		mg/kg	1.3
SD21	2	Longfin sanddab	Liver	Lipids	16.2		wt%	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD21	2	Longfin sanddab	Liver	Manganese	1.74		mg/kg	0.23
SD21	2	Longfin sanddab	Liver	Mercury	0.0895		mg/kg	0.012
SD21	2	Longfin sanddab	Liver	o,p-DDE	9.5	E	ug/kg	
SD21	2	Longfin sanddab	Liver	p,p-DDD	11	E	ug/kg	
SD21	2	Longfin sanddab	Liver	p,p-DDE	1100		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	p,p-DDT	16		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 101	15		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 105	13	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 110	9.5	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 118	58		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 123	4.9	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 128	14		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 138	110		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 149	11	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 151	11	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 153/168	152		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 156	7.9	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 158	6.7	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 167	3.9	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 170	28		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 177	10	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 180	60		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 183	19		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 187	68		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 194	22		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 201	14		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	PCB 206	12	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 28	1.6	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 66	5.7	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 70	1.1	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 74	4.1	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 87	1.3	E	ug/kg	
SD21	2	Longfin sanddab	Liver	PCB 99	33		ug/kg	13.3
SD21	2	Longfin sanddab	Liver	Selenium	0.97		mg/kg	0.13
SD21	2	Longfin sanddab	Liver	Total Solids	33.1		wt%	0.4
SD21	2	Longfin sanddab	Liver	Trans Nonachlor	9.1	E	ug/kg	
SD21	2	Longfin sanddab	Liver	Zinc	27.4		mg/kg	0.58
SD21	3	Longfin sanddab	Liver	Aluminum	18.6		mg/kg	2.6
SD21	3	Longfin sanddab	Liver	Arsenic	4.6		mg/kg	1.4
SD21	3	Longfin sanddab	Liver	Cadmium	2.85		mg/kg	0.34
SD21	3	Longfin sanddab	Liver	Copper	14.1		mg/kg	0.76
SD21	3	Longfin sanddab	Liver	Iron	182		mg/kg	1.3
SD21	3	Longfin sanddab	Liver	Lipids	8.75		wt%	
SD21	3	Longfin sanddab	Liver	Manganese	1.9		mg/kg	0.23
SD21	3	Longfin sanddab	Liver	Mercury	0.0985		mg/kg	0.012
SD21	3	Longfin sanddab	Liver	o,p-DDE	3	E	ug/kg	
SD21	3	Longfin sanddab	Liver	p,p-DDD	1.8	E	ug/kg	
SD21	3	Longfin sanddab	Liver	p,p-DDE	400		ug/kg	13.3
SD21	3	Longfin sanddab	Liver	p,p-DDT	4.7	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 101	4.4	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 105	5.5	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD21	3	Longfin sanddab	Liver	PCB 110	3.2	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 118	29		ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 123	2.9	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 128	6.3	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 138	57		ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 149	4	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 151	5.3	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 153/168	88		ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 156	4.9	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 158	2.9	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 170	15		ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 177	3.6	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 180	35		ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 183	12	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 187	38		ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 194	14		ug/kg	13.3
SD21	3	Longfin sanddab	Liver	PCB 201	8.6	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 206	8.9	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 66	1.4	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 74	1.4	E	ug/kg	
SD21	3	Longfin sanddab	Liver	PCB 99	14		ug/kg	13.3
SD21	3	Longfin sanddab	Liver	Selenium	1.65		mg/kg	0.43
SD21	3	Longfin sanddab	Liver	Total Solids	26.5		wt%	0.4
SD21	3	Longfin sanddab	Liver	Trans Nonachlor	3.2	E	ug/kg	
SD21	3	Longfin sanddab	Liver	Zinc	28.3		mg/kg	0.58

October 2001

Station	Rep	Common Name	Tissue	Parameter	Value	Units	MDL
RF3	1	Vermilion rockfish	Muscle	Arsenic	1.9	mg/kg	1.4
RF3	1	Vermilion rockfish	Muscle	Chromium	0.49	mg/kg	0.3
RF3	1	Vermilion rockfish	Muscle	Copper	3.56	mg/kg	0.76
RF3	1	Vermilion rockfish	Muscle	Hexachlorobenzene	0.1 E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	Lipids	0.35	wt%	0.005
RF3	1	Vermilion rockfish	Muscle	Manganese	0.24	mg/kg	0.23
RF3	1	Vermilion rockfish	Muscle	p,p-DDD	0.1 E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	p,p-DDE	3.5	ug/kg	1.33
RF3	1	Vermilion rockfish	Muscle	PCB 101	0.2 E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 110	0.1 E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 118	0.2 E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 138	0.2 E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 149	0.2 E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 153/168	0.4 E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 180	0.2 E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 187	0.2 E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	PCB 99	0.1 E	ug/kg	
RF3	1	Vermilion rockfish	Muscle	Selenium	0.2	mg/kg	0.13
RF3	1	Vermilion rockfish	Muscle	Total Solids	21.5	wt%	0.4
RF3	1	Vermilion rockfish	Muscle	Zinc	2.99	mg/kg	0.58
RF3	2	Vermilion rockfish	Muscle	Chromium	0.79	mg/kg	0.3
RF3	2	Vermilion rockfish	Muscle	Copper	1.23	mg/kg	0.76
RF3	2	Vermilion rockfish	Muscle	Iron	4.5	mg/kg	1.3
RF3	2	Vermilion rockfish	Muscle	Lipids	0.21	wt%	0.005
RF3	2	Vermilion rockfish	Muscle	p,p-DDE	2.6	ug/kg	1.33
RF3	2	Vermilion rockfish	Muscle	PCB 101	0.1 E	ug/kg	
RF3	2	Vermilion rockfish	Muscle	PCB 118	0.1 E	ug/kg	
RF3	2	Vermilion rockfish	Muscle	PCB 138	0.1 E	ug/kg	
RF3	2	Vermilion rockfish	Muscle	PCB 153/168	0.2 E	ug/kg	
RF3	2	Vermilion rockfish	Muscle	Selenium	0.17	mg/kg	0.13
RF3	2	Vermilion rockfish	Muscle	Total Solids	21.2	wt%	0.4
RF3	2	Vermilion rockfish	Muscle	Zinc	3.06	mg/kg	0.58
RF3	3	Ca. scorpionfish	Muscle	Aluminum	6.4	mg/kg	2.6
RF3	3	Ca. scorpionfish	Muscle	Arsenic	2.7	mg/kg	1.4
RF3	3	Ca. scorpionfish	Muscle	Copper	3.47	mg/kg	0.76
RF3	3	Ca. scorpionfish	Muscle	Hexachlorobenzene	0.2 E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	Iron	3.45	mg/kg	1.3
RF3	3	Ca. scorpionfish	Muscle	Lipids	0.67	wt%	0.005
RF3	3	Ca. scorpionfish	Muscle	Mercury	0.078	mg/kg	0.012
RF3	3	Ca. scorpionfish	Muscle	o,p-DDE	3	ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	p,p-DDD	5.6	ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	p,p-DDE	250	ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	p,p-DDT	0.6 E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 101	2.4	ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	PCB 105	1.1 E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 110	1.6	ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	PCB 118	3.5	ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	PCB 119	0.2 E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 123	0.4 E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
RF3	3	Ca. scorpionfish	Muscle	PCB 128	0.7	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 138	2.8		ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	PCB 149	1	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 151	0.5	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 153/168	4.2		ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	PCB 156	0.4	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 157	0.1	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 158	0.3	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 167	0.3	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 177	0.5	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 180	1.9		ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	PCB 183	0.5	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 187	1.3	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 194	0.3	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 206	0.2	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 28	0.3	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 44	0.3	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 49	0.6	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 52	1	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 66	1.3	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 70	0.8	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 74	0.9	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 77	0.1	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 87	0.7	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	PCB 99	1.8		ug/kg	1.33
RF3	3	Ca. scorpionfish	Muscle	Selenium	0.345		mg/kg	0.16
RF3	3	Ca. scorpionfish	Muscle	Total Solids	21.6		wt%	0.4
RF3	3	Ca. scorpionfish	Muscle	Trans Nonachlor	0.6	E	ug/kg	
RF3	3	Ca. scorpionfish	Muscle	Zinc	2.91		mg/kg	0.58
RF4	1	Ca. scorpionfish	Muscle	Arsenic	1.8		mg/kg	1.4
RF4	1	Ca. scorpionfish	Muscle	Iron	4.9		mg/kg	1.3
RF4	1	Ca. scorpionfish	Muscle	Lipids	0.12		wt%	0.005
RF4	1	Ca. scorpionfish	Muscle	Mercury	0.133		mg/kg	0.012
RF4	1	Ca. scorpionfish	Muscle	p,p-DDE	6.4		ug/kg	1.33
RF4	1	Ca. scorpionfish	Muscle	PCB 101	0.2	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 118	0.2	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 138	0.2	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 149	0.1	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 153/168	0.4	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 180	0.1	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 187	0.2	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	PCB 99	0.1	E	ug/kg	
RF4	1	Ca. scorpionfish	Muscle	Selenium	0.25		mg/kg	0.13
RF4	1	Ca. scorpionfish	Muscle	Total Solids	23.2		wt%	0.4
RF4	1	Ca. scorpionfish	Muscle	Zinc	3.54		mg/kg	0.58
RF4	2	Ca. scorpionfish	Muscle	Chromium	0.48		mg/kg	0.3
RF4	2	Ca. scorpionfish	Muscle	Iron	4		mg/kg	1.3
RF4	2	Ca. scorpionfish	Muscle	Lipids	0.16		wt%	0.005
RF4	2	Ca. scorpionfish	Muscle	p,p-DDD	0.2	E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	p,p-DDE	8.3		ug/kg	1.33
RF4	2	Ca. scorpionfish	Muscle	p,p-DDT	0.1	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
RF4	2	Ca. scorpionfish	Muscle	PCB 101	0.2	E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 118	0.3	E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 138	0.2	E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 153/168	0.5	E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 180	0.1	E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	PCB 99	0.1	E	ug/kg	
RF4	2	Ca. scorpionfish	Muscle	Selenium	0.13		mg/kg	0.13
RF4	2	Ca. scorpionfish	Muscle	Total Solids	20.7		wt%	0.4
RF4	2	Ca. scorpionfish	Muscle	Zinc	5.66		mg/kg	0.58
RF4	3	Ca. scorpionfish	Muscle	Copper	5.11		mg/kg	0.76
RF4	3	Ca. scorpionfish	Muscle	Iron	6		mg/kg	1.3
RF4	3	Ca. scorpionfish	Muscle	Lipids	0.2		wt%	0.005
RF4	3	Ca. scorpionfish	Muscle	Mercury	0.039		mg/kg	0.012
RF4	3	Ca. scorpionfish	Muscle	p,p-DDE	3.8		ug/kg	1.33
RF4	3	Ca. scorpionfish	Muscle	PCB 101	0.2	E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 118	0.2	E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 138	0.1	E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 153/168	0.4	E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 180	0.2	E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	PCB 187	0.2	E	ug/kg	
RF4	3	Ca. scorpionfish	Muscle	Selenium	0.23		mg/kg	0.13
RF4	3	Ca. scorpionfish	Muscle	Total Solids	23		wt%	0.4
RF4	3	Ca. scorpionfish	Muscle	Zinc	4.42		mg/kg	0.58
SD15	1	Ca. scorpionfish	Liver	Aluminum	8.4		mg/kg	2.6
SD15	1	Ca. scorpionfish	Liver	Cadmium	2.39		mg/kg	0.34
SD15	1	Ca. scorpionfish	Liver	Copper	17.3		mg/kg	0.76
SD15	1	Ca. scorpionfish	Liver	Hexachlorobenzene	2.2	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	Iron	182		mg/kg	1.3
SD15	1	Ca. scorpionfish	Liver	Lipids	15.4		wt%	0.005
SD15	1	Ca. scorpionfish	Liver	Manganese	0.34		mg/kg	0.23
SD15	1	Ca. scorpionfish	Liver	Mercury	0.144		mg/kg	0.012
SD15	1	Ca. scorpionfish	Liver	o,p-DDE	1.3	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	p,p-DDD	7.3	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	p,p-DDE	400		ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	p,p-DDT	3.2	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 101	11	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 105	3.8	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 110	4.2	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 118	14		ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 123	1.9	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 128	6	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 138	22		ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 149	6.7	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 151	4.4	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 153/168	41		ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 156	2.3	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 158	1.8	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 167	1.3	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 177	4.2	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 180	19		ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 183	5.1	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD15	1	Ca. scorpionfish	Liver	PCB 187	16		ug/kg	13.3
SD15	1	Ca. scorpionfish	Liver	PCB 194	3.4	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 206	3.1	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 49	1.5	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 52	2.8	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 66	1.8	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 74	1.1	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 87	2.6	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	PCB 99	9.3	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	Selenium	1.06		mg/kg	0.17
SD15	1	Ca. scorpionfish	Liver	Total Solids	35.5		wt%	0.4
SD15	1	Ca. scorpionfish	Liver	Trans Nonachlor	7.9	E	ug/kg	
SD15	1	Ca. scorpionfish	Liver	Zinc	127		mg/kg	0.58
SD15	2	Ca. scorpionfish	Liver	Aluminum	8.8		mg/kg	2.6
SD15	2	Ca. scorpionfish	Liver	Cadmium	2.19		mg/kg	0.34
SD15	2	Ca. scorpionfish	Liver	Chromium	3.86		mg/kg	0.3
SD15	2	Ca. scorpionfish	Liver	Copper	10.1		mg/kg	0.76
SD15	2	Ca. scorpionfish	Liver	Hexachlorobenzene	2.8	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	Iron	120		mg/kg	1.3
SD15	2	Ca. scorpionfish	Liver	Lipids	11.7		wt%	0.005
SD15	2	Ca. scorpionfish	Liver	Manganese	0.68		mg/kg	0.23
SD15	2	Ca. scorpionfish	Liver	Mercury	0.121		mg/kg	0.012
SD15	2	Ca. scorpionfish	Liver	p,p-DDD	4.9	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	p,p-DDE	200		ug/kg	13.3
SD15	2	Ca. scorpionfish	Liver	p,p-DDT	1.4	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 101	5.1	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 105	1.4	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 110	2.3	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 118	6.5	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 138	6.9	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 149	3.1	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 153/168	11	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 177	1	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 180	6	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 187	3.9	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 194	1.2	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 206	1.8	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 49	0.7	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 52	1.8	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 66	1	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 70	0.9	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 74	1	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	PCB 99	2.6	E	ug/kg	
SD15	2	Ca. scorpionfish	Liver	Selenium	0.67		mg/kg	0.13
SD15	2	Ca. scorpionfish	Liver	Total Solids	36.6		wt%	0.4
SD15	2	Ca. scorpionfish	Liver	Zinc	71.4		mg/kg	0.58
SD15	3	Ca. scorpionfish	Liver	Aluminum	10.7		mg/kg	2.6
SD15	3	Ca. scorpionfish	Liver	Cadmium	0.9		mg/kg	0.34
SD15	3	Ca. scorpionfish	Liver	Chromium	1.13		mg/kg	0.3
SD15	3	Ca. scorpionfish	Liver	Copper	26.4		mg/kg	0.76
SD15	3	Ca. scorpionfish	Liver	Hexachlorobenzene	4.2	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD15	3	Ca. scorpionfish	Liver	Iron	178		mg/kg	1.3
SD15	3	Ca. scorpionfish	Liver	Lipids	17.6		wt%	0.005
SD15	3	Ca. scorpionfish	Liver	Manganese	0.65		mg/kg	0.23
SD15	3	Ca. scorpionfish	Liver	Mercury	0.126		mg/kg	0.012
SD15	3	Ca. scorpionfish	Liver	o,p-DDE	2.3	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	p,p-DDD	11	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	p,p-DDE	400		ug/kg	13.3
SD15	3	Ca. scorpionfish	Liver	p,p-DDT	3.2	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 101	8.5	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 105	4	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 110	5.2	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 118	13	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 123	1.7	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 128	4.6	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 138	15		ug/kg	13.3
SD15	3	Ca. scorpionfish	Liver	PCB 149	5.6	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 151	3.3	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 153/168	26		ug/kg	13.3
SD15	3	Ca. scorpionfish	Liver	PCB 156	1.6	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 167	1	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 177	3.3	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 180	11	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 183	3.8	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 187	11	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 194	1.9	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 206	2	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 49	1.9	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 52	3	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 66	2.4	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 70	1.6	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 74	1.6	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 87	2.3	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	PCB 99	7.5	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	Selenium	0.63		mg/kg	0.13
SD15	3	Ca. scorpionfish	Liver	Total Solids	36.7		wt%	0.4
SD15	3	Ca. scorpionfish	Liver	Trans Nonachlor	6.2	E	ug/kg	
SD15	3	Ca. scorpionfish	Liver	Zinc	86.3		mg/kg	0.58
SD16	1	Longfin sanddab	Liver	Alpha (cis) Chlordane	12	E	ug/kg	
SD16	1	Longfin sanddab	Liver	Aluminum	20.8		mg/kg	2.6
SD16	1	Longfin sanddab	Liver	Cadmium	1.71		mg/kg	0.34
SD16	1	Longfin sanddab	Liver	Cis Nonachlor	10	E	ug/kg	
SD16	1	Longfin sanddab	Liver	Copper	9.66		mg/kg	0.76
SD16	1	Longfin sanddab	Liver	Hexachlorobenzene	7.4	E	ug/kg	
SD16	1	Longfin sanddab	Liver	Iron	75.4		mg/kg	1.3
SD16	1	Longfin sanddab	Liver	Lipids	38.2		wt%	0.005
SD16	1	Longfin sanddab	Liver	Manganese	1.21		mg/kg	0.23
SD16	1	Longfin sanddab	Liver	Mercury	0.104		mg/kg	0.012
SD16	1	Longfin sanddab	Liver	Mirex	3.1	E	ug/kg	
SD16	1	Longfin sanddab	Liver	o,p-DDD	3.1	E	ug/kg	
SD16	1	Longfin sanddab	Liver	o,p-DDE	37		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	o,p-DDT	13	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD16	1	Longfin sanddab	Liver	p,p-DDD	54		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	p,p-DDE	1900		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	p,p-DDT	32		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 101	29		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 105	15		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 110	7.3	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 118	64		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 119	1.1	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 123	4	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 128	27		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 138	140		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 149	31		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 151	23		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 153/168	220		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 156	7.7	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 157	2	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 158	9.1	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 167	4.6	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 170	47		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 177	20		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 180	94		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 183	29		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 187	81		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 189	1.1	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 194	15		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 201	19		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	PCB 206	5.6	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 28	2.1	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 49	2.2	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 52	12	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 66	5.4	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 70	2	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 74	6.8	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 87	2.9	E	ug/kg	
SD16	1	Longfin sanddab	Liver	PCB 99	62		ug/kg	13.3
SD16	1	Longfin sanddab	Liver	Selenium	0.69		mg/kg	0.13
SD16	1	Longfin sanddab	Liver	Total Solids	42.6		wt%	0.4
SD16	1	Longfin sanddab	Liver	Trans Nonachlor	60		ug/kg	20
SD16	1	Longfin sanddab	Liver	Zinc	24.5		mg/kg	0.58
SD16	2	Ca. scorpionfish	Liver	Aluminum	10.3		mg/kg	2.6
SD16	2	Ca. scorpionfish	Liver	Cadmium	1.83		mg/kg	0.34
SD16	2	Ca. scorpionfish	Liver	Chromium	4.25		mg/kg	0.3
SD16	2	Ca. scorpionfish	Liver	Copper	18.5		mg/kg	0.76
SD16	2	Ca. scorpionfish	Liver	Hexachlorobenzene	2.5	E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Iron	253		mg/kg	1.3
SD16	2	Ca. scorpionfish	Liver	Lipids	18.6		wt%	0.005
SD16	2	Ca. scorpionfish	Liver	Manganese	0.69		mg/kg	0.23
SD16	2	Ca. scorpionfish	Liver	Mercury	0.256		mg/kg	0.012
SD16	2	Ca. scorpionfish	Liver	p,p-DDD	7.1	E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	p,p-DDE	360		ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	p,p-DDT	4.5	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value	Units	MDL
SD16	2	Ca. scorpionfish	Liver	PCB 101	8.7 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 105	5.1 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 110	5.3 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 118	21	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 123	1.7 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 128	5.5 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 138	25	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 149	4.5 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 151	3.5 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 153/168	47	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 158	1.5 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 167	1.5 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 170	7.7 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 177	3.9 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 180	18	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 183	4.6 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 187	16	ug/kg	13.3
SD16	2	Ca. scorpionfish	Liver	PCB 194	3.6 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 206	2.3 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 49	1.7 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 52	3.1 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 66	1.9 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 74	1.3 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 87	2.5 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	PCB 99	8.6 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Selenium	0.77	mg/kg	0.13
SD16	2	Ca. scorpionfish	Liver	Total Solids	42.3	wt%	0.4
SD16	2	Ca. scorpionfish	Liver	Trans Nonachlor	6.6 E	ug/kg	
SD16	2	Ca. scorpionfish	Liver	Zinc	98.7	mg/kg	0.58
SD16	3	Ca. scorpionfish	Liver	Alpha (cis) Chlordane	11 E	ug/kg	
SD16	3	Ca. scorpionfish	Liver	Aluminum	6.25	mg/kg	2.6
SD16	3	Ca. scorpionfish	Liver	Cadmium	1.97	mg/kg	0.34
SD16	3	Ca. scorpionfish	Liver	Chromium	0.37	mg/kg	0.3
SD16	3	Ca. scorpionfish	Liver	Copper	16.8	mg/kg	0.76
SD16	3	Ca. scorpionfish	Liver	Hexachlorobenzene	2.6 E	ug/kg	
SD16	3	Ca. scorpionfish	Liver	Iron	203	mg/kg	1.3
SD16	3	Ca. scorpionfish	Liver	Lipids	10.5	wt%	0.005
SD16	3	Ca. scorpionfish	Liver	Manganese	0.435	mg/kg	0.23
SD16	3	Ca. scorpionfish	Liver	Mercury	0.193	mg/kg	0.012
SD16	3	Ca. scorpionfish	Liver	o,p-DDE	260	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	p,p-DDD	720	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	p,p-DDE	13000	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	p,p-DDT	39	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 101	130	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 105	74	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 110	89	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 118	200	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 119	4.5 E	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 123	18	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 128	36	ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 138	140	ug/kg	13.3

