ORANGE COUNTY SANITATION DISTRICT

Marine Monitoring Annual Report

Year 2017-2018

Orange County, California

ORANGE COUNTY SANITATION DISTRICT
LABORATORY, MONITORING, AND COMPLIANCE DIVISION
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March 12, 2019

Hope Smythe
Executive Officer
California Regional Water Quality Control Board
Santa Ana Region 8
3737 Main Street, Suite 500
Riverside, CA 92501-3348

SUBJECT: Board Order No. R8-2012-0035, NPDES No. CA0110604, 2017-18 Marine Monitoring Annual Report

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Dear Ms. Smythe,

Enclosed is the Orange County Sanitation District's (OCSD) 2017-18 Marine Monitoring Annual Report. This report focuses on the findings and conclusions for the monitoring period July 1, 2017 to June 30, 2018. The results of the monitoring program document that the discharge of our combined secondary-treated wastewater and water reclamation flows (collectively, the final effluent) into the coastal waters off Huntington Beach and Newport Beach, California, does not affect the environment and human health.

The results of the 2017-18 monitoring effort showed minor changes in the coastal receiving water. Plume-related changes in dissolved oxygen, pH, and transmissivity beyond the zone of initial dilution (ZID) were well within the range of natural variability and compliance with numeric receiving water criteria was achieved over 96% of the time. This demonstrated that the receiving water outside the ZID was not been degraded by OCSD's final effluent discharge. The low concentrations of fecal indicator bacteria in water contact zones, together with the low concentrations of ammonium at depth, also suggest that the final effluent discharge posed no human health risk and did not compromise recreational use.

There were no impacts to the benthic animal communities within and adjacent to the ZID. Infauna and fish communities in the monitoring area were healthy based on, respectively, the low Benthic Response Index and Fish Response Index values. In addition, contaminants in nearly all sediment samples remained at background levels and no measurable toxicity was observed in whole sediment toxicity tests. The low levels of contaminants in fish tissues and the low incidence of external abnormalities and diseases in fish populations demonstrated that the outfall was not an epicenter of disease.

Should you have questions regarding the information provided in this report, or wish to meet with OCSD's staff to discuss any aspect of our ocean monitoring program, please feel free to contact me at (714) 593-7550 or at ltyner@ocsd.com.

However, you may also contact Dr. Jeff Armstrong, the supervisor of our Ocean Monitoring section, who may be reached at (714) 593-7455 or at jarmstrong@ocsd.com.

Lorenzo Tyner
Assistant General Manager

JA:ja

Enclosure

cc: Alexis Strauss, U.S. EPA, Region IX

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March 12, 2019

Certification Statement

The following certification satisfies Attachment E of the Orange County Sanitation District's Monitoring and Reporting Program, Order No. R8-2012-0035, NPDES No. CA0110604, for the submittal of the attached OCSD Annual Report 2019 – Marine Monitoring.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for known violations.

Lorenzo Tyner
Assistant General Manager

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EXECUTIVE SUMMARY

The Orange County Sanitation District (OCSD) conducts extensive water quality, sediment quality, fish and invertebrate community, and fish health monitoring off the coastal cities of Huntington Beach and Newport Beach, California. The purpose of this monitoring program is to evaluate potential environmental and public health risks from OCSD's ocean discharge of combined secondary-treated wastewater and water reclamation flows (final effluent). The final effluent is released through a 120-in outfall extending 4.4 miles offshore in 197 ft of water. The data collected are used to determine compliance with receiving water conditions as specified in OCSD's 2012 National Pollution Discharge Elimination System permit (Order No. R8-2012-0035, NPDES No. CA0110604), issued jointly by the U.S. Environmental Protection Agency, Region IX and the Regional Water Quality Control Board, Region 8. This report focuses on monitoring results and conclusions from July 2017 through June 2018.