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD16	3	Ca. scorpionfish	Liver	PCB 149	55		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 151	21		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 153/168	190		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 156	17		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 157	3.9	E	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 158	15		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 167	7.9	E	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 170	41		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 177	16		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 180	78		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 183	21		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 187	53		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 189	1.2	E	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 194	13	E	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 206	7.7	E	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 28	22		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 44	25		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 49	43		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 52	69		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 66	86		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 70	37		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 74	67		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 77	2.6	E	ug/kg	
SD16	3	Ca. scorpionfish	Liver	PCB 87	49		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	PCB 99	100		ug/kg	13.3
SD16	3	Ca. scorpionfish	Liver	Selenium	0.63		mg/kg	0.13
SD16	3	Ca. scorpionfish	Liver	Total Solids	35.6		wt%	0.4
SD16	3	Ca. scorpionfish	Liver	Trans Nonachlor	18	E	ug/kg	
SD16	3	Ca. scorpionfish	Liver	Zinc	73.5		mg/kg	0.58
SD17	1	Hornyhead turbot	Liver	Aluminum	7.9		mg/kg	2.6
SD17	1	Hornyhead turbot	Liver	Cadmium	2.85		mg/kg	0.34
SD17	1	Hornyhead turbot	Liver	Copper	3.4		mg/kg	0.76
SD17	1	Hornyhead turbot	Liver	Hexachlorobenzene	0.9	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	Iron	36.1		mg/kg	1.3
SD17	1	Hornyhead turbot	Liver	Lipids	10		wt%	0.005
SD17	1	Hornyhead turbot	Liver	Manganese	1.43		mg/kg	0.23
SD17	1	Hornyhead turbot	Liver	Mercury	0.162		mg/kg	0.012
SD17	1	Hornyhead turbot	Liver	o,p-DDE	1.4	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	p,p-DDD	2.4	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	p,p-DDE	100		ug/kg	13.3
SD17	1	Hornyhead turbot	Liver	PCB 101	1.8	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 105	1	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 118	3.4	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 138	5.8	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 149	1.5	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 153/168	11	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 180	7.1	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 183	2.2	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 187	4.6	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 194	1.2	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 206	2	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD17	1	Hornyhead turbot	Liver	PCB 52	0.9	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 66	1	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	PCB 99	2.4	E	ug/kg	
SD17	1	Hornyhead turbot	Liver	Selenium	0.67		mg/kg	0.17
SD17	1	Hornyhead turbot	Liver	Total Solids	29.2		wt%	0.4
SD17	1	Hornyhead turbot	Liver	Zinc	46.8		mg/kg	0.58
SD17	2	Ca. scorpionfish	Liver	Alpha (cis) Chlordane	5.8	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	Aluminum	33.6		mg/kg	2.6
SD17	2	Ca. scorpionfish	Liver	Cadmium	3.45		mg/kg	0.34
SD17	2	Ca. scorpionfish	Liver	Copper	23.1		mg/kg	0.76
SD17	2	Ca. scorpionfish	Liver	Hexachlorobenzene	3.5	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	Iron	175		mg/kg	1.3
SD17	2	Ca. scorpionfish	Liver	Lipids	22		wt%	0.005
SD17	2	Ca. scorpionfish	Liver	Manganese	0.48		mg/kg	0.23
SD17	2	Ca. scorpionfish	Liver	Mercury	0.347		mg/kg	0.012
SD17	2	Ca. scorpionfish	Liver	o,p-DDE	1.6	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	p,p-DDD	8.7	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	p,p-DDE	560		ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	p,p-DDT	2.8	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 101	15		ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 105	5.6	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 110	8.9	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 118	25		ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 119	1.1	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 123	2.9	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 128	6.3	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 138	28		ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 149	8.3	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 151	4.1	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 153/168	51		ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 158	2.4	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 167	2.3	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 177	4.1	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 180	22		ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 183	5.9	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 187	19		ug/kg	13.3
SD17	2	Ca. scorpionfish	Liver	PCB 194	3.9	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 206	2.7	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 28	0.9	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 49	2.2	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 52	4.5	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 66	3.1	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 70	1.8	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 74	2.1	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 87	3.2	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	PCB 99	13	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	Selenium	1.13		mg/kg	0.26
SD17	2	Ca. scorpionfish	Liver	Total Solids	46.7		wt%	0.4
SD17	2	Ca. scorpionfish	Liver	Trans Nonachlor	8.7	E	ug/kg	
SD17	2	Ca. scorpionfish	Liver	Zinc	117		mg/kg	0.58
SD17	3	Ca. scorpionfish	Liver	Aluminum	7.1		mg/kg	2.6

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD17	3	Ca. scorpionfish	Liver	Cadmium	2.03		mg/kg	0.34
SD17	3	Ca. scorpionfish	Liver	Chromium	4.89		mg/kg	0.3
SD17	3	Ca. scorpionfish	Liver	Copper	20.6		mg/kg	0.76
SD17	3	Ca. scorpionfish	Liver	Hexachlorobenzene	3.5	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	Iron	177		mg/kg	1.3
SD17	3	Ca. scorpionfish	Liver	Lipids	14.9		wt%	0.005
SD17	3	Ca. scorpionfish	Liver	Manganese	0.95		mg/kg	0.23
SD17	3	Ca. scorpionfish	Liver	Mercury	0.25		mg/kg	0.012
SD17	3	Ca. scorpionfish	Liver	Nickel	1.04		mg/kg	0.79
SD17	3	Ca. scorpionfish	Liver	o,p-DDE	2.4	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	p,p-DDD	11	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	p,p-DDE	850		ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	p,p-DDT	3.9	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 101	23		ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 105	11	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 110	12	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 118	49		ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 119	1.4	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 123	4.6	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 128	15		ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 138	65		ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 149	11	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 151	9.3	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 153/168	99		ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 156	7.7	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 157	1.5	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 158	6	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 167	4.2	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 170	30		ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 177	9.4	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 180	54		ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 183	15		ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 187	33		ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	PCB 189	0.9	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 194	9.6	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 206	4.9	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 28	1.1	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 44	1.7	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 49	4.2	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 52	6.1	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 66	5.6	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 70	1.3	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 74	2.7	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	PCB 99	25		ug/kg	13.3
SD17	3	Ca. scorpionfish	Liver	Selenium	0.8		mg/kg	0.26
SD17	3	Ca. scorpionfish	Liver	Total Solids	43.2		wt%	0.4
SD17	3	Ca. scorpionfish	Liver	Trans Nonachlor	13	E	ug/kg	
SD17	3	Ca. scorpionfish	Liver	Zinc	97		mg/kg	0.58
SD18	1	Hornyhead turbot	Liver	Aluminum	7.3		mg/kg	2.6
SD18	1	Hornyhead turbot	Liver	Cadmium	5.8		mg/kg	0.34
SD18	1	Hornyhead turbot	Liver	Copper	10		mg/kg	0.76

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD18	1	Hornyhead turbot	Liver	Iron	39.1		mg/kg	1.3
SD18	1	Hornyhead turbot	Liver	Lipids	5.36		wt%	0.005
SD18	1	Hornyhead turbot	Liver	Manganese	1.19		mg/kg	0.23
SD18	1	Hornyhead turbot	Liver	Mercury	0.141		mg/kg	0.012
SD18	1	Hornyhead turbot	Liver	p,p-DDE	86		ug/kg	13.3
SD18	1	Hornyhead turbot	Liver	PCB 101	1.5	E	ug/kg	
SD18	1	Hornyhead turbot	Liver	PCB 118	2.5	E	ug/kg	
SD18	1	Hornyhead turbot	Liver	PCB 138	4.2	E	ug/kg	
SD18	1	Hornyhead turbot	Liver	PCB 149	1.7	E	ug/kg	
SD18	1	Hornyhead turbot	Liver	PCB 153/168	7.7	E	ug/kg	
SD18	1	Hornyhead turbot	Liver	PCB 180	4.2	E	ug/kg	
SD18	1	Hornyhead turbot	Liver	PCB 183	1	E	ug/kg	
SD18	1	Hornyhead turbot	Liver	PCB 187	3.6	E	ug/kg	
SD18	1	Hornyhead turbot	Liver	PCB 206	1.5	E	ug/kg	
SD18	1	Hornyhead turbot	Liver	PCB 66	0.6	E	ug/kg	
SD18	1	Hornyhead turbot	Liver	PCB 99	1.7	E	ug/kg	
SD18	1	Hornyhead turbot	Liver	Selenium	0.58		mg/kg	0.17
SD18	1	Hornyhead turbot	Liver	Total Solids	31.8		wt%	0.4
SD18	1	Hornyhead turbot	Liver	Zinc	61.9		mg/kg	0.58
SD18	2	Ca. scorpionfish	Liver	Aluminum	4.1		mg/kg	2.6
SD18	2	Ca. scorpionfish	Liver	Cadmium	2.48		mg/kg	0.34
SD18	2	Ca. scorpionfish	Liver	Copper	25.9		mg/kg	0.76
SD18	2	Ca. scorpionfish	Liver	Hexachlorobenzene	4.2	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	Iron	111		mg/kg	1.3
SD18	2	Ca. scorpionfish	Liver	Lead	2.8		mg/kg	2.5
SD18	2	Ca. scorpionfish	Liver	Lipids	25.6		wt%	0.005
SD18	2	Ca. scorpionfish	Liver	Manganese	0.39		mg/kg	0.23
SD18	2	Ca. scorpionfish	Liver	Mercury	0.325		mg/kg	0.012
SD18	2	Ca. scorpionfish	Liver	o,p-DDE	4.9	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	p,p-DDD	17		ug/kg	13.3
SD18	2	Ca. scorpionfish	Liver	p,p-DDE	980		ug/kg	13.3
SD18	2	Ca. scorpionfish	Liver	p,p-DDT	5.6	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 101	19		ug/kg	13.3
SD18	2	Ca. scorpionfish	Liver	PCB 105	9.8	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 110	8.5	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 118	32		ug/kg	13.3
SD18	2	Ca. scorpionfish	Liver	PCB 119	1.4	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 123	3.7	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 126	1.6	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 128	13	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 138	46		ug/kg	13.3
SD18	2	Ca. scorpionfish	Liver	PCB 149	13	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 151	9.1	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 153/168	80		ug/kg	13.3
SD18	2	Ca. scorpionfish	Liver	PCB 156	5.6	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 157	1.7	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 158	3.4	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 167	3.4	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 170	21		ug/kg	13.3
SD18	2	Ca. scorpionfish	Liver	PCB 177	11	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 180	39		ug/kg	13.3

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD18	2	Ca. scorpionfish	Liver	PCB 183	11	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 187	37		ug/kg	13.3
SD18	2	Ca. scorpionfish	Liver	PCB 194	7.8	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 206	4.6	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 28	1.9	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 37	1.7	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 44	2.3	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 49	3.6	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 52	4.9	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 66	5.8	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 70	1.4	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 74	3.2	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 87	5.6	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	PCB 99	17		ug/kg	13.3
SD18	2	Ca. scorpionfish	Liver	Selenium	0.63		mg/kg	0.13
SD18	2	Ca. scorpionfish	Liver	Total Solids	34.2		wt%	0.4
SD18	2	Ca. scorpionfish	Liver	Trans Nonachlor	12	E	ug/kg	
SD18	2	Ca. scorpionfish	Liver	Zinc	108		mg/kg	0.58
SD18	3	Ca. scorpionfish	Liver	Aluminum	9.9		mg/kg	2.6
SD18	3	Ca. scorpionfish	Liver	Cadmium	4.54		mg/kg	0.34
SD18	3	Ca. scorpionfish	Liver	Chromium	0.6		mg/kg	0.3
SD18	3	Ca. scorpionfish	Liver	Copper	27.5		mg/kg	0.76
SD18	3	Ca. scorpionfish	Liver	Hexachlorobenzene	1.65		ug/kg	
SD18	3	Ca. scorpionfish	Liver	Iron	227		mg/kg	1.3
SD18	3	Ca. scorpionfish	Liver	Lipids	6.82		wt%	0.005
SD18	3	Ca. scorpionfish	Liver	Manganese	0.5		mg/kg	0.23
SD18	3	Ca. scorpionfish	Liver	Mercury	0.434		mg/kg	0.012
SD18	3	Ca. scorpionfish	Liver	p,p-DDD	3.7		ug/kg	
SD18	3	Ca. scorpionfish	Liver	p,p-DDE	335		ug/kg	13.3
SD18	3	Ca. scorpionfish	Liver	p,p-DDT	2.7		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 101	17.5		ug/kg	13.3
SD18	3	Ca. scorpionfish	Liver	PCB 105	8.05		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 110	14		ug/kg	13.3
SD18	3	Ca. scorpionfish	Liver	PCB 118	28		ug/kg	13.3
SD18	3	Ca. scorpionfish	Liver	PCB 119	0.6		ug/kg	13.3
SD18	3	Ca. scorpionfish	Liver	PCB 123	2.55		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 128	7.85		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 138	27		ug/kg	13.3
SD18	3	Ca. scorpionfish	Liver	PCB 149	6.95		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 151	4		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 153/168	36.5		ug/kg	13.3
SD18	3	Ca. scorpionfish	Liver	PCB 156	3.25		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 158	2.65		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 167	1.55		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 177	3.85		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 180	16.5		ug/kg	13.3
SD18	3	Ca. scorpionfish	Liver	PCB 183	3.8		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 187	12		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 194	2.5	E	ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 206	2.15		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 44	0.4		ug/kg	13.3

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD18	3	Ca. scorpionfish	Liver	PCB 49	1.55		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 52	4.35		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 66	2.1		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 70	3.3		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 74	1.8	E	ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 87	7.9		ug/kg	
SD18	3	Ca. scorpionfish	Liver	PCB 99	12	E	ug/kg	
SD18	3	Ca. scorpionfish	Liver	Selenium	0.79		mg/kg	0.13
SD18	3	Ca. scorpionfish	Liver	Total Solids	34.3		wt%	0.4
SD18	3	Ca. scorpionfish	Liver	Trans Nonachlor	3.1		ug/kg	20
SD18	3	Ca. scorpionfish	Liver	Zinc	114		mg/kg	0.58
SD19	1	Longfin sanddab	Liver	Aluminum	2.7		mg/kg	2.6
SD19	1	Longfin sanddab	Liver	Arsenic	2		mg/kg	1.4
SD19	1	Longfin sanddab	Liver	Cadmium	1.51		mg/kg	0.34
SD19	1	Longfin sanddab	Liver	Chromium	0.89		mg/kg	0.3
SD19	1	Longfin sanddab	Liver	Copper	7.57		mg/kg	0.76
SD19	1	Longfin sanddab	Liver	Hexachlorobenzene	4.1	E	ug/kg	
SD19	1	Longfin sanddab	Liver	Iron	89.9		mg/kg	1.3
SD19	1	Longfin sanddab	Liver	Lipids	31.6		wt%	0.005
SD19	1	Longfin sanddab	Liver	Manganese	0.85		mg/kg	0.23
SD19	1	Longfin sanddab	Liver	Mercury	0.087		mg/kg	0.012
SD19	1	Longfin sanddab	Liver	o,p-DDD	2.3	E	ug/kg	
SD19	1	Longfin sanddab	Liver	o,p-DDE	6.5	E	ug/kg	
SD19	1	Longfin sanddab	Liver	o,p-DDT	1.3	E	ug/kg	
SD19	1	Longfin sanddab	Liver	p,p-DDD	10	E	ug/kg	
SD19	1	Longfin sanddab	Liver	p,p-DDE	590		ug/kg	13.3
SD19	1	Longfin sanddab	Liver	p,p-DDT	8.1	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 101	8.3	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 105	6.4	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 110	4.6	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 118	23		ug/kg	13.3
SD19	1	Longfin sanddab	Liver	PCB 119	0.5	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 123	2.9	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 126	0.9	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 128	8.3	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 138	43		ug/kg	13.3
SD19	1	Longfin sanddab	Liver	PCB 149	9	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 151	6.6	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 153/168	66		ug/kg	13.3
SD19	1	Longfin sanddab	Liver	PCB 156	4	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 158	2.2	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 167	2.8	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 170	20		ug/kg	13.3
SD19	1	Longfin sanddab	Liver	PCB 177	7.5	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 180	37		ug/kg	13.3
SD19	1	Longfin sanddab	Liver	PCB 183	12	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 187	33		ug/kg	13.3
SD19	1	Longfin sanddab	Liver	PCB 189	1.4	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 194	8	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 201	8.8	E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 206	4.1	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value	Units	MDL
SD19	1	Longfin sanddab	Liver	PCB 28	2.9 E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 37	1 E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 49	1.7 E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 52	3.5 E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 66	3.7 E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 70	2 E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 74	2.6 E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 77	1.2 E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 81	0.7 E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 87	2 E	ug/kg	
SD19	1	Longfin sanddab	Liver	PCB 99	12 E	ug/kg	
SD19	1	Longfin sanddab	Liver	Selenium	0.64	mg/kg	0.17
SD19	1	Longfin sanddab	Liver	Total Solids	52.8	wt%	0.4
SD19	1	Longfin sanddab	Liver	Trans Nonachlor	4.6 E	ug/kg	
SD19	1	Longfin sanddab	Liver	Zinc	18.8	mg/kg	0.58
SD19	2	Longfin sanddab	Liver	Alpha (cis) Chlordane	4 E	ug/kg	
SD19	2	Longfin sanddab	Liver	Aluminum	22	mg/kg	2.6
SD19	2	Longfin sanddab	Liver	Arsenic	8.2	mg/kg	1.4
SD19	2	Longfin sanddab	Liver	Cadmium	1.26	mg/kg	0.34
SD19	2	Longfin sanddab	Liver	Chromium	3.56	mg/kg	0.3
SD19	2	Longfin sanddab	Liver	Copper	8.07	mg/kg	0.76
SD19	2	Longfin sanddab	Liver	Hexachlorobenzene	4.5 E	ug/kg	
SD19	2	Longfin sanddab	Liver	Iron	104	mg/kg	1.3
SD19	2	Longfin sanddab	Liver	Lipids	32.7	wt%	0.005
SD19	2	Longfin sanddab	Liver	Manganese	1.86	mg/kg	0.23
SD19	2	Longfin sanddab	Liver	Mercury	0.256	mg/kg	0.012
SD19	2	Longfin sanddab	Liver	o,p-DDD	3 E	ug/kg	
SD19	2	Longfin sanddab	Liver	o,p-DDE	590	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	p,p-DDD	27	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	p,p-DDE	10000	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	p,p-DDT	54	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 101	19	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 105	38	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 110	27	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 118	130	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 119	0.7 E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 123	12 E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 128	26	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 138	140	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 149	12 E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 151	18	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 153/168	170	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 156	14	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 157	3.1 E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 158	12 E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 167	7.4 E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 170	41	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 177	12 E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 180	77	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 183	23	ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 187	55	ug/kg	13.3

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD19	2	Longfin sanddab	Liver	PCB 189	1.3	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 194	15		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 201	16		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 206	6.5	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 28	4.1	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 49	2	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 52	10	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 66	21		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 70	2.2	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 74	25		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	PCB 87	4.7	E	ug/kg	
SD19	2	Longfin sanddab	Liver	PCB 99	77		ug/kg	13.3
SD19	2	Longfin sanddab	Liver	Selenium	0.82		mg/kg	0.17
SD19	2	Longfin sanddab	Liver	Total Solids	50.3		wt%	0.4
SD19	2	Longfin sanddab	Liver	Trans Nonachlor	7.1	E	ug/kg	
SD19	2	Longfin sanddab	Liver	Zinc	22.3		mg/kg	0.58
SD19	3	Ca. scorpionfish	Liver	Aluminum	24.3		mg/kg	2.6
SD19	3	Ca. scorpionfish	Liver	Cadmium	2.57		mg/kg	0.34
SD19	3	Ca. scorpionfish	Liver	Chromium	2.9		mg/kg	0.3
SD19	3	Ca. scorpionfish	Liver	Copper	22.2		mg/kg	0.76
SD19	3	Ca. scorpionfish	Liver	Hexachlorobenzene	1.3	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	Iron	310		mg/kg	1.3
SD19	3	Ca. scorpionfish	Liver	Lipids	13.7		wt%	0.005
SD19	3	Ca. scorpionfish	Liver	Manganese	0.57		mg/kg	0.23
SD19	3	Ca. scorpionfish	Liver	Mercury	0.067		mg/kg	0.012
SD19	3	Ca. scorpionfish	Liver	o,p-DDE	2.2	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	p,p-DDD	7.5	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	p,p-DDE	500		ug/kg	13.3
SD19	3	Ca. scorpionfish	Liver	p,p-DDT	3	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 101	9.8	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 105	5.6	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 110	5.2	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 118	20		ug/kg	13.3
SD19	3	Ca. scorpionfish	Liver	PCB 123	1.5	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 128	6	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 138	29		ug/kg	13.3
SD19	3	Ca. scorpionfish	Liver	PCB 149	8.4	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 151	4.2	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 153/168	44		ug/kg	13.3
SD19	3	Ca. scorpionfish	Liver	PCB 158	2.4	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 167	1.5	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 177	5.3	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 180	25		ug/kg	13.3
SD19	3	Ca. scorpionfish	Liver	PCB 183	6.6	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 187	23		ug/kg	13.3
SD19	3	Ca. scorpionfish	Liver	PCB 194	4.9	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 206	3.1	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 28	0.6	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 49	1.9	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 52	2.7	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 66	2.9	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD19	3	Ca. scorpionfish	Liver	PCB 74	1.5	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 87	2.4	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	PCB 99	9.5	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	Selenium	0.79		mg/kg	0.17
SD19	3	Ca. scorpionfish	Liver	Total Solids	39		wt%	0.4
SD19	3	Ca. scorpionfish	Liver	Trans Nonachlor	7.8	E	ug/kg	
SD19	3	Ca. scorpionfish	Liver	Zinc	120		mg/kg	0.58
SD20	1	Longfin sanddab	Liver	Aluminum	24.5		mg/kg	2.6
SD20	1	Longfin sanddab	Liver	Cadmium	1.92		mg/kg	0.34
SD20	1	Longfin sanddab	Liver	Chromium	0.64		mg/kg	0.3
SD20	1	Longfin sanddab	Liver	Copper	9.65		mg/kg	0.76
SD20	1	Longfin sanddab	Liver	Hexachlorobenzene	4.1	E	ug/kg	
SD20	1	Longfin sanddab	Liver	Iron	92.1		mg/kg	1.3
SD20	1	Longfin sanddab	Liver	Lipids	37.9		wt%	0.005
SD20	1	Longfin sanddab	Liver	Manganese	0.74		mg/kg	0.23
SD20	1	Longfin sanddab	Liver	Mercury	0.096		mg/kg	0.012
SD20	1	Longfin sanddab	Liver	o,p-DDD	1.4	E	ug/kg	
SD20	1	Longfin sanddab	Liver	o,p-DDE	6.5	E	ug/kg	
SD20	1	Longfin sanddab	Liver	p,p-DDD	12	E	ug/kg	
SD20	1	Longfin sanddab	Liver	p,p-DDE	590		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	p,p-DDT	9	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 101	10	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 105	7.9	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 110	5.6	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 118	34		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 123	2.8	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 128	10	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 138	62		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 149	10	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 151	6.5	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 153/168	87		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 156	4.4	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 157	1.1	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 158	3.5	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 167	2.3	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 170	23		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 177	7.7	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 180	39		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 183	13	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 187	41		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	PCB 189	1.1	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 194	9.8	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 201	9.4	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 206	4.7	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 28	2.5	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 44	2	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 49	2.2	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 52	3.8	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 66	4.3	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 70	1.5	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 74	2.6	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD20	1	Longfin sanddab	Liver	PCB 87	1.6	E	ug/kg	
SD20	1	Longfin sanddab	Liver	PCB 99	20		ug/kg	13.3
SD20	1	Longfin sanddab	Liver	Selenium	0.64		mg/kg	0.17
SD20	1	Longfin sanddab	Liver	Total Solids	61.9		wt%	0.4
SD20	1	Longfin sanddab	Liver	Trans Nonachlor	5	E	ug/kg	
SD20	1	Longfin sanddab	Liver	Zinc	14.8		mg/kg	0.58
SD20	2	Ca. scorpionfish	Liver	Aluminum	23.5		mg/kg	2.6
SD20	2	Ca. scorpionfish	Liver	Cadmium	3.43		mg/kg	0.34
SD20	2	Ca. scorpionfish	Liver	Chromium	0.48		mg/kg	0.3
SD20	2	Ca. scorpionfish	Liver	Copper	16.6		mg/kg	0.76
SD20	2	Ca. scorpionfish	Liver	Hexachlorobenzene	1.2	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	Iron	292		mg/kg	1.3
SD20	2	Ca. scorpionfish	Liver	Lipids	6.47		wt%	0.005
SD20	2	Ca. scorpionfish	Liver	Manganese	0.4		mg/kg	0.23
SD20	2	Ca. scorpionfish	Liver	Mercury	0.079		mg/kg	0.012
SD20	2	Ca. scorpionfish	Liver	p,p-DDD	3.1	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	p,p-DDE	330		ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	p,p-DDT	1.3	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 101	7.4	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 105	5.4	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 110	5.3	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 118	21		ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 123	2.2	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 128	6.9	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 138	32		ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 149	4.4	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 151	4	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 153/168	48		ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 156	3	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 158	2.1	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 167	2	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 170	14		ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 177	5.6	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 180	24		ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 183	7.3	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 187	20		ug/kg	13.3
SD20	2	Ca. scorpionfish	Liver	PCB 194	5.6	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 206	3.2	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 49	1.3	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 52	1.9	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 66	2.2	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 74	1.5	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	PCB 99	11	E	ug/kg	
SD20	2	Ca. scorpionfish	Liver	Selenium	0.72		mg/kg	0.13
SD20	2	Ca. scorpionfish	Liver	Silver	0.74		mg/kg	0.62
SD20	2	Ca. scorpionfish	Liver	Total Solids	38.9		wt%	0.4
SD20	2	Ca. scorpionfish	Liver	Zinc	78.2		mg/kg	0.58
SD20	3	Ca. scorpionfish	Liver	Aluminum	13.4		mg/kg	2.6
SD20	3	Ca. scorpionfish	Liver	Cadmium	6.74		mg/kg	0.34
SD20	3	Ca. scorpionfish	Liver	Copper	24.5		mg/kg	0.76
SD20	3	Ca. scorpionfish	Liver	Hexachlorobenzene	1.8	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD20	3	Ca. scorpionfish	Liver	Iron	260		mg/kg	1.3
SD20	3	Ca. scorpionfish	Liver	Lipids	12.3		wt%	0.005
SD20	3	Ca. scorpionfish	Liver	Manganese	0.585		mg/kg	0.23
SD20	3	Ca. scorpionfish	Liver	Mercury	0.369		mg/kg	0.012
SD20	3	Ca. scorpionfish	Liver	o,p-DDE	1.3	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	p,p-DDD	7.3	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	p,p-DDE	530		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	p,p-DDT	2.5	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 101	12	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 105	5.8	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 110	6.4	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 118	20		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 119	0.7	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 123	2.6	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 128	6.5	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 138	29		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 149	6.5	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 151	5.2	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 153/168	47		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 156	3.1	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 157	1	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 158	2.7	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 167	2.1	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 170	13	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 177	5.3	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 180	22		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 183	6.4	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 187	20		ug/kg	13.3
SD20	3	Ca. scorpionfish	Liver	PCB 189	0.9	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 194	4.3	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 201	7.2	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 206	2.7	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 49	1.3	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 52	2.9	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 66	3	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 70	1.2	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 74	1.9	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 87	3.3	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	PCB 99	11	E	ug/kg	
SD20	3	Ca. scorpionfish	Liver	Selenium	1.02		mg/kg	0.13
SD20	3	Ca. scorpionfish	Liver	Total Solids	32		wt%	0.4
SD20	3	Ca. scorpionfish	Liver	Zinc	75.7		mg/kg	0.58
SD21	1	Longfin sanddab	Liver	Aluminum	18.2		mg/kg	2.6
SD21	1	Longfin sanddab	Liver	Arsenic	3.5		mg/kg	1.4
SD21	1	Longfin sanddab	Liver	Cadmium	1.04		mg/kg	0.34
SD21	1	Longfin sanddab	Liver	Chromium	0.59		mg/kg	0.3
SD21	1	Longfin sanddab	Liver	Copper	11.4		mg/kg	0.76
SD21	1	Longfin sanddab	Liver	Hexachlorobenzene	3.3	E	ug/kg	
SD21	1	Longfin sanddab	Liver	Iron	103		mg/kg	1.3
SD21	1	Longfin sanddab	Liver	Lipids	31.2		wt%	0.005
SD21	1	Longfin sanddab	Liver	Manganese	0.67		mg/kg	0.23

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD21	1	Longfin sanddab	Liver	Mercury	0.097		mg/kg	0.012
SD21	1	Longfin sanddab	Liver	o,p-DDD	1.2	E	ug/kg	
SD21	1	Longfin sanddab	Liver	o,p-DDE	5.7	E	ug/kg	
SD21	1	Longfin sanddab	Liver	p,p-DDD	8.5	E	ug/kg	
SD21	1	Longfin sanddab	Liver	p,p-DDE	330		ug/kg	13.3
SD21	1	Longfin sanddab	Liver	p,p-DDT	3.6	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 101	8.8	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 105	5.8	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 110	4.7	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 118	23		ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 123	2.9	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 128	7.4	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 138	40		ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 149	10	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 151	4.8	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 153/168	61		ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 156	2.9	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 157	0.8	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 158	1.5	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 167	2.2	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 170	16		ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 177	5.5	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 180	29		ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 183	8	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 187	25		ug/kg	13.3
SD21	1	Longfin sanddab	Liver	PCB 201	7.7	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 206	4.3	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 28	2.4	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 44	1	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 49	2	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 52	3.2	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 66	3.4	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 70	1.4	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 74	2.2	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 87	0.9	E	ug/kg	
SD21	1	Longfin sanddab	Liver	PCB 99	13	E	ug/kg	
SD21	1	Longfin sanddab	Liver	Selenium	0.965		mg/kg	0.17
SD21	1	Longfin sanddab	Liver	Total Solids	52.3		wt%	0.4
SD21	1	Longfin sanddab	Liver	Zinc	17.7		mg/kg	0.58
SD21	2	Ca. scorpionfish	Liver	Aluminum	37.9		mg/kg	2.6
SD21	2	Ca. scorpionfish	Liver	Cadmium	0.44		mg/kg	0.34
SD21	2	Ca. scorpionfish	Liver	Chromium	0.87		mg/kg	0.3
SD21	2	Ca. scorpionfish	Liver	Copper	24.8		mg/kg	0.76
SD21	2	Ca. scorpionfish	Liver	Hexachlorobenzene	1.5	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	Iron	162		mg/kg	1.3
SD21	2	Ca. scorpionfish	Liver	Lipids	14		wt%	0.005
SD21	2	Ca. scorpionfish	Liver	Manganese	0.49		mg/kg	0.23
SD21	2	Ca. scorpionfish	Liver	Mercury	0.154		mg/kg	0.012
SD21	2	Ca. scorpionfish	Liver	p,p-DDD	6.2	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	p,p-DDE	320		ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	p,p-DDT	1.8	E	ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD21	2	Ca. scorpionfish	Liver	PCB 101	25		ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 105	13	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 110	12	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 118	51		ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 119	0.9	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 123	5.6	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 128	17		ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 138	65		ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 149	14		ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 151	6.7	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 153/168	110		ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 156	5.2	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 157	1.5	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 158	4.5	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 167	4.3	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 177	9	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 180	37		ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 183	13	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 187	42		ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	PCB 194	4.8	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 206	4.1	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 28	1.6	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 49	3.9	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 52	6.6	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 66	7.5	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 70	1.1	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 74	4.7	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 87	4.4	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	PCB 99	30		ug/kg	13.3
SD21	2	Ca. scorpionfish	Liver	Selenium	0.57		mg/kg	0.13
SD21	2	Ca. scorpionfish	Liver	Total Solids	45.9		wt%	0.4
SD21	2	Ca. scorpionfish	Liver	Trans Nonachlor	8.8	E	ug/kg	
SD21	2	Ca. scorpionfish	Liver	Zinc	67.2		mg/kg	0.58
SD21	3	Ca. scorpionfish	Liver	Aluminum	12.7		mg/kg	2.6
SD21	3	Ca. scorpionfish	Liver	Cadmium	1.52		mg/kg	0.34
SD21	3	Ca. scorpionfish	Liver	Chromium	4.13		mg/kg	0.3
SD21	3	Ca. scorpionfish	Liver	Copper	19.8		mg/kg	0.76
SD21	3	Ca. scorpionfish	Liver	Hexachlorobenzene	3.05		ug/kg	
SD21	3	Ca. scorpionfish	Liver	Iron	222		mg/kg	1.3
SD21	3	Ca. scorpionfish	Liver	Lipids	10.9		wt%	0.005
SD21	3	Ca. scorpionfish	Liver	Manganese	0.53		mg/kg	0.23
SD21	3	Ca. scorpionfish	Liver	Mercury	0.165		mg/kg	0.012
SD21	3	Ca. scorpionfish	Liver	o,p-DDE	1.8		ug/kg	
SD21	3	Ca. scorpionfish	Liver	p,p-DDD	8.15		ug/kg	
SD21	3	Ca. scorpionfish	Liver	p,p-DDE	610		ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	p,p-DDT	3.3	E	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 101	14.5		ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 105	8.7		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 110	9.05		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 118	33.5		ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 119	0.75		ug/kg	