WATER QUALITY

The public health risks and measured environmental effects to the receiving water continue to be negligible. Consistent with previous years, minor changes in measured water quality parameters related to the discharge of final effluent to the coastal ocean were detected. Plume-related changes in temperature, salinity, dissolved oxygen, pH, and light transmissivity were measurable beyond the initial mixing zone (<1.2 miles) during some surveys. These changes were within the ranges of natural variability for the study area and reflected seasonal and yearly changes of large-scale regional influences. Furthermore, the limited observable plume effects occurred primarily at depth, even during the winter when stratification was weakest. All state and federal offshore bacterial standards were met during the monitoring period. In summary, the 2017-18 discharge of final effluent did not greatly affect the receiving water environment; therefore, beneficial uses were protected and maintained.

SEDIMENT QUALITY

As in previous years, mean concentrations of organic contaminants and metals tended to increase with increasing depth, with the highest in depositional areas (>656 ft). Sediment parameter values were comparable between stations situated within and beyond the zone of initial dilution (ZID), and nearly all values were below the Effects Range-Median guidelines of biological concern. In addition, whole sediment toxicity tests showed no measurable toxicity. These results together with the presence of diverse fish and invertebrate communities adjacent to and farther afield from the outfall (see below) indicate good sediment quality in the monitoring area.

BIOLOGICAL COMMUNITIES

Infaunal Communities

As with previous years, the community measures of infauna were markedly lower at stations deeper than 394 ft. Infaunal communities were similar at within-ZID and non-ZID stations based on multivariate analyses. Moreover, the infaunal communities within the monitoring area can be classified as reference condition based on their low Benthic Response Index values and high Infaunal Trophic Index values. These results indicate that the outfall discharge had an overall negligible effect on the benthic community structure within the monitoring area.

Demersal Fishes and Epibenthic Macroinvertebrates

Community measure values of the epibenthic macroinvertebrates (EMIs) and demersal fishes collected at outfall and non-outfall stations were generally comparable. Furthermore, fish communities at all stations were classified as reference condition based on their low Fish Response Index values. These results indicate that the monitoring area supports normal fish and EMI populations.

Fish Bioaccumulation

Concentrations of trace metals and chlorinated pesticides in muscle and/or liver tissues of flatfishes and rockfishes were similar between outfall and non-outfall locations. Furthermore, concentrations of these contaminants in muscle tissue of rockfishes were below federal and state human consumption guidelines. These results suggest that demersal fishes residing near the outfall are not more prone to bioaccumulation of contaminants and demonstrate there is negligible human health risk from consuming demersal fishes captured in the monitored areas.

Fish Health

The color and odor of demersal fishes appeared normal during the monitoring period. The absence of tumors, fin erosion, and skin lesions in demersal fishes showed that fishes in the monitoring area were healthy. External parasites and morphological abnormalities occurred in less than 1% of the fishes collected, which is comparable to southern California Bight background levels. These results indicate that the outfall is not an epicenter of disease.

CONCLUSION

California Ocean Plan criteria for water quality, as well as State and federal bacterial standards, were met within the monitoring area. Sediment quality was not degraded by chemical contaminants or by physical changes from the discharge of final effluent. This was supported by the absence of sediment toxicity in controlled laboratory tests, the presence of normal invertebrate and fish communities throughout the monitoring area, and no exceedances in federal and state fish consumption guidelines in rockfish samples. In summary, OCSD’s discharge of final effluent to coastal waters neither affected the marine environment nor posed a risk to human health.

CHAPTER 1
The Ocean Monitoring Program

INTRODUCTION

The Orange County Sanitation District (OCSD) operates 2 wastewater treatment facilities located in Fountain Valley (Plant 1) and Huntington Beach (Plant 2), California. OCSD discharges treated wastewater to the Pacific Ocean through a 120-in (305-cm) submarine outfall located offshore of the Santa Ana River (Figure 1-1). This discharge is regulated by the US Environmental Protection Agency (EPA), Region IX and the Regional Water Quality Control Board (RWQCB), Region 8 under the Federal Clean Water Act, the California Ocean Plan, and the RWQCB Basin Plan. Specific discharge and monitoring requirements are contained in a National Pollutant Discharge Elimination System (NPDES) permit issued jointly by the EPA and the RWQCB (Order No. R8-2012-0035, NPDES No. CA0110604) on June 15, 2012.