Station	Rep	Common Name	Tissue	Parameter	Value		Units	MDL
SD21	3	Ca. scorpionfish	Liver	PCB 123	3.15		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 128	10.5		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 138	41.5		ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 149	8.15		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 151	5.65		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 153/168	65.5		ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 156	5		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 157	1.35		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 158	3.4		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 167	2.6		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 170	19.5		ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 177	7.1		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 180	33		ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 183	9.95		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 187	26		ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 189	0.35		ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	PCB 194	7.1		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 206	4.25		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 28	1.05		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 44	0.95		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 49	2.45		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 52	3.55		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 66	4.2	E	ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 70	1.65		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 74	2.15		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 87	3.7		ug/kg	
SD21	3	Ca. scorpionfish	Liver	PCB 99	15		ug/kg	13.3
SD21	3	Ca. scorpionfish	Liver	Selenium	0.7		mg/kg	0.13
SD21	3	Ca. scorpionfish	Liver	Total Solids	37.4		wt%	0.4
SD21	3	Ca. scorpionfish	Liver	Trans Nonachlor	9.2		ug/kg	
SD21	3	Ca. scorpionfish	Liver	Zinc	89.9		mg/kg	0.58

Appendix D

Random Sample Survey for the San Diego Region
(July 2001)

Sediment Quality

Appendix D

Regional Survey off San Diego
(July 2001)

Sediment Quality

INTRODUCTION

The City of San Diego has conducted summer surveys of sediment conditions throughout the San Diego region from 1994 through 2001. 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. The 1994 and 1998 surveys off San Diego were conducted as part of the Southern California Bight 1994 Pilot Project (SCBPP) and the 1998 Southern California Bight Monitoring Survey (Bight'98), two large-scale surveys which included other major southern California dischargers. The same randomized sampling design was used in the surveys limited to the San Diego region (1995–1997 and 1999–2001). These surveys were conducted by the City of San Diego as part of contractual agreements for monitoring in the vicinity of the South Bay Ocean Outfall (see Chapter 1).

This appendix presents summaries and analyses of the sediment particle size and chemistry data collected during the San Diego regional survey of 2001. Various parameters were measured for the purpose of examining the quality and characteristics of sediments and to aid in identifying reference areas for the region.

MATERIALS & METHODS

Field Sampling

Sediment samples were collected at a total of 38 stations off the coast of San Diego during July of 2001 (Figure D.1). All stations were randomly selected using the USEPA probability-based EMAP design (Bight'98 Steering Committee 1998). Although 40 stations were initially selected, samples could not be collected at two sites due to the presence of incompatible substrates (e.g., rocky reefs). Stations that were sampled ranged from 44 to 660 ft (13–201 m) in depth and spanned an area from Solana Beach, California south to the United States and Mexico border. This area included the section of the mainland shelf from nearshore to shallow slope depths. Benthic sediment samples were collected using a modified 0.1 m^2 chain-rigged van Veen grab. These samples were taken from the top 2 cm of the sediment surface and handled according to EPA guidelines (USEPA 1987).

Laboratory Analyses

All sediment analyses were performed at the City of San Diego Wastewater Chemistry Laboratory. Particle size analyses were performed using a Horiba LA-900 laser analyzer, which measures particles ranging in size from 0

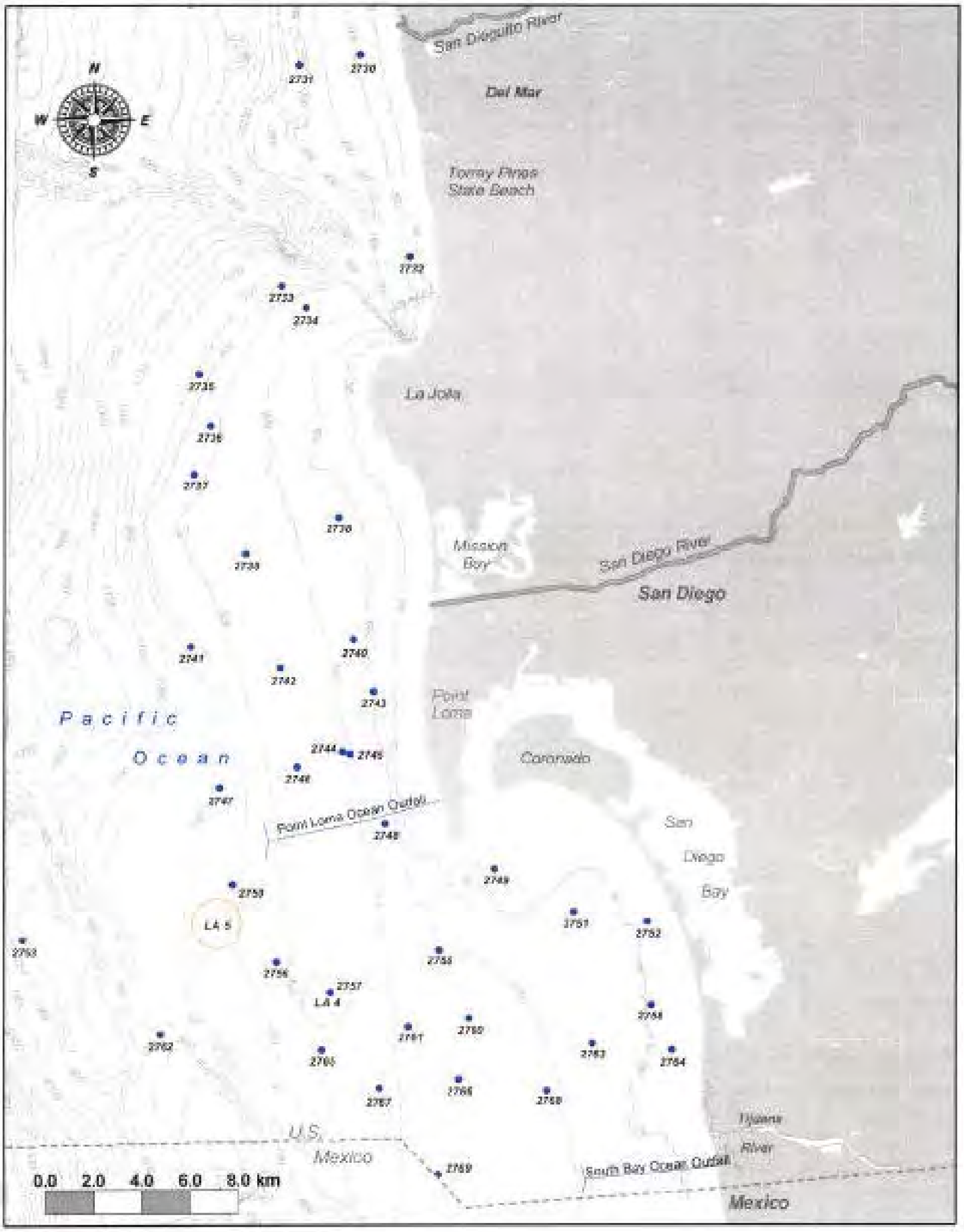


Figure D.1

Randomly selected sediment quality stations sampled off San Diego during the July 2001 regional survey.

to 10 phi (i.e., sand, silt and clay fractions). Sand was defined as particles ranging in size from 0 to <4 phi; silt as particles from >4 to <8.0 phi; and clay as particles >8.0 phi. The fraction of coarser sediments (e.g., very coarse sand, gravel, shell hash) in each sample was determined by measuring the weight of particles retained on a 1.0 mm mesh sieve (i.e., <0 phi), and expressed as the percent weight of the total sample sieved. This coarse fraction is represented as "Coarse" in Table D.1.

Data Analyses

A number of particle size parameters were calculated using a normal probability scale (see Folk 1968). These include median and mean phi size, sorting coefficient (standard deviation), skewness, kurtosis and percent sediment type (i.e., coarse particles > 1.0 mm in diameter, sand, silt, clay). Sediment chemical parameters that were analyzed include total organic carbon (TOC), total nitrogen, total sulfides, trace metals, chlorinated pesticides, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyl compounds (PCBs). Prior to analysis, the data were generally limited to values above method detection limits (MDLs). Some parameters 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. Null values (i.e, values below the MDL without an estimate) were eliminated from the dataset and are not intended to represent the absence of a particular parameter.

Data for all of the sites sampled in 2001 were examined in relation to 50% Cumulative Distribution Function (CDF) levels for trace metals, total nitrogen, total organic carbon and pesticides (i.e., p,p-DDT). The CDFs were established for the Southern California Bight (SCB) using data from the 1994 SCBPP survey (Schiff and Gossett 1998), and allow for comparison of sediment parameters from the San Diego area to that of the entire SCB.

RESULTS

Particle Size Analysis

The distribution of sediment particles in 2001 was similar to that of the previous region-wide surveys off San Diego, with particles generally decreasing in size with depth (see City of San Diego 1998, 2000, 2001). In general, sand content was high in shallow nearshore areas and then decreased to a mixture of mostly coarse silt and fine sand at the deeper offshore sites (Table D.1, Figure D.2). For example, the shallow water stations had an average sand content of 80% with a corresponding mean phi of 2.7, while the deep water stations contained 58% sand with an average mean phi of 3.8. Exceptions to this pattern occurred primarily to the south and exemplify the patchy sediments in this area. For example, coarse sediment sites were found in deeper water along a rocky ridge located southwest of the Point Loma (e.g., station 2753), at a site located between the LA-4 and LA-5 dredged materials disposal sites (station 2756) and at a site next to the Point Loma Ocean Outfall (station 2748). Additionally, several shallow water locations west of the Tijuana River contained finer material, probably the result of sediment deposition from the Tijuana River and to a lesser extent from San Diego Bay (stations 2751, 2752, 2758, 2763, 2764). Sites further offshore contained coarse detrital sediments that included deposits of relict red sands (stations 2755, 2760, 2761, 2766, 2769).

Table D.1

Summary of particle size parameters at randomly selected regional sediment stations off San Diego during July 2001. Data presented includes: station; depth (ft); mean phi size (Mean); standard deviation (SD); percent values for coarse fraction (Coarse); percent sand; percent silt; percent clay. Data for organic indicators include total sulfides (ppm); total nitrogen (TN) (wt%); and total organic carbon (TOC) (wt%). Also included are method detection limits, area means and the 50% CDF value for the Southern California Bight where available (see Schiff and Gosset 1998). Bold numbers for TN and TOC indicate values that were higher than the 50% CDF.

Station	Depth (ft)	Mean Phi	SD Phi	% Coarse	% Sand	% Silt	% Clay	% Sulfides	TN	TOC
50% CDF									0.051	0.748
MDL								0.1	0.001	0.009
Shallow depths										
2764	44	3.4	0.8	0.0	84.4	14.6	1.0	0.9	0.016	0.111
2752	45	3.8	1.0	0.0	61.5	37.5	1.0	9.7	0.029	0.307
2758	50	3.0	0.8	0.7	92.2	6.6	0.4	0.7	0.014	0.097
2749	54	2.3	0.7	0.7	95.0	3.2	1.0	2.1	0.009	0.066
2732	62	2.7	0.8	0.0	89.9	9.9	0.2	9.8	0.024	0.122
2751	63	3.1	1.1	0.0	83.7	15.2	1.0	3.3	0.022	0.189
2763	72	3.2	0.7	0.0	89.3	9.9	0.7	1.0	0.015	0.138
2730	80	2.9	1.0	0.0	89.1	10.2	0.6	2.7	0.023	0.131
2755	98	0.3	0.7	69.8	30.2	0.0	0.0	1.1	0.036	0.208
Mean	63	2.7	0.8	7.9	79.5	11.9	0.7	3.5	0.021	0.152
Mid-depths										
2768	106	3.5	0.8	0.0	78.5	20.2	1.3	1.3	0.020	0.193
2743	107	2.2	0.9	0.0	96.5	3.5	0.0	2.9	0.030	0.194
2760	132	1.0	0.6	0.0	97.4	2.6	0.0	0.6	0.022	0.219
2738	138	3.8	1.3	0.0	70.2	27.5	2.2	2.5	0.046	0.407
2748	141	0.9	0.7	5.6	94.4	0.0	0.0	0.3	0.021	0.118
2740	144	3.2	1.1	0.0	82.4	16.0	1.5	1.8	0.046	0.375
2766	144	1.7	0.9	0.0	100.0	0.0	0.0	0.2	0.011	0.066
2769	159	0.8	0.8	10.3	89.7	0.0	0.0	0.1	0.009	0.047
2761	179	1.8	0.5	10.5	86.9	2.6	0.0	0.3	0.043	0.446
2745	200	4.3	1.6	0.0	54.5	41.1	4.3	3.5	**0.072**	0.714
2744	210	4.6	1.7	0.0	48.1	45.4	6.5	2.2	**0.070**	0.709
2767	237	2.6	1.2	0.0	86.9	11.4	1.7	0.9	0.028	0.319
2739	247	4.1	2.4	3.8	46.3	44.8	5.1	5.6	**0.090**	**0.989**
2742	252	4.9	1.6	0.0	35.3	58.8	5.9	2.8	**0.085**	**0.856**
2734	257	4.3	1.5	0.0	58.0	38.1	3.9	12.0	**0.056**	0.512
2746	265	4.6	1.5	0.0	42.4	52.7	5.0	2.2	**0.070**	0.680
2757	273	4.1	1.8	0.0	61.9	33.0	5.0	2.3	0.042	0.487
2765	292	3.6	0.9	0.0	84.0	13.5	2.5	2.7	0.041	0.460
2736	312	4.5	1.6	0.0	49.9	45.0	5.1	3.4	**0.067**	0.677
2737	315	4.3	1.9	1.9	51.2	42.3	4.6	2.6	**0.063**	0.626
2756	318	1.4	1.4	10.7	83.2	5.3	0.7	3.3	0.039	0.499
Mean	211	3.2	1.3	2.0	71.3	24.0	2.6	2.5	0.046	0.457
Deepwater										
2733	383	3.5	2.8	11.3	47.6	35.9	5.2	13.8	**0.052**	0.480
2750	428	4.2	1.6	0.0	64.5	29.8	5.6	2.4	0.048	0.569
2731	485	4.1	2.5	5.7	49.4	38.8	6.0	3.2	**0.062**	0.706
2741	500	4.5	1.7	0.0	56.0	38.5	5.5	1.7	**0.069**	0.706
2753	507	0.7	0.5	7.6	92.4	0.0	0.0	0.8	0.031	0.399
2735	585	4.2	1.5	0.0	67.9	28.1	3.9	12.3	**0.072**	0.721
2747	585	5.0	1.7	0.0	32.8	60.7	6.5	1.9	**0.104**	**1.140**
2762	660	3.9	2.6	5.8	53.7	34.5	5.9	1.1	**0.079**	**0.877**
Mean	517	3.8	1.8	3.8	58.0	33.3	4.8	4.7	0.065	0.700
Area mean	240	3.2	1.3	3.8	70.5	23.1	2.6	3.2	0.044	0.436