ENVIRONMENTAL SETTING

OCSD's ocean monitoring area is adjacent to one of the most highly urbanized areas in the United States, covering most of the San Pedro Shelf and extending off the shelf (Figure 1-1). These nearshore coastal waters receive wastes from a variety of human-related sources, such as wastewater discharges, dredged material disposal, oil and gas activities, boat/vessel discharges, urban and agricultural runoff, and atmospheric fallout. The majority of municipal and industrial sources are located between Point Dume and San Mateo Point (Figure 1-1) while discharges from the Los Angeles, San Gabriel, and Santa Ana Rivers are responsible for substantial surface water contaminant inputs to the Southern California Bight (SCB) (Schafer and Gossett 1988, SCCWRP 1992, Schiff and Tiefenthaler 2001).

The San Pedro Shelf is primarily composed of soft sediments (sands with silts and clays) and is inhabited by biological communities typical of these environments (OCSD 2004). Seafloor depths increase gradually from the shoreline to approximately 80 m (262 ft), after which it increases rapidly down to the open basin. The outfall diffuser lies at about 60 m (197 ft) depth on the shelf between the Newport and San Gabriel submarine canyons, located southeast and northwest, respectively. The area southeast of the San Pedro Shelf is characterized by a much narrower shelf and deeper water offshore (Figure 1-1).

The 120-in outfall represents one of the largest artificial reefs in this coastal region and supports communities typical of hard substrates that would not otherwise be found in the monitoring area (Lewis and McKee 1989, OCSD 2000). Together with OCSD's 78-in (198-cm) outfall, approximately 1.1×10^6 ft^2 (102,193 m^2) of seafloor was converted from a flat, sandy habitat into a raised, hard-bottom substrate.

Conditions within OCSD's monitoring area are affected by both regional- and local-scale currents. Large regional climatic and current conditions, such as El Niño and the California Current, influence

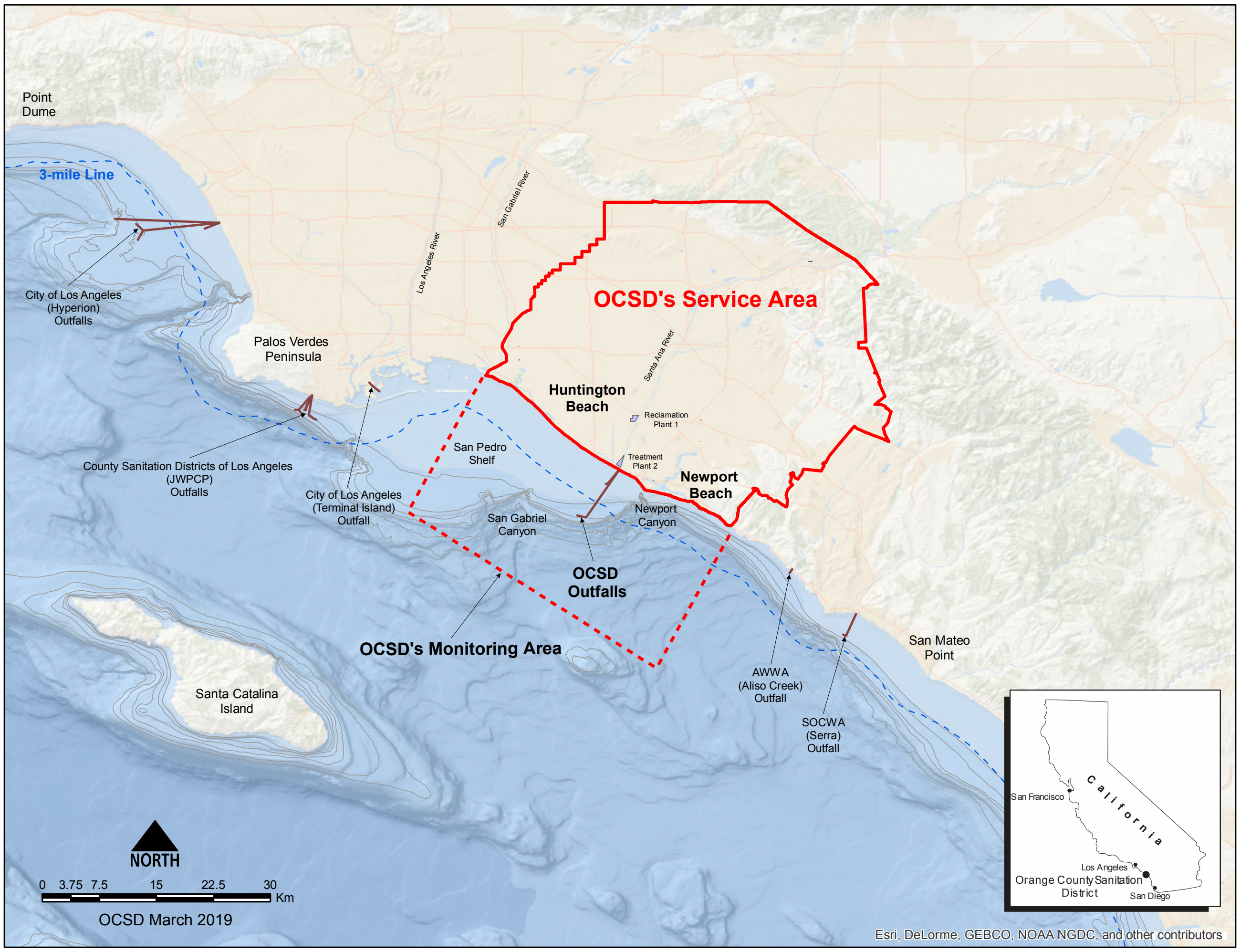

Figure 1–1 Regional setting and sampling area for OCSD's Ocean Monitoring Program.

the water characteristics and the direction of water flow along the Orange County coastline (Hood 1993). Locally, the predominant low-frequency current flows in the monitoring area are alongshore (i.e., either upcoast or downcoast) with minor across-shelf (i.e., toward the beach) transport (OCSD 1997, 1998, 2004, 2011; SAIC 2001, 2009, 2011). The specific direction of the flows varies with depth and is subject to reversals over time periods of days to weeks (SAIC 2011).

Other natural oceanographic processes, such as upwelling, coastal eddies and algal blooms, also influence the characteristics of receiving waters on the San Pedro Shelf. Tidal flows, currents, and internal waves mix and transport OCSD's wastewater discharge with coastal waters and resuspended sediments. Tidal currents in the study region are relatively weak compared to lower frequency currents, which are responsible for transporting material over long distances (OCSD 2001, 2004). Combined, these processes contribute to the variability of seawater movement observed within the monitoring area. Harmful algal blooms, while variable, have both regional and local distributions that can impact human and marine organism health (UCSC 2018, CeNCOOS 2019).

Episodic storms, drought, and climatic cycles influence environmental conditions and biological communities within the monitoring area. For example, stormwater runoff has a large influence on sediment movement in the region (Brownlie and Taylor 1981, Warrick and Millikan 2003). Major storms contribute large amounts of contaminants to the ocean and can generate waves capable of extensive shoreline erosion, sediment resuspension, and movement of sediments along the coast as well as offshore. Some of the greatest effects are produced by wet weather cycles, periods of drought, and periodic oceanographic events, such as El Niño and La Niña conditions. An understanding of the effects of the inputs from rivers and watersheds, particularly non-point source runoff, is important for evaluating spatial and temporal trends in the environmental quality of coastal areas. River flows, together with urban stormwater runoff, represent significant, episodic sources of freshwater, sediments, suspended particles, nutrients, bacteria and other contaminants to the coastal area (Hood 1993, Grant et al. 2001, Warwick et al. 2007), although some studies indicate that the spatial impact of these effects may be limited (Ahn et al. 2005, Reifel et al. 2009). While many of the materials supplied to coastal waters by rivers are essential to natural biogeochemical cycles, an excess or a deficit may have important environmental consequences. For example, in 2016-17, total rainfall for Newport Beach and annual Santa Ana River flows were nearly 1.5 times their historical averages (OCSD 2018a), which led to significant negative impacts on local beach bacteria levels (Heal the Bay 2017). For 2017-18, both annual rainfall (NCEI 2018) and Santa Ana River flows (USGS 2018) were well below historical average values (Figure 1-2A, B).