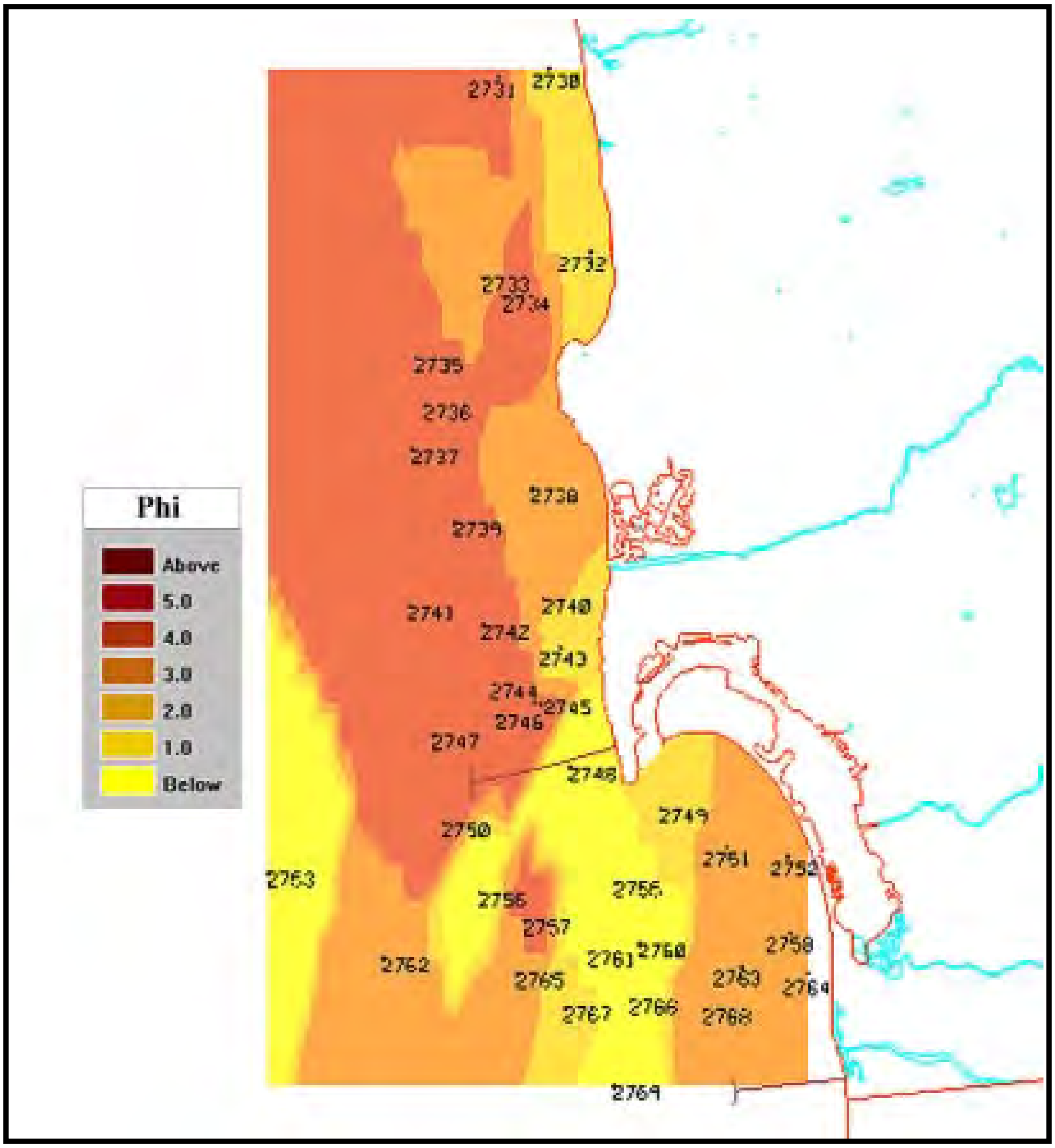


Figure D.2

Horizontal contour profile of mean phi size data at randomly selected regional sediment stations off San Diego (July 2001).

Organic Indicators

In general, elevated concentrations of organic particulate matter are associated with fine-grained sediments, and this relationship becomes more pronounced with increased depth and distance from shore (Emery 1960, Anderson et al. 1993). During the 2001 survey, sediment concentrations of total organic carbon and total nitrogen were generally higher north of Point Loma and increased with depth and decreasing grain size. With the exception of station 2762, all levels of total organic carbon and total nitrogen that exceeded the 50% CDF levels for the Southern California Bight occurred north of Point Loma and primarily at deeper sites consisting of coarse silt (mean phi >4.0) (Table D.1). While sulfide levels exhibited no strong trend, the three highest concentrations of sulfides also occurred north of Point Loma in sediments composed largely of fine particles (mean phi 3.5 to 4.3).

Trace Metals

Ten of the 17 metals sampled were detected at all or nearly all 38 survey stations (Table D.2). Concentrations of trace metals were generally more prevalent north of Point Loma, along gradients of increasing depth and decreasing particle size. Stations with sediment concentrations of aluminum, copper, iron, mercury, and selenium higher that exceeded the 50% CDF levels were found at deeper stations with fine sediments (mean phi >3.5). The few exceptions to this trend (i.e., stations 2753, 2755 and 2756) occurred south of Point Loma. These trends were most evident for aluminum and iron, two metals that occur naturally in high concentrations (Anderson et al. 1993). Many metals also show a strong covariance with iron (Schiff and Gossett 1998), and this pattern was evident for the ten widely distributed metals (Table D.2).

Finally, three of the 17 metals (i.e., silver, thallium, and tin) went undetected, and four others, though rare, occurred in concentrations that exceeded the 50% CDF: Antimony (stations 2755 and 2739), beryllium (station 2749), cadmium (stations 2755 and 2762), and lead (station 2745).

Pesticides, PAHs and PCBs

No PCBs were detected in the 2001 regional survey, while pesticides and PAHs were detected rarely (Table D.3). The pesticide p,p-DDT was found at station 2757 near the LA-4 dredge materials disposal site in concentrations that exceeded the 50% CDF of 10,000 ppt for total DDT. PAHs were detected at three stations: one between the LA-4 and LA-5 disposal sites (station 2756); one east of the LA-4 disposal site (station 2755); a mid-depth station off La Jolla (station 2737). Concentrations of the various PAHs were fairly low, below 46 ppt for all but the one occurrence off La Jolla. The presence of pesticides and PAHs at stations near the two disposal sites is expected (see Anderson et al. 1993, City of San Diego 1998, 2000, 2001a); however, the relatively high concentration of fluoranthene off La Jolla is less easily understood. Previous surveys have not detected elevated PAH compounds in this area (see City of San Diego 2000, 2001a). The few sites where PAHs and DDT were found had varied sediment composition suggesting no relationship with sediment grain size.

DISCUSSION & SUMMARY

The distribution of sediment particles off San Diego was similar in 2001 to that of the previous annual surveys of the region and to the Southern California Bight (SCB) in general, with particle size decreasing with increased depth. Stations less than 100 ft in depth averaged 80% fine sand and 12% silt, while stations deeper than 350 ft averaged 58% fine sand and over 33% silt. Exceptions to this pattern occurred primarily south of Point Loma. These included sites along a deep rocky ridge located southwest of the Point Loma, sites near the LA-4 and LA-5 dredge disposal sites, two different areas west of the Tijuana River, and at one site next to the Point Loma Ocean Outfall. Several organic indicators (e.g., total nitrogen, TOC) and trace metals (e.g., aluminum, iron) were most prevalent north of the Point Loma and showed increasing concentrations with decreasing particle size, and thus increasing depth. The

Table D.2

Summary of metals concentrations (ppm) at randomly selected regional sediment quality stations off San Diego during 2001. Data for each station include: depth (ft); mean phi size (Mean); aluminum (Al); antimony (Sb); arsenic (As); 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); and zinc (Zn). Values below detection limits are designated by "nd". Also included are area means, method detection limits (MDL), and the 50% CDF values for the Southern California Bight (see Schiff and Gosset 1998). Values that exceed the 50% CDF are indicated in bold type.

Station	Depth	Mean	Al	Sb	As	Be	Cd	Cr	Cu	Fe	Pb
MDL			5	5.00	0.08	0.20	0.5	3	2	3	5.00
50% CDF			9400	0.2	4.8	0.26	0.29	34	12	16800	10.2
Shallow Depths											
2764	44	3.4	5520	nd	2.05	nd	nd	6.1	3.5	7440	nd
2752	45	3.8	**9450**	nd	2.60	nd	nd	9.0	8.9	11900	nd
2758	50	3.0	3910	nd	1.16	nd	nd	5.6	4.0	4040	nd
2749	54	2.3	2670	nd	1.64	**0.48**	nd	nd	2.9	3690	nd
2732	62	2.7	4310	nd	1.40	nd	nd	8.4	5.3	5230	nd
2751	63	3.1	8170	nd	3.00	nd	nd	8.0	8.9	9280	nd
2763	72	3.2	4830	nd	1.50	nd	nd	6.2	5.7	4720	nd
2730	80	2.9	5160	nd	1.94	nd	nd	9.8	7.8	7170	5.1
2755	98	0.3	6430	**8.00**	**11.00**	nd	**1.07**	3.2	7.3	**20100**	6.0
Mean	63	2.7	5606	8.00	2.92	0.48	1.07	7.0	6.0	8174	5.6
Mid-depths											
2768	106	3.5	9290	nd	1.92	nd	nd	8.2	9.7	8820	nd
2743	107	2.2	3740	nd	2.89	nd	nd	10.2	6.4	6470	nd
2760	132	1.0	5720	nd	2.23	nd	nd	7.0	5.0	6840	nd
2738	138	3.8	6790	nd	2.36	nd	nd	12.3	6.4	7930	nd
2748	141	0.9	1920	nd	2.36	nd	nd	6.2	3.7	3630	nd
2766	144	1.7	1500	nd	3.32	nd	nd	5.2	nd	5290	nd
2740	144	3.2	6250	nd	2.17	nd	nd	11.9	9.6	8150	nd
2769	159	0.8	1230	nd	**9.33**	nd	nd	5.1	5.0	6730	nd
2761	179	1.8	6360	nd	2.55	nd	nd	7.4	9.7	8340	6.7
2745	200	4.3	**10600**	nd	4.21	nd	nd	19.2	**13.9**	13700	**10.7**
2744	210	4.6	**13400**	nd	3.43	nd	nd	22.0	**15.1**	15600	**10.2**
2767	237	2.6	5160	nd	2.43	nd	nd	6.6	5.1	6370	nd
2739	247	4.1	**15700**	**5.90**	**5.20**	nd	nd	26.8	**17.9**	**19900**	nd
2742	252	4.9	**16600**	nd	**5.10**	nd	nd	25.4	**15.0**	**18100**	nd
2734	257	4.3	8890	nd	2.06	nd	nd	10.5	6.2	12900	nd
2746	265	4.6	**15200**	nd	**4.95**	nd	nd	21.2	**13.1**	16400	8.8
2757	273	4.1	**9660**	nd	2.78	nd	nd	9.1	8.5	11200	nd
2765	292	3.6	6820	nd	2.68	nd	nd	12.9	**13.3**	8110	nd
2736	312	4.5	**11000**	nd	2.40	nd	nd	21.3	9.9	13900	5.5
2737	315	4.3	**10700**	nd	2.97	nd	nd	18.2	8.6	13300	7.5
2756	318	1.4	**10700**	nd	2.48	nd	nd	9.3	**15.5**	14300	nd
Mean	211	3.2	8440	5.90	3.32	nd	nd	13.1	9.9	10761	8.23
Deep Water											
2733	383	3.5	**9620**	nd	2.14	nd	nd	18.5	10.4	11500	nd
2750	428	4.2	**10600**	nd	2.85	nd	nd	19.3	**14.6**	13100	nd
2731	485	4.1	**10300**	nd	3.15	nd	nd	18.0	**16.2**	13500	8.8
2741	500	4.5	8510	nd	2.63	nd	nd	17.5	10.1	11400	9.2
2753	507	0.7	4820	nd	3.87	nd	nd	17.9	7.9	11400	nd
2735	585	4.2	**11200**	nd	1.98	nd	nd	21.4	**13.0**	12800	7.3
2747	585	5.0	**13400**	nd	2.94	nd	nd	24.8	**17.3**	15500	5.1
2762	660	3.9	**11300**	nd	**7.47**	nd	**1.32**	26.0	11.3	**29000**	7.6
Mean	517	3.8	9969	nd	3.38	nd	1.32	20.4	12.6	14775	7.6
Area Mean	240	3.2	8090	0.37	3.24	0.01	0.06	13.0	9.3	10993	2.6

Table D.2 Con't

Station	Depth	Mean	Mn	Hg	Ni	Se	Ag	Tl	Sn	Zn
MDL			0.5	0.03	3.0	0.11	3.0	10	12.0	4.0
50% CDF			**	0.04	**	0.29	0.17	**	**	56
Shallow Depths										
2764	44	3.4	61.0	nd	nd	nd	nd	nd	nd	13.6
2752	45	3.8	106.0	0.016	5.4	nd	nd	nd	nd	29.1
2758	50	3.0	43.1	nd	nd	nd	nd	nd	nd	7.9
2749	54	2.3	37.5	nd	nd	0.12	nd	nd	nd	7.4
2732	62	2.7	64.1	nd	nd	nd	nd	nd	nd	11.9
2751	63	3.1	90.8	nd	3.7	nd	nd	nd	nd	21.2
2763	72	3.2	51.3	nd	nd	nd	nd	nd	nd	9.8
2730	80	2.9	79.5	nd	nd	nd	nd	nd	nd	13.1
2755	98	0.3	96.1	nd	3.7	0.15	nd	nd	nd	31.2
Mean	63	2.7	69.9	0.02	4.3	0.14	nd	nd	nd	16.1
Mid-depths										
2768	106	3.5	84.8	nd	nd	nd	nd	nd	nd	20.3
2743	107	2.2	63.4	nd	nd	nd	nd	nd	nd	13.0
2760	132	1.0	52.7	nd	3.2	nd	nd	nd	nd	14.1
2738	138	3.8	91.2	nd	nd	0.12	nd	nd	nd	19.6
2748	141	0.9	32.8	nd	nd	nd	nd	nd	nd	7.9
2766	144	1.7	14.3	nd	nd	nd	nd	nd	nd	6.0
2740	144	3.2	82.9	nd	3.6	0.11	nd	nd	nd	18.9
2769	159	0.8	19.3	nd	nd	nd	nd	nd	nd	6.0
2761	179	1.8	62.4	nd	5.7	0.15	nd	nd	nd	18.0
2745	200	4.3	119.0	**0.041**	9.1	0.21	nd	nd	nd	34.9
2744	210	4.6	132.0	**0.044**	10.5	0.18	nd	nd	nd	39.5
2767	237	2.6	45.1	nd	nd	nd	nd	nd	nd	13.2
2739	247	4.1	144.0	nd	12.5	**0.40**	nd	nd	nd	44.4
2742	252	4.9	140.0	0.038	12.5	**0.34**	nd	nd	nd	41.1
2734	257	4.3	102.0	nd	7.6	0.14	nd	nd	nd	26.9
2746	265	4.6	138.0	0.038	10.0	0.20	nd	nd	nd	36.0
2757	273	4.1	87.4	nd	7.2	0.21	nd	nd	nd	25.3
2765	292	3.6	61.7	**0.040**	3.3	0.15	nd	nd	nd	19.1
2736	312	4.5	109.0	nd	4.3	0.19	nd	nd	nd	31.0
2737	315	4.3	102.0	0.016	5.9	0.20	nd	nd	nd	27.5
2756	318	1.4	97.9	nd	7.2	0.19	nd	nd	nd	30.5
Mean	211	3.2	84.9	0.04	7.3	0.20	nd	nd	nd	23.5
Deep Water										
2733	383	3.5	89.0	0.018	4.4	**0.29**	nd	nd	nd	31.1
2750	428	4.2	89.9	**0.044**	6.0	0.25	nd	nd	nd	30.7
2731	485	4.1	112.0	0.018	5.8	0.28	nd	nd	nd	32.2
2741	500	4.5	83.0	nd	9.3	0.27	nd	nd	nd	26.6
2753	507	0.7	26.6	nd	4.3	**0.32**	nd	nd	nd	18.5
2735	585	4.2	107.0	0.017	6.6	0.24	nd	nd	nd	31.4
2747	585	5.0	119.0	nd	14.5	**0.48**	nd	nd	nd	39.5
2762	660	3.9	65.4	nd	12.7	**0.59**	nd	nd	nd	38.3
Mean	517	3.8	86.5	0.024	8.0	0.34	nd	nd	nd	31.0
Area Mean	240	3.2	81.7	0.009	4.7	0.15	nd	nd	nd	23.3

Table D.3

Concentrations of pesticides (p,p-DDT), and polycyclic aromatic hydrocarbons (PAHs) at randomly selected regional sediment stations off San Diego during 2001. Also included are method detection limits (MDL) and the 50% CDF values for the Southern California Bight (see Schiff and Gosset 1998). Concentrations are expressed as parts per thousand (ppt).

	Pesticides	PAHs					
Station	p,p-DDT	Benzo[A] pyrene	Benzo[E] pyrene	Chrysene	Fluoranthene	Phenanthrene	3,4-benzo(B) fluoranthene
MDL	410	18	18	21	46	37	27
50%CDF	10,000						
2737					3,640		
2755						45.5	
2756		37.6	26.8	22.9			43.4
2757	**17,000**	18.3					32.7

organic indicators and metal concentrations that exceeded median levels for the SCB occurred primarily at stations characterized by sediments ranging from very fine sand to coarse silt (i.e., mean phi >3.5). Pesticide and PAH contamination remains low in the region and appear to be unrelated to depth or sediment particle size.

LITERATURE CITED

Anderson, J. W., D.J. Reish, R. B. Spies, M.E. Brady, and E. W. Segelhorst. (1993). Human Impacts. In: Dailey, M.D., D.J. Reish and J. W. Anderson, (eds.). Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berkeley, CA. p. 682-766

Bight'98 Steering Committee. (1998). Southern California Bight 1998 Regional Marine Monitoring Survey (Bight'98) Coastal Ecology Workplan. Prepared for Southern California Coastal Water Research Project, Westminster, CA., accessible via Southern California Coastal Water Research Project homepage on the WWW (ftp://ftp.sccwrp.org/pub/download/PDFs/bight98cewkpln.pdf)

City of San Diego. (1998). San Diego Regional Monitoring Report for 1994-1997. City of San Diego. Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2000). Annual Monitoring Report for the South Bay Ocean Outfall (1999). City of San Diego Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2001). Annual Monitoring Report for the South Bay Ocean Outfall (2000). City of San Diego Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

Emery, K. O. (1960). The Sea Off Southern California. John Wiley, New York, 366 pp.

Folk, R. L. (1968). Petrology of Sedimentary Rocks. Austin, Texas: Hemphill, 182 pp. http://www.lib.utexas.edu/geo/FolkReady/TitlePage.html

Schiff, K. C., and R. W. Gossett. (1998). Southern California Bight 1994 Pilot Project: Volume III. Sediment Chemistry. Southern California Coastal Water Research Project. Westminister, CA.