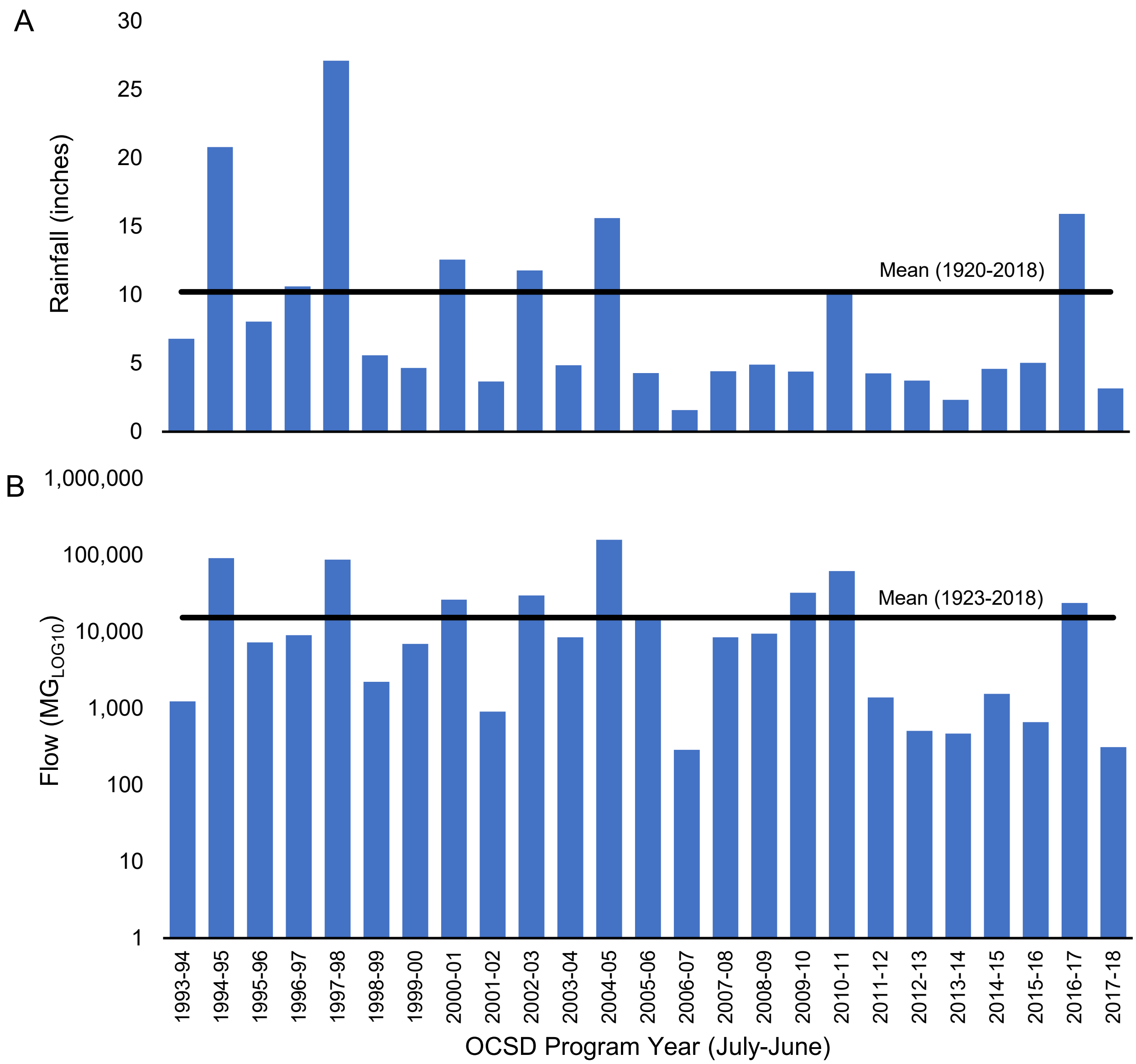

Figure 1–2 Annual Newport Harbor rainfall (A) and Santa Ana River flows (B), 1993-2018.

Beaches are a primary reason for people to visit coastal California (Kildow and Colgan 2005, NOAA 2015). Although highest visitations occur during the summer, Southern California's Mediterranean climate and convenient beach access results in significant year-round use by the public; over 250,000 beachgoers can visit the City of Newport Beach (CNB) during the typically cooler, rainier winter months of December to February (Figure 1-3A; City of Newport Beach 2018). As a result, a large percentage of the local economies rely on beach use and its associated recreational activities, which are highly dependent upon water quality conditions (Turbow and Jiang 2004, Leeworthy and Wiley 2007, Leggett et al. 2014). In 2012, Orange County's coastal economy accounted

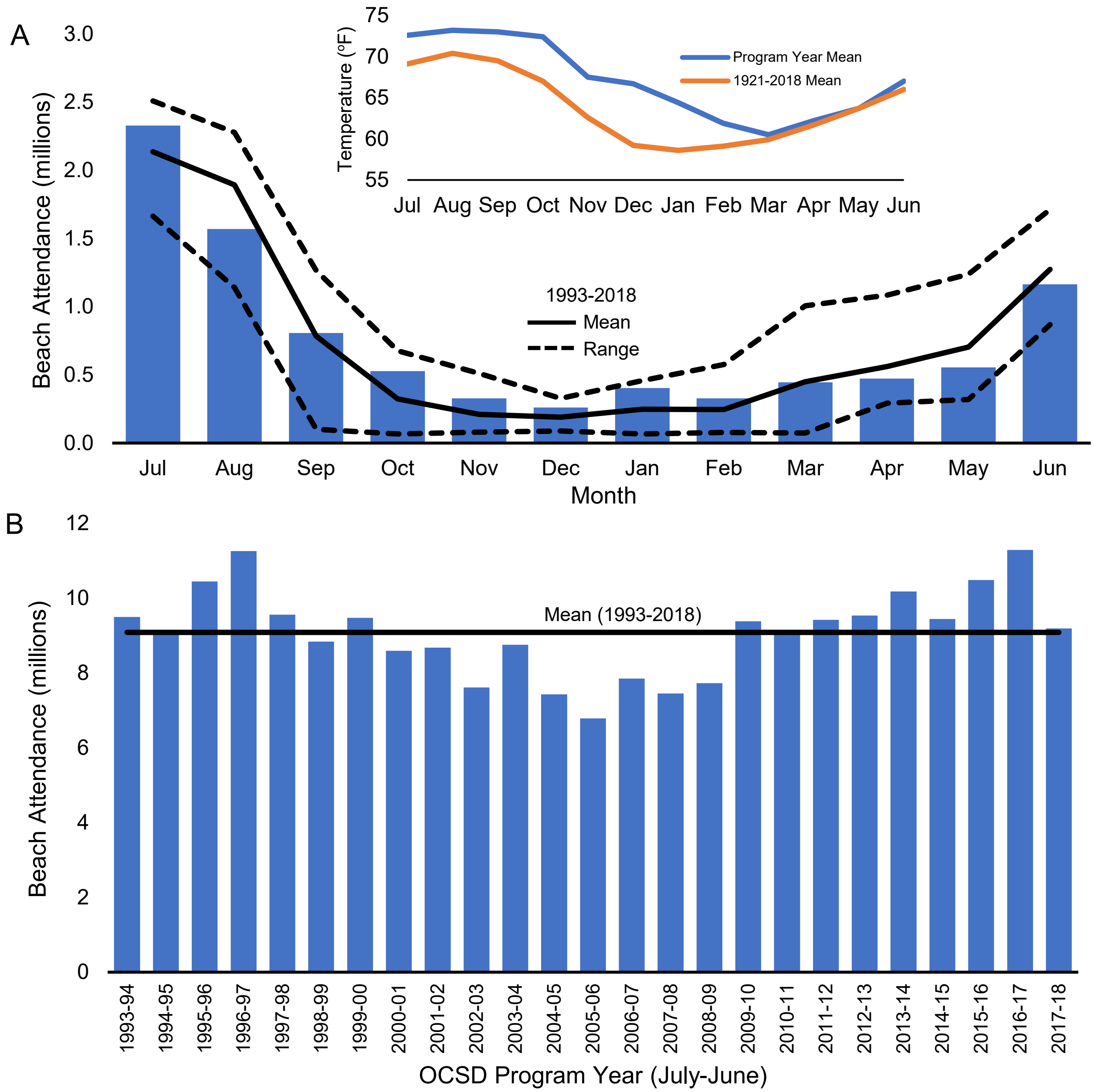

Figure 1–3 Monthly 2017-18 beach attendance and air temperature (A) and annual beach attendance (B) for the City of Newport Beach, California.

for \$3.8 billion (2%) of the County's Gross Domestic Product (NOAA 2015). It has been estimated that a single day of beach closure at Bolsa Chica State Beach would result in an economic loss of \$7.3 million (WHOI 2003).