USEPA (United States Environmental Protection Agency). (1987). Quality Assurance and Quality Control (QA/QC) for 301(h) Monitoring Programs: Guidance on Field and Laboratory Methods. EPA Document 430/9-86-004. Office of Marine and Estuarine Protection. 267 p.

Appendix E

Random Sample Survey for the San Diego Region
(July 2001)

Benthic Infauna

Appendix E

Regional Survey off San Diego (July 2001)

Benthic Infauna

INTRODUCTION

The City of San Diego has conducted regional benthic monitoring surveys off the San Diego coast since 1994. These annual surveys are based on an array of stations that are randomly selected each year by the United States Environmental Protection Agency (USEPA) using the USEPA probability-based EMAP design. During the summers of 1994 and 1998, the City participated with other major municipal wastewater dischargers in large-scale surveys of the entire Southern California Bight, the Southern California Bight 1994 Pilot Project (SCBPP) and the 1998 Southern California Bight Monitoring Survey (Bight'98). Results of the SCBPP benthic survey are available in Bergen et al. (1998, 2001), while those for the Bight'98 project have not yet been completed. Subsequent to the SCBPP, the City of San Diego continued to conduct similar but less extensive annual surveys of the San Diego region as part of monitoring efforts for the South Bay Ocean Outfall (SBOO). From 1995 through 1997, these surveys were conducted as part of the SBOO baseline monitoring program (see City of San Diego 1999a, 2000a, 2001), while the 1999 through 2001 surveys were performed in conjunction with post-discharge monitoring activities for the area (see Chapter 1). The main objectives of these surveys are: (1) to characterize benthic conditions for the large and diverse coastal region off San Diego; (2) to characterize the ecological health of the marine benthos in the area; (3) to gain a better understanding of regional conditions in order to distinguish between areas impacted by anthropogenic and natural events.

This section presents an analysis and interpretation of the benthic macrofaunal data collected during the San Diego regional survey of 2001. Included are descriptions and comparisons of the region's soft-bottom macrobenthic assemblages, and analysis of benthic community structure. Results of the sediment quality analyses for this survey are provided in Appendix D of this report.

MATERIALS & METHODS

Collection and Processing of Benthic Samples

Benthic samples were collected at 38 stations off the San Diego coast during July 2001 (Figure E.1). These stations were located at depths ranging from 37 to 660 ft (11-201 m) and covered an area ranging from the border between the United States and Mexico to Solana Beach in northern San Diego County, California. All stations were randomly selected using the USEPA probablility-based EMAP design (Bight'98 Steering Committee 1998).

Figure E.1
Randomly selected benthic infauna stations sampled off San Diego during the 2001 regional survey.

Although 40 stations were initially selected for the 2001 survey, samples were not collected at two sites due to the presence of incompatible substrates (e.g., rocky reefs).

Samples for benthic community analysis were collected from two replicate 0.1 m^2 van Veen grabs at each station. The criteria established by the 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 2002). 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 (MEC Analytical Systems, Inc., Carlsbad, California). The biomass for each sample was measured as the wet weight in grams for each of the following taxonomic categories: Polychaeta (Annelida), Crustacea (Arthropoda), Mollusca, Ophiuroidea (Echinodermata), non-ophiuroid Echinodermata, and all other phyla combined (e.g., Cnidaria, Platyhelminthes, Phoronida, Sipuncula, etc.). Values for ophiuroids (i.e., brittle stars) were combined with those for all other echinoderms 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 benthic community structure parameters were calculated for each station: (1) species richness (number of species per grab); (2) abundance (number of individuals per grab); (3) biomass (grams per grab, wet weight); (4) Shannon diversity index (H' per grab); (5) Pielou's evenness index (J' per grab); (6) Swartz dominance (number of species comprising 75% of the abundance in each grab); (7) Infaunal Trophic Index (ITI per grab) (see Word 1980).

Ordination (principal coordinates) and classification (hierarchical agglomerative clustering) analyses were performed to compare the overall similarity of benthic assemblages in the region. These analyses were performed using Ecological Analysis Package (EAP) software (see Smith 1982; Smith et al. 1988). The macrofaunal abundance data were transformed by a square root and standardized by the species mean abundance values greater than zero.

RESULTS & DISCUSSION

Classification of Assemblages and Dominant Macrofauna

Ordination and classification analyses separated the sites into six major clusters based on the overall similarity of their benthic assemblages (Figure E.2). Sediment composition of each group is summarized in Table E.1. The dominant species within each cluster group are listed in Table E.2. Similar to previous random sample surveys of the region, depth and sediment composition were the primary factors affecting the distribution of assemblages (e.g., City of San Diego 1999a, 2000a, 2001, Bergen et al. 2001).

Table E.1

Sediment composition of the major groups derived from cluster analysis of macrofaunal abundance data for the July 2001 random survey of regional stations off San Diego. Data are expressed as means over all stations in each group (see Figure E.2); ranges in parentheses are for individual replicate samples.

Cluster Groups	Depth (ft)	Mean Phi	Sand (%)	Fines (%)	Cluster Group Description	Total Organic Carbon	Total Nitrogen
Group A (n=2)	584 (507-660)	2.3 (0.7-3.9)	73 (54-92)	20 (0-41)	Deep Water Rise	0.64 (0.40-0.88)	0.06 (0.03-0.08)
Group B (n=6)	494 (383-585)	4.3 (3.5-5.0)	53 (33-68)	44 (32-67)	Deep Water Fine Sediments	0.72 (0.48-1.14)	0.07 (0.05-0.10)
Group C (n=12)	265 (200-318)	3.9 (1.4-4.9)	59 (35-87)	40 (6-65)	Mid-Depth Mixed Sediments (most > 35% fines)	0.63 (0.32-0.99)	0.06 (0.03-0.09)
Group D (n=5)	147 (132-179)	2.2 (0.9-3.8)	86 (70-97)	11 (0-30)	'Shallow' Mid-Depth Coarse Sediments	0.31 (0.12-0.45)	0.04 (0.02-0.05)
Group E (n=4)	127 (98-159)	1.3 (0.3-2.2)	79 (30-100)	0.9 (0-4)	'Shallow' Mid-Depth Coarse Sediments (Relict Red and Black Sands)	0.13 (0.05-0.21)	0.02 (0.01-0.04)
Group F (n=9)	64 (44-106)	3.1 (2.3-3.8)	85 (62-95)	15 (4-39)	Shallow Water Coarse Sediments (most < 16% fines)	0.15 (0.07-0.31)	0.02 (0.01-0.03)

The first split in the dendrogram was associated primarily with depth, and separated the sites into two main clusters, groups A-D versus groups E-F (see split 1 in Figure E.2). The stations in cluster groups A-D occurred at depths greater than 132 ft, while those in groups E-F occurred at depths less than 160 ft (Table E.1). Differences in sediment composition and dominant taxa distinguished groups D and E, which overlap in depth.

Cluster groups A-D separated from each other along both depth and sediment gradients (see splits 3 - 5 in Figure E.2). Groups A and B comprised samples from the eight deepest sampling sites in the region (> 383 ft), while group C consisted of samples from mid-shelf depths (i.e., 200 - 318 ft) (Table E.1). The two deepwater groups had considerably different benthic assemblages. Group A represented two sites (stations 2753 and 2762) with quite different sediment composition that occurred along an isolated deepwater rise. The most abundant species characterizing this deepwater area included the molluscs *Caecum crebricinctum* and *Huxleyia munita*, along with the crustacean *Leptochelia dubia* (Table E.2). Group B consisted of sites with an average of 44% fines that occurred along the shelf break from Point Loma northward. The four most abundant species in these deep, relatively fine sediments were the polychaetes *Spiophanes fimbriata*, *Paradiopatra parva*, *Chaetozone hartmanae* and *Myriochele* sp M.

Nearly one-third of the 38 stations sampled comprised station group C, the mid-shelf sites ranging in depth from 200 ft to 318 ft (Figure E.2). This cluster group, with the exception of station 2756, was characterized by mixed sediments of about 13 to 65% fines (Table E.1, Figure E.3). Infaunal assemblages that occurred at these sites are similar to those that dominate much of the mainland shelf off southern California. The two most abundant species characterizing this mid-depth group included the polychaete *Myriochele* sp M and the ophiuroid *Amphiodia urtica*. *Myriochele* sp M is an opportunistic species whose populations vary greatly. While it is listed as the most abundant animal within station group C, with an average abundance of 146 animals per 0.1 m^2, 75% of its total abundance (1,374 individuals) was found in at single station (2739). If this station is excluded, the average abundance of *Myriochele* sp M becomes 88 individuals per 0.1 m^2 for the 11 remaining sites within group C. *Amphiodia urtica* averaged about 62 animals per 0.1 m^2 (Table E.2); however, this number underestimates actual populations since juveniles are difficult to identify and are usually recorded at either the genus (*Amphiodia* sp) or family (Amphiuridae) level. For example, *Amphiodia* sp and Amphiuridae were the third and sixth most abundant taxa in this cluster group, averaging 20 and 8 individuals per 0.1 m^2, respectively. Combining the average abundances of the three taxa yields an estimated population size for *A. urtica* of about 90 animals per sample. Other characteristic species of group C included the polychaetes *Myriochele gracilis* and *Proclea* sp A.

Group D represented animal assemblages that are transitional between the >200 ft, fine sediment assemblages, and the shallow, more coarse assemblages in the region (Table E.1, Figures E.2 and E.3). The group includes five shallow, mid-depth stations (132-179 ft), three of which had less than 3% fines. In addition to having species representative of both mid-water and shallow depths, the group had several characteristics associated with a "transitional community," such as high species richness and low dominance. The dominant species at these sites included the polychaetes *Spiophanes duplex*, *S. bombyx*, *S. berkeleyorum*, *Syllis (Ehlersia) heterochaeta*, *Aricidia (Acmira) simplex* and *Sternaspis fossor*, the amphipod *Ampelisca brevisimulata*, and the ophiuroid *Amphiodia urtica* (Table E.2).

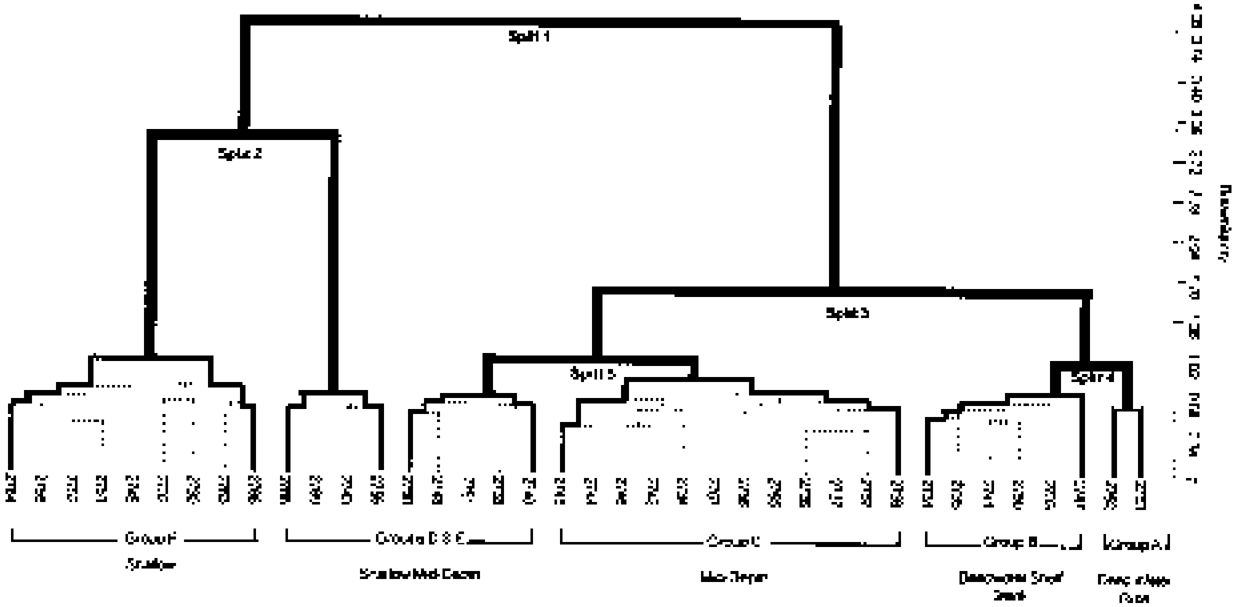


Figure E.2

Dendogram illustrating cluster results of macrofaunal abundance data collected at randomly selected stations off San Diego (July 2001). Major cluster groups delineated by heavy lines. Splits 1-5 represent major branches referred to in text.

The eleven shallowest sites (i.e., <107 ft) plus two relict red sand sites (2766 and 2769) comprised cluster groups E and F (see Appendix D, Table E.1, Figures E.2 and E.3). Sediments at the four stations of group E included more coarse materials, such as coarse black sand and gravel or relict red sands, which are typically associated with unique benthic assemblages (e.g., see Chapter 4 of this report). Group E was dominated by two polychates, the sabellid *Euchone arenae* and the spionid *Spiophanes bombyx*, the gastropod mollusc *Caecum crebrecinctum*, and the sipunculid worm *Apionsoma misakianum* (Table E.2). The dominant species of group F were representative of the "typical" shallow water assemblage: the spionid polychate *Spiophanes bombyx*, the bivalve *Tellina modesta*, the phoxocephalid amphipods *Rhepoxynius menziesi* and *R. abronius*, and the cumacean *Diastylopsis tenuis.*

Community Parameters

Number of Speaccies

Overall, the 2001 survey had relatively high species diversity. A total of 817 infaunal taxa were identified during the July 2001 survey, an increase of 15% over 2000. Rare or unidentifiable taxa that occurred only once accounted for 20% of these 817 taxa.

Species richness (i.e., the number of species per sample) was highly variable, averaging from 36 to 157 species per 0.1 m^2 grab (Table E.3, Figure E.4a). The number of species varied among stations within cluster groups, but was highest (>85) among the mid-shelf and deeper stations (station groups A - D). The "transitional" assemblage

Table E.2

Summary of the most abundant species comprising cluster groups A - F derived from the 2001 regional survey of randomly selected stations off San Diego. Data are included for any species that represented at least one of the ten most abundant taxa in a group. Values for the dominant species discussed in the text are underlined and the species name bolded. Data are expressed as the mean abundance per sample (0.1 m^2). n = number of station/ survey entitles comprising each cluster group.

		Cluster Group					
Species/Taxon	Higher Taxa Code*	A (n=2)	B (n=6)	C (n=12)	D (n=5)	E (n=6)	F (n=9)
Typhlotanais crassus	C	4.5	.	.	.	.	.
Huxleyia munita	M	8.0	0.1	<0.1	.	.	.
Spiophanes fimbriata	P	.	31.6	3.5	.	.	0.1
Tellina cadieni	M	4.2	5.5	0.8	.	.	.
Fauveliopsis sp SD 1	P	.	8.0	.	.	0.4	.
Chaetozone hartmanae	P	.	12.8	2.9	0.6	0.1	0.1
Myriochele gracilis	P	1.2	4.3	17.8	0.2	.	0.1
Paradiopatra parva	P	5.8	16.5	6.2	1.2	0.1	0.3
Prionospio (Prionospio) dubia	P	0.5	7.0	2.7	1.1	.	.
Ampelisca careyi	C	6.0	0.8	1.3	0.7	.	.
***Amphiodia* sp**	E	1.8	2.5	20.0	3.9	0.1	0.2
Sternaspis fossor	P	.	4.6	6.1	6.6	.	0.4
Praxillella pacifica	P	.	7.6	2.5	2.6	.	0.3
Amphiuridae	E	1.8	2.3	7.6	2.4	1.5	0.3
***Myriochele* sp M**	P	.	10.2	146.1	4.0	0.2	0.1
Amphiodia urtica	E	.	8.2	62.4	6.6	0.1	.
Proclea sp A	P	.	3.4	10.3	.	0.5	0.1
Axinopsida serricata	M	.	2.0	6.8	0.7	.	.
Caecum crebricinctum	M	11.8	2.9	.	.	11.4	.
Scalibregma inflatum	P	.	0.1	2.7	4.6	4.6	0.3
Spiophanes berkeleyorum	P	.	1.3	1.1	6.9	0.1	0.6
Ampelisca brevisimulata	C	0.2	0.4	1.3	6.8	.	0.7
Pista sp B	P	4.5	3.2	0.5	2.1	0.5	0.4
Aricidea (Acmira) simplex	P	.	1.4	1.4	6.8	0.1	.
Leptochelia dubia	C	10.8	0.7	1.6	1.6	2.6	0.4
Maldanidae	P	0.2	7.3	3.8	6.3	0.4	1.9
Mediomastus sp	P	1.8	7.2	1.9	0.7	0.2	2.6
Pectinaria californiensis	P	2.8	3.4	2.8	1.7	0.2	3.5
Amphiodia digitata	E	5.8	1.2	0.2	0.7	0.1	0.4
Sthenelanella uniformis	P	.	0.2	0.7	5.9	.	0.2
Syllis (Ehlersia) heterochaeta	P	0.8	0.4	0.1	7.9	.	0.1
Exogone lourei	P	4.8	0.1	0.2	.	.	0.4
Apionsoma misakianum	O	0.2	.	0.1	4.4	10.8	.
Euchone arenae	P	0.5	0.4	0.5	0.2	17.5	.
Ophiuroconis bispinosa	E	.	0.1	1.5	2.8	8.5	0.4
Foxiphalus obtusidens	C	2.2	0.1	0.1	1.2	4.5	0.6
Ampelisca cristata cristata	C	.	.	.	0.1	6.6	0.8
Spiophanes bombyx	P	.	.	<0.1	6.7	13.0	4.8
Spiophanes duplex	P	.	2.6	5.2	13.5	0.1	3.6
Photis brevipes	C	.	.	0.1	1.1	0.1	3.7
Sigalion spinosus	P	.	0.1	0.2	2.5	1.8	3.1
Spio maculata	P	.	.	.	0.2	5.4	.
Mooreonuphis sp SD 1	P	.	.	.	.	6.2	.
Edwardsia sp G (MEC)	O	.	.	.	0.1	.	3.3
Tellina modesta	M	.	.	<0.1	0.1	0.1	5.4
Rhepoxynius menziesi	C	.	.	.	1.2	.	5.0
Rhepoxynius abronius	C	.	.	.	.	.	5.1
Diastylopsis tenuis	C	.	.	.	.	.	4.3

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

(group D) averaged the highest number of species (116 species/sample). In contrast, species richness averaged 78 and 58 species per sample at the red relict sand and shallow water sites (groups E and F, respectively).

Infaunal Abundance

Macrofaunal abundance was highly variable across the region. Excluding station 2739 with a mean infaunal abundance of 1,060 due to the presence of large numbers of the polychaete *Myriochele* sp M, infaunal abundance was similar to last year, ranging from 77 to 685 per sample (Table E.3, Figure E.4b). Peak abundance occurred at the mid-depth stations (station group C) with densities of about 454 animals per sample for all stations within the group; 399 animals per sample with station 2739 excluded. The deepwater rise and shallow water habitats averaged 218 and 165 animals per sample, respectively.

Biomass

Infaunal biomass was also quite variable, averaging from 0.4 to 89.5 g per sample (0.7 to 45.7 per station) (Table E.3, Figure E.4c). The only clear pattern was that biomass was generally higher at the deepwater sites. Relatively high biomass values (> 10 g/sample) were typically associated with the collection of a few large animals (e.g., echinoids, holothuroids, gastropods) or large numbers of individual taxa (e.g., ophiuroids or molluscs), a pattern similar to that seen throughout the Southern California Bight. For example, station 2753 included one grab sample with a biomass of 89.5 g due to a single specimen of the echinoid *Allocentrotis fragilis*, while the second grab did not include any echinoids and had a total biomass of 1.9 g.

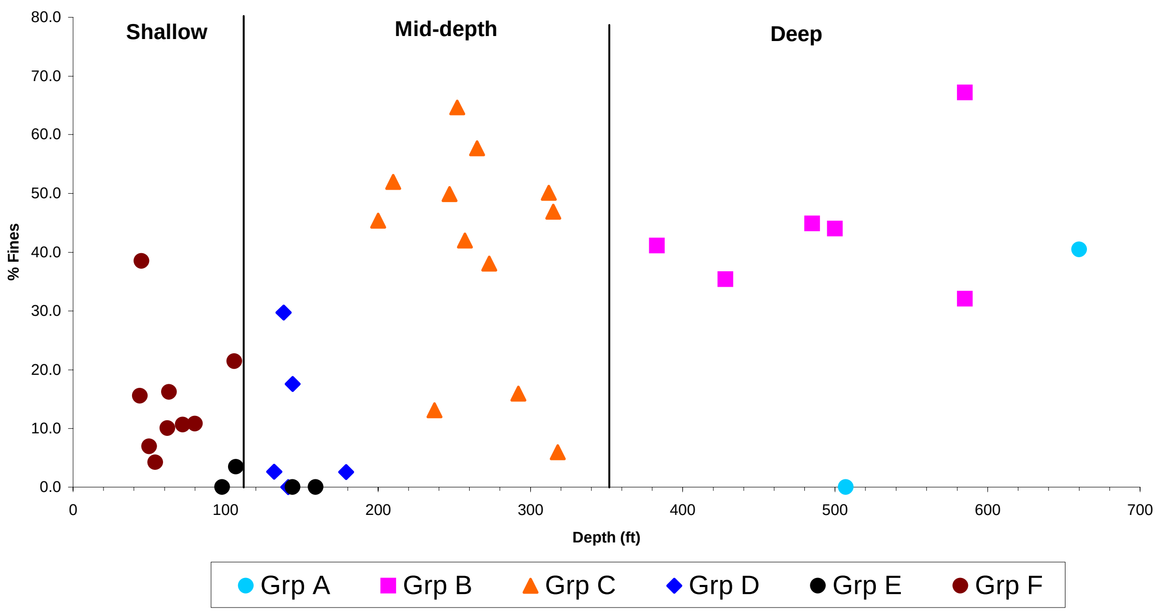


Figure E.3

Sediment composition vs. depth for the 2001 regional survey of randomly selected stations off San Diego. Data are expressed as the percent fines (<63μm) in the sediments at each station. Groups A - F correspond to the six major benthic infaunal cluster groups (see Table E.1 and Figure E.2 for details).

Table E.3

Summary of the major benthic community parameters for the 2001 regional survey of randomly selected stations off San Diego. Data for each station are expressed as means per 0.1 m^2 grab for: (1) species richness (SR); (2) abundance (Abun); (3) biomass = grams, wet weight; (4) diversity (H'); (5) evenness (J'); (6) Swartz dominance (Dom); (7) Infaunal Trophic Index (ITI).

Station	Station Grp	Depth (ft)	SR	Abun	Biomass	H'	J'	Dom	ITI
Deepwater stations									
2753	A	507	91	264	45.7	4.0	0.89	36	79
2762	A	660	79	173	14.1	4.1	0.93	36	87
	Grp A mean	**584**	**85**	**218**	**29.9**	**4.1**	**0.91**	**36**	**83**
2733	B	383	156	685	10.7	4.2	0.84	42	79
2750	B	428	102	367	5.9	4.0	0.86	36	84
2731	B	485	98	359	9.9	3.9	0.85	32	79
2741	B	500	81	243	20.2	3.8	0.87	30	81
2735	B	585	59	194	38.3	3.5	0.86	21	81
2747	B	585	49	154	23.1	3.3	0.84	17	84
	Grp B mean	**494**	**91**	**333**	**18.0**	**3.8**	**0.85**	**29**	**81**
Mid-depth stations									
2745	C	200	91	392	7.8	3.6	0.79	22	81
2744	C	210	96	540	7.5	3.2	0.70	20	78
2767	C	237	99	219	2.7	4.1	0.89	45	79
2739	C	247	87	1060	8.1	1.8	0.39	3	74
2742	C	252	94	471	9.0	2.9	0.65	18	81
2734	C	257	86	579	11.1	2.8	0.63	11	78
2746	C	265	83	429	9.9	3.1	0.70	16	89
2757	C	273	73	331	5.9	3.2	0.74	16	90
2765	C	292	76	244	6.1	3.7	0.86	27	86
2736	C	312	86	492	6.9	3.1	0.70	17	79
2737	C	315	85	473	7.2	2.9	0.65	14	76
2756	C	318	80	223	4.2	3.9	0.88	34	80
	Grp C mean	**265**	**86**	**454**	**7.2**	**3.2**	**0.72**	**20**	**81**
2760	D	132	111	266	6.4	4.3	0.92	50	85
2738	D	138	78	206	4.9	3.9	0.91	32	84
2748	D	141	108	339	7.7	4.0	0.87	42	80
2740	D	144	127	347	6.4	4.4	0.92	53	80
2761	D	179	157	470	7.3	4.6	0.90	61	86
	Grp D mean	**147**	**116**	**325**	**6.5**	**4.2**	**0.90**	**47**	**83**
2755	E	98	86	274	17.6	3.9	0.87	29	74
2743	E	107	104	369	5.5	4.0	0.87	36	86
2766	E	144	62	192	3.5	3.6	0.87	23	90
2769	E	159	61	166	5.4	3.4	0.83	24	92
	Grp E mean	**127**	**78**	**250**	**8.0**	**3.7**	**0.86**	**28**	**85**
Shallow-water stations									
2764	F	44	36	113	0.7	2.9	0.82	13	73
2752	F	45	49	129	1.5	3.4	0.87	21	76
2758	F	50	36	77	2.8	3.2	0.89	18	79
2749	F	54	84	356	6.2	3.9	0.87	28	71
2732	F	62	67	222	1.9	3.6	0.85	24	89
2751	F	63	54	102	1.7	3.7	0.93	29	76
2763	F	72	65	141	1.8	3.9	0.93	31	82
2730	F	80	61	174	2.0	3.6	0.89	24	79
2768	F	106	68	174	3.6	3.9	0.94	32	83
	Grp F mean	**64**	**58**	**165**	**2.5**	**3.6**	**0.89**	**24**	**78.5**
	Area mean	**240**	**83**	**316**	**9.0**	**3.6**	**0.83**	**28**	**81**

Species Diversity and Dominance

Species diversity varied among stations, with values of H' ranging from 1.8 to 4.6 (Table E.3, Figure E.4d). Diversity was relatively high in 2001 with 66% of the stations having H' values >3.5, compared to 53% in 2000 (see City of San Diego 2001). The highest values occurred at stations within group D (mean H'=4.2). Dominance, measured as the minimum number of species comprising 75% of a community by abundance (see Swartz 1978), is inversely proportional to numerical dominance. These values also varied widely throughout the region, and averaged from three to 61 species per station . Stations within group D also had the lowest dominance (i.e., highest average values for Swartz dominance, 47). Again, the presence of high numbers of the polychaete *Myriochele* sp M affected the results at station 2739, which had the lowest diversity and dominance values.

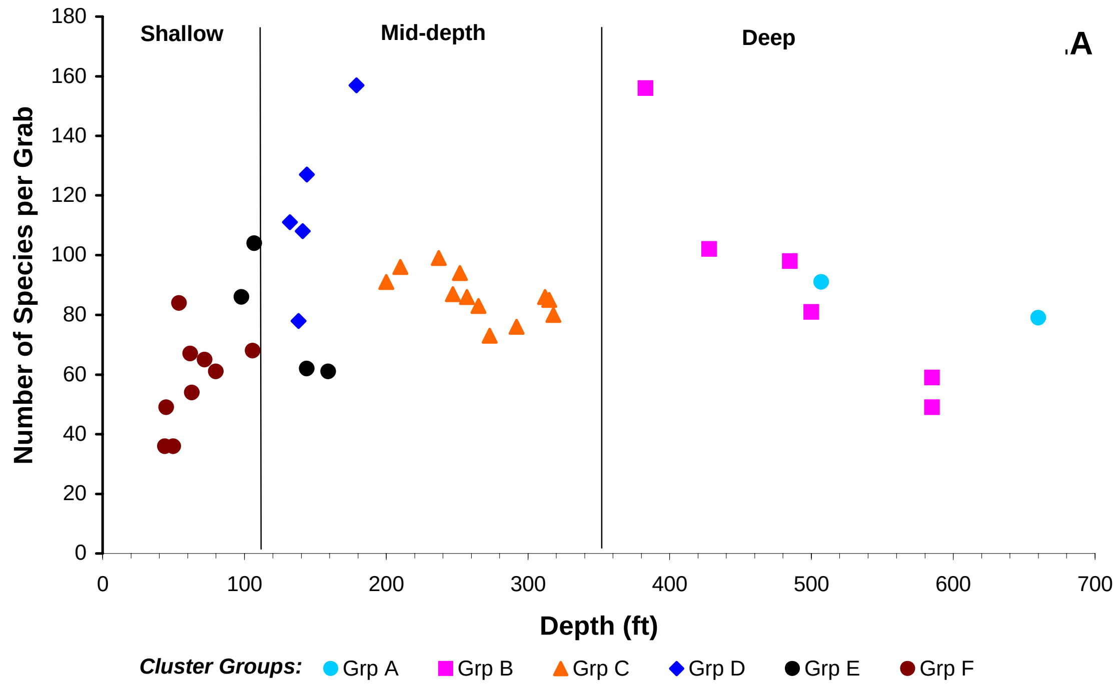
Infaunal Trophic Index (ITI)

Average ITI values were similar to those of 2000, ranging from 71 to 92 throughout the San Diego region (Table E.3, Figure E.4f). These relatively high values (i.e., > 60) are generally considered characteristic of "normal" benthic conditions (Bascom et al. 1979). The shallow stations (station group F) generally had lower ITI values than mid-shelf and deeper stations. Two of the shallow stations had the lowest recorded values, 68 and 69 for individual grabs at stations 2752 and 2755, respectively. Station 2739 had the lowest value among the mid-shelf assemblage, which is probably a result of the high numbers of the polychaete *Myriochele* sp M, a category II surface deposit feeder (see Word 1980).

SUMMARY & CONCLUSIONS

The Southern California Bight (SCB) benthos has long been considered a "patchy" habitat, with the distribution of species and communities varying in space and time. Results of the 2001 regional survey support this characterization. Barnard and Ziesenhenne (1961) described the SCB shelf as consisting of an *Amphiodia* "mega-community" with other sub-communities representing simple variations determined by differences in substrate type and microhabitat, i.e., the ophiuroid *Amphiodia urtica* appears to be a sub-dominant or co-dominant species in these other assemblages. The present and previous regional surveys off San Diego generally support these claims (e.g., see City of San Diego 1999a, 2000b, 2001). Several distinct benthic assemblages identified during the 2001 survey were similar to the *Amphiodia* "mega-community" common in the region (i.e., station groups B, C and D), while others demonstrated the variety of different habitats also present off San Diego (i.e., station groups A, E and F) . These assemblages segregated mostly due to differences in habitat (e.g., depth and sediment grain size), and not their proximity to input from anthropogenic sources.

The *Amphiodia* "mega-community" was characteristic of the mid-shelf assemblage (station group C) and occurred at depths between 200 ft and 318 ft in sediments composed of relatively fine particles (e.g., mean phi of 3.9 with 40% fines). It was also represented in the deeper (383-660 ft) and shallower (130-180 ft) assemblages, station group B and D, respectively. In addition to the ophiuroid *A. urtica* and the opportunistic polychaete *Myriochele* sp M, other species characteristic of this community included the spionid polychaetes *Spiophanes fimbriata*, *S. duplex* and *S. berkeleyorum*, the onuphid *Paradiopatra parva*, and the ampeliscid amphipod



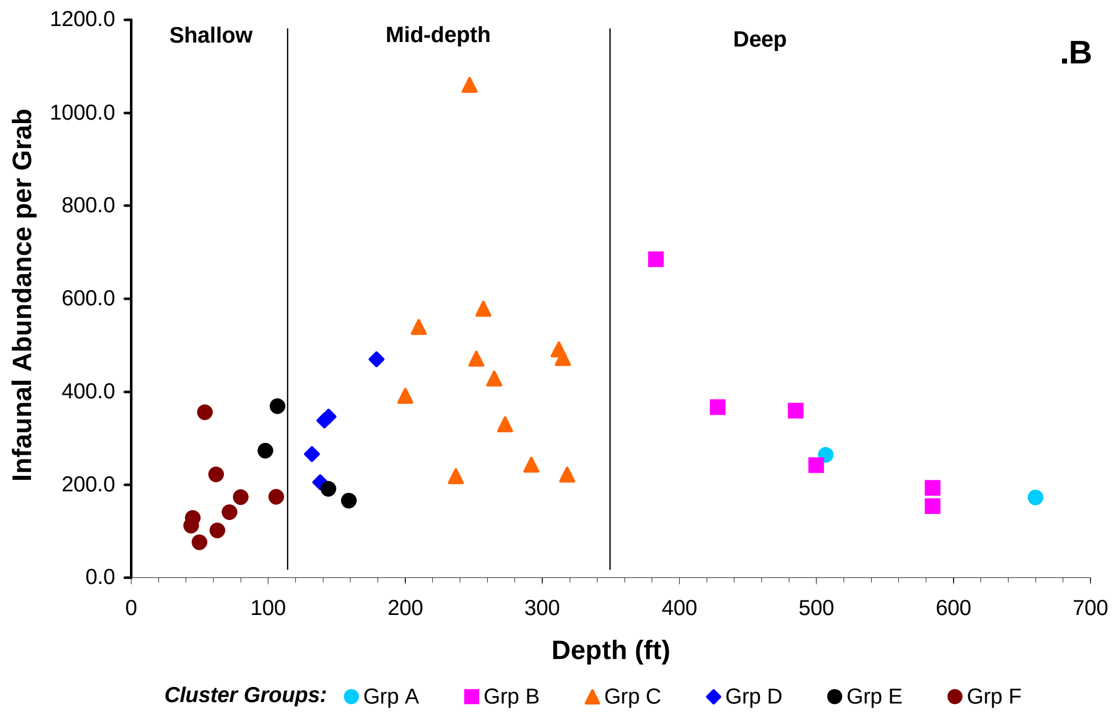
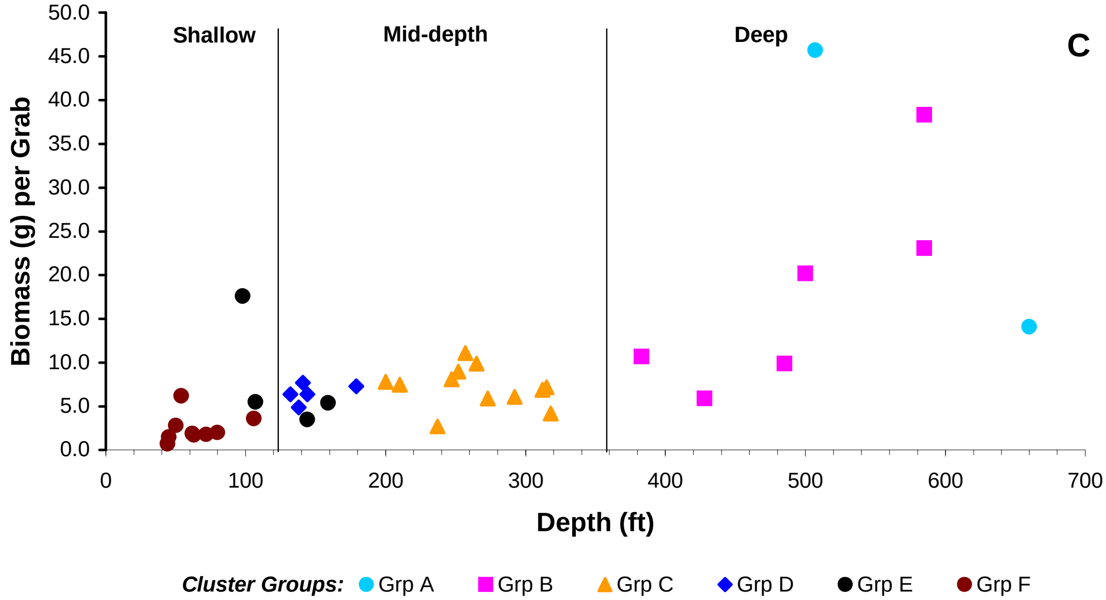


Figure E.4

Summary of benthic community parameters vs depth for the 2001 regional survey of randomly selected stations off San Diego. Data are expressed as mean values per 0.1 m^2 grab for: (A) species richness; (B) infaunal abundance; (C) biomass (g, wet weight); (D) diversity (H'); (E) Swartz dominance; (F) infaunal trophic index (ITI). See Table E.1 and Figure E.2 for details of cluster groups A - F.



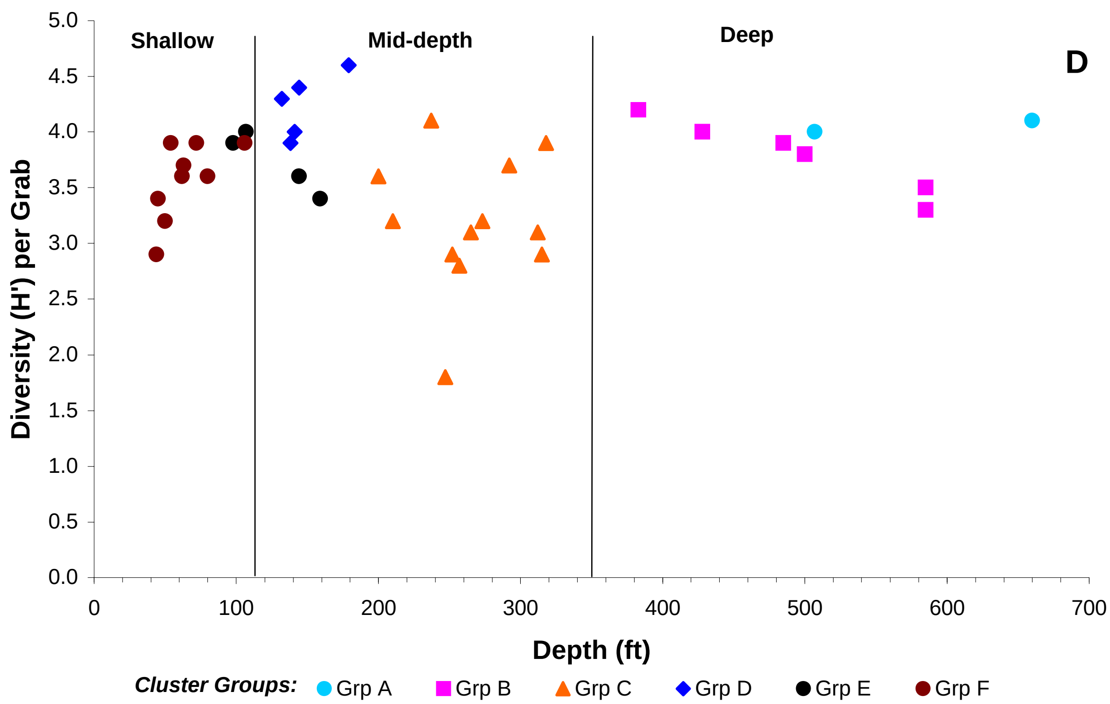
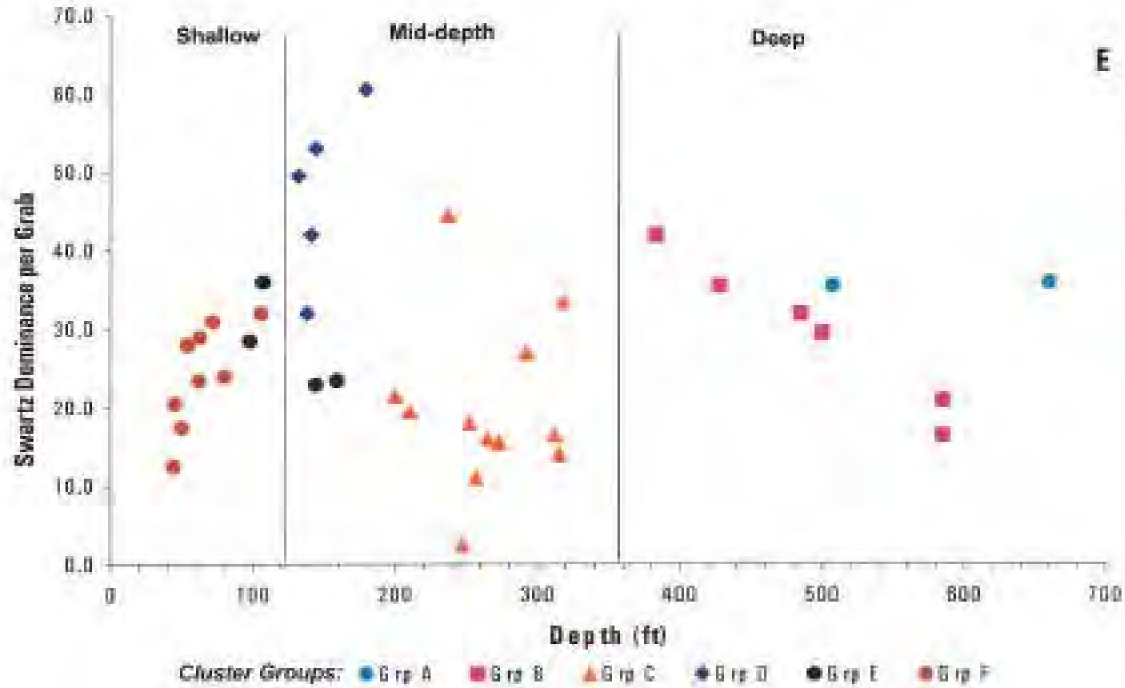


Figure E.4 (continued)



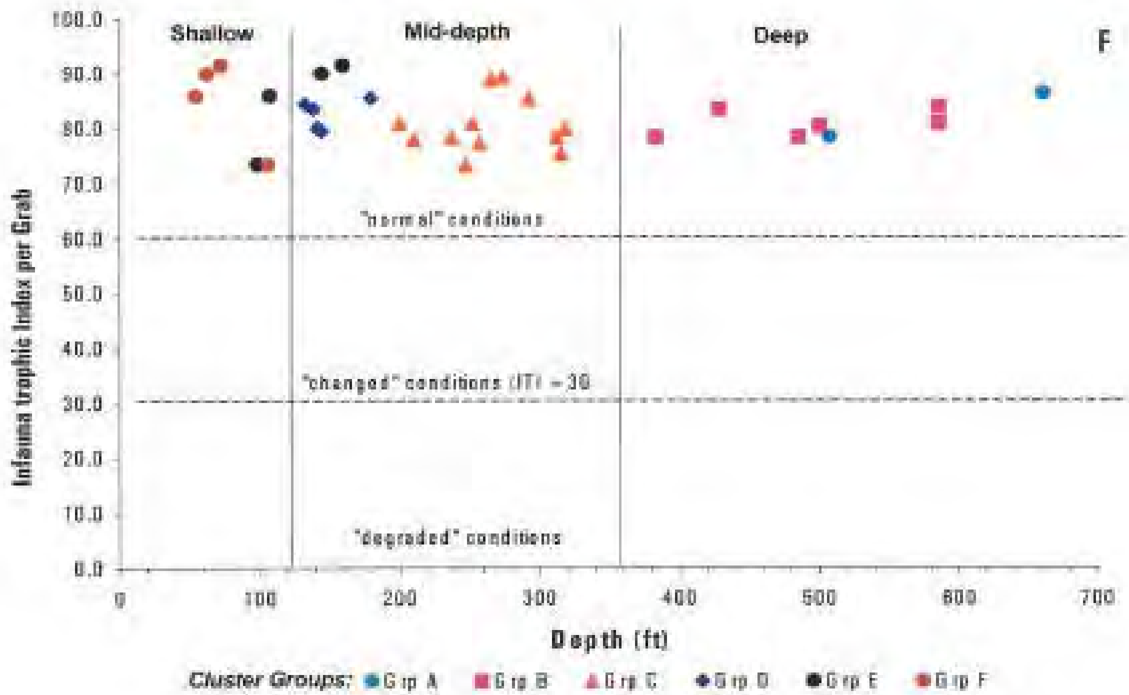


Figure E.4 (continued)

Ampelisca brevisimulata. Similar ophiuroid-polychaete dominated assemblages have been described by Barnard and Ziesenhenne (1961), Jones (1969), Fauchald and Jones (1979), Thompson et al. (1987, 1992, 1993), EcoAnalysis et al. (1993), Zmarzly et al. (1994), Diener and Fuller (1995) and Bergen et al. (1988, 2001).

Deepwater assemblages in the region were highly variable depending upon whether they occurred along the shelf-break or a deepwater rise. The two sites located along the deepwater rise off Point Loma were dominated by the molluscs *Caecum crebricinctum* and *Huxleyia minuta*, and the crustacean *Leptochelia dubia*. In contrast, the fine sediment sites occurring along the shelf-break were dominated by polychaetes, including *Spiophanes fimbriata*, *Paradiopatra parva* and *Chaetozone hartmanae*. Similar deepwater assemblages have been described in previous years (e.g., Bergen et al. 1998, 2001, City of San Diego 2000b, 2001).

Station group D was represented a group of transitional stations that separated the fine sediment stations of the mid-shelf region from the sandy sediments common in shallow waters. This group of five stations was characterized by relatively high species richness and low dominance. The co-dominant taxa in this station group included the polychaetes *Spiophanes duplex*, *S. bombyx*, *S. berkeleyorum*, *Syllis (Ehlersia) heterochaeta*, *Aricidia simplex* and *Sternaspis fossor*, the amphipod *Ampelisca brevisimulata*, and the ophiuroid *Amphipoda urtica*.

Benthic assemblages at the shallower sites (e.g., < 130 ft) were quite varied. They included several very coarse black or red relict sand stations, along with the "typical" sandy, shallow water assemblage. The latter comprised station group F and was generally less diverse and similar to other shallow, sandy sediment communities in the SCB (see Barnard 1963, Jones 1969, Thompson et al. 1987, 1992, ES Engineering-Science 1988). At many of these stations, species such as the polychaete *Spiophanes bombyx*, the bivalve *Tellina modesta*, the amphipods *Rhepoxynius menziesii* and *R. abronius*, and the cumacean *Diastylopsis tenuis* become numerically dominant. However, sites within station group E were characterized by unique sediments composed of relict red or black sands that are typically associated with distinct benthic assemblages. This assemblage was dominated by the polychaetes *Euchone arenae* and *Spiophanes bombyx*, the gastropod *Caecum crebricinctum*, and the sipunculid worm *Apionsoma misakianum*.

No evidence of anthropogenic influences was observed off San Diego in the 2001 regional survey of randomly selected stations. All stations had mean ITI values above 60, characteristic of normal sediment conditions, and there was no indication that either the Point Loma Ocean Outfall or the South Bay Ocean Outfall had any impact on benthic community structure in the region. There was also little clear evidence that local bays or non-point sources adversely affected nearshore benthic communities. However, abundances of soft-bottom invertebrates exhibit substantial spatial and temporal variability that may mask the effects of natural or anthropogenic disturbances (Morrisey et al. 1992a, 1992b, Otway 1995). For example the opportunistic polychaete *Myriochele* sp M, present in very high abundances at station (2739), affected species richness, diversity (H'), dominance and even ITI values, making them artificially low relative to other stations of similar habitat. Future region-wide surveys may provide additional information useful in understanding these types of population fluctuations.

LITERATURE CITED

Barnard, J.L. (1963). Relationship of benthic Amphipoda to invertebrate communities of inshore sublittoral sands of southern California. Pac. Nat., 3: 439-467

Barnard, J.L., and F.C. Ziesenhenne. (1961). Ophiuroidea communities of southern Californian coastal bottoms. Pac. Nat., 2: 131-152

Bascom, W., A.J. Mearns, and J.Q. Word. (1979). Establishing boundaries between normal, changed, and degraded areas. In: Southern California Coastal Water Research Project Annual Report, 1978. Long Beach, CA. pp. 81-95

Bergen, M., S.B. Weisberg, D. Cadien, A. Dalkey, D. Montagne, R.W. Smith, J.K. Stull, and R.G. Velarde. (1998). Southern California Bight 1994 Pilot Project: IV. Benthic Infauna. Southern California Coastal Water Research Project, Westminster, CA.

Bergen, M., S.B. Weisberg, R.W. Smith, D.B. Cadien, A. Dalkey, D.E. Montagne, J.K. Stull, R.G. Velarde, and J.A. Ranasinghe. (2001). Relationship between depth, sediment, latitude, and the structure of benthic infaunal assemblages on the mainland shelf of southern California. Mar. Biol., 138: 637-647

Bight'98 Steering Committee. (1998). Southern California Bight 1998 Regional Marine Monitoring Survey (Bight'98) Coastal Ecology Workplan. Prepared for Southern California Coastal Water Research Project, Westminster, CA., accessible via Southern California Coastal Water Research Project homepage on the WWW (ftp://ftp.sccwrp.org/pub/download/PDFs/bight98cewkpln.pdf)

City of San Diego. (1999a). San Diego Regional Monitoring Report for 1994-1997. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (1999b). Receiving Waters Monitoring Report for 1998. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2000a). Final Baseline Monitoring Report for the South Bay Ocean Outfall (1995-1998). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2000b). Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (1999). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2001). Annual Receiving Waters Monitoring Report for the South Bay Ocean Outfall (1999). City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

City of San Diego. (2002). 2000 Quality Assurance Manual. City of San Diego Ocean Monitoring Program, Metropolitan Wastewater Department, Environmental Monitoring and Technical Services Division.

Diener, D.R., and S.C. Fuller. (1995). Infaunal patterns in the vicinity of a small coastal wastewater outfall and the lack of infaunal community response to secondary treatment. Bull. Southern Cal. Acad. Sci., 94: 5-20

EcoAnalysis, SCCWRP, and Tetra Tech. (1993). Analyses of Ambient Monitoring Data for the Southern California Bight. Final Report to U.S. EPA, Wetlands, Oceans and Estuaries Branch, Region IX, San Francisco, CA (EPA Contract No. 68-C1-008).

ES Engineering Science, Inc. (1988). Tijuana Oceanographic Engineering Study (TOES) Ocean Measurement Program Summary Phases I-III (May 1986-December 1988). ES Engineering Science, Inc., San Diego, CA.

Fauchald, K., and G.F. Jones. (1979). Variation in community structures on shelf, slope, and basin macrofaunal communities of the Southern California Bight. In: Southern California Outer Continental Shelf Environmental Baseline Study, 1976/1977 (second year) benthic program. Vol. II, Principal Invest. Reps., Ser. 2, Rep. 19. Available from: NTIS, Springfield, Virginia; PB80-16601. Science Applications, Inc., La Jolla, CA.

Jones, G.F. (1969). The benthic macrofauna of the mainland shelf of southern California. Allan Hancock Monogr. Mar. Biol., 4: 1-219

Morrisey, D.J., L. Howitt, A.J. Underwood, and J.S. Stark. (1992a). Spatial variation in soft-sediment benthos. Mar. Ecol. Prog. Ser., 81: 197-204

Morrisey, D.J., A.J. Underwood, L. Howitt, and J.S. Stark. (1992b). Temporal variation in soft-sediment benthos. J. Exp. Mar. Biol. Ecol., 164: 233-245

Otway, N.M. (1995). Assessing impacts of deepwater sewage disposal: a case study from New South Wales, Australia. Mar. Poll. Bull., 31: 347-354

Swartz, R.C. (1978). Techniques for sampling and analyzing the marine macrobenthos. U.S. Environmental Protection Agency (EPA), Doc. EPA-600/3-78-030, EPA, Corvallis, Oregon. 27 p.

Smith, R.W. (1982). Analysis of ecological survey data with SAS and EAP. Proc. 7th Annual SAS Users' Group International, 705 pp. (SUGI). SAS Institute, Inc., Cary, N C. p. 610-615

Smith, R.W., B.B. Bernstein, and R.L. Cimberg. (1988). Community-environmental relationships in the benthos: Applications of multivariate techniques. In: Soule, D.F., and G.S. Kleppel, eds. Marine Organisms as Indicators. Springer-Verlag, N Y. p. 247-326

Thompson, B., J. Dixon, S. Schroeter, and D.J. Reish. (1993). Chapter 8. Benthic invertebrates. In: Dailey, M.D., D.J. Reish, and J.W. Anderson, eds. Ecology of the Southern California Bight: A synthesis and interpretation. University of California Press, Berkeley, CA. p. 369-458

Thompson, B.E., J.D. Laughlin, and D.T. Tsukada. (1987). 1985 Reference Site Survey. Tech. Rep. No. 221, Southern California Coastal Water Research Project, Long Beach, C A.

Thompson, B.E., D. Tsukada, and D. O'Donohue. (1992). 1990 Reference Survey. Tech. Rep. No. 355, Southern California Coastal Water Research Project, Long Beach, CA.

USEPA (United States Environmental Protection Agency). (1987). Quality Assurance and Quality Control (QA/QC) for 301(h) Monitoring Programs: Guidance on Field and Laboratory Methods. EPA Document 430/9-86-004. Office of Marine and Estuarine Protection. 267 p.

Word, J.Q. (1980). Classification of benthic invertebrates into infaunal trophic index feeding groups. In: Bascom, W., ed. Biennial Report for the Years 1979-1980, Southern California Coastal Water Research Project, Long Beach, CA. p. 103-121

Zmarzly, D.L., T.D. Stebbins, D. Pasko, R.M. Duggan, and K.L. Barwick. (1994). Spatial patterns and temporal succession in soft-bottom macroinvertebrate assemblages surrounding an ocean outfall on the southern San Diego shelf: Relation to anthropogenic and natural events. Mar. Biol., 118: 293-307