For 2017-18, annual CNB beach attendance exceeded 9 million (Figure 1-3B; City of Newport Beach 2018). Monthly visitations ranged from 260,000 in December 2017 to over 2.3 million in July 2017 (Figure 1-3A) with monthly visitation patterns near historical averages for most of the year. Average monthly air temperatures were higher than average for much of the year (Figure 1-3A).

DESCRIPTION OF OCSD'S OPERATIONS

OCSD's mission is to safely collect, process, recycle, and dispose of treated wastewater while protecting human health and the environment in accordance with federal, state, and local laws and regulations. These objectives are achieved through extensive industrial pre-treatment (source control), secondary treatment processes, biosolids management, and water reuse programs.

OCSD's 2 wastewater treatment plants receive domestic sewage from approximately 80% of the County's 3.2 million residents and industrial wastewater from 688 permitted businesses within its service area. Under normal operations, the treated wastewater (final effluent) is discharged through a 120-in diameter ocean outfall, which extends 4.4 miles (7.1 km) from the Huntington Beach shoreline (Figure 1-1). The last 1.1 miles (1.8 km) of the outfall consists of a diffuser with 503 ports that discharge the final effluent at an approximate depth of 60 m.

Since 1999, OCSD has accepted a total of 9 billion gallons of dry-weather urban runoff from various locations in North and Central Orange County that would otherwise have entered the ocean without treatment (OCSD 2018b). The collection and treatment of dry-weather runoff, which began as a regional effort to reduce beach bacterial pollution associated with chronic dry-weather flows, has grown to include accepting diversions of high selenium flows to protect Orange County's waterways. Currently there are 21 active diversions including stormwater pump stations, the Santa Ana River, several creeks, and 3 flood control channels. For 2017-18, the monthly average daily diversion flows ranged from 0.29–1.90 million gallons per day (MGD) ($1.1–7.2{\times}10^6$ L/day) with an average daily amount of 1.66 MGD ($6.3{\times}10^6$ L/day).

OCSD has a long history of providing treated wastewater to the Orange County Water District (OCWD) for water reclamation starting with Water Factory 21 in the late 1970s. Since July 1986, 3–10 MGD ($1.1–3.8{\times}10^7$ L/day) of the final effluent has been provided to OCWD where it received further (tertiary) treatment to remove residual solids in support of the Green Acres Project (GAP). OCWD provides this water for a variety of uses including public landscape irrigation (e.g., freeways, golf courses) and for use as a saltwater intrusion barrier in the local aquifer OCWD manages. In 2007-08, OCSD began diverting additional flows to OCWD for the Groundwater Replenishment System (GWRS) totaling 35 MGD ($1.3{\times}10^8$ L/day). Over time, the average net GAP and GWRS diversions (diversions minus return flows to OCSD) increased to 44 MGD ($1.7{\times}10^8$ L/day) in 2008-09, 61 MGD ($2.3{\times}10^8$ L/day) in 2013-14, and 97 MGD ($3.7{\times}10^8$ L/day) in 2017-18 (Figure 1-4).

During 2017-18, OCSD's 2 wastewater treatment plants received and processed influent volumes averaging 185 MGD ($7.0{\times}10^8$ L/day). After diversions to the GAP and GWRS and the return of OCWD's reject flows (e.g., brines), OCSD discharged an average of 87.6 MGD ($3.3{\times}10^8$ L/day) of treated wastewater to the ocean (Figure 1-4). The year's peak flow of 134.9 MGD ($5.1{\times}10^8$ L/day) in February of 2017 was well below the historical peak of 550 MGD ($2.1{\times}10^9$ L/day) that occurred during an extreme rainfall event in the winter of 1996. Reductions in influent and effluent flows have been attributed to improved water efficiency and decreases in water use.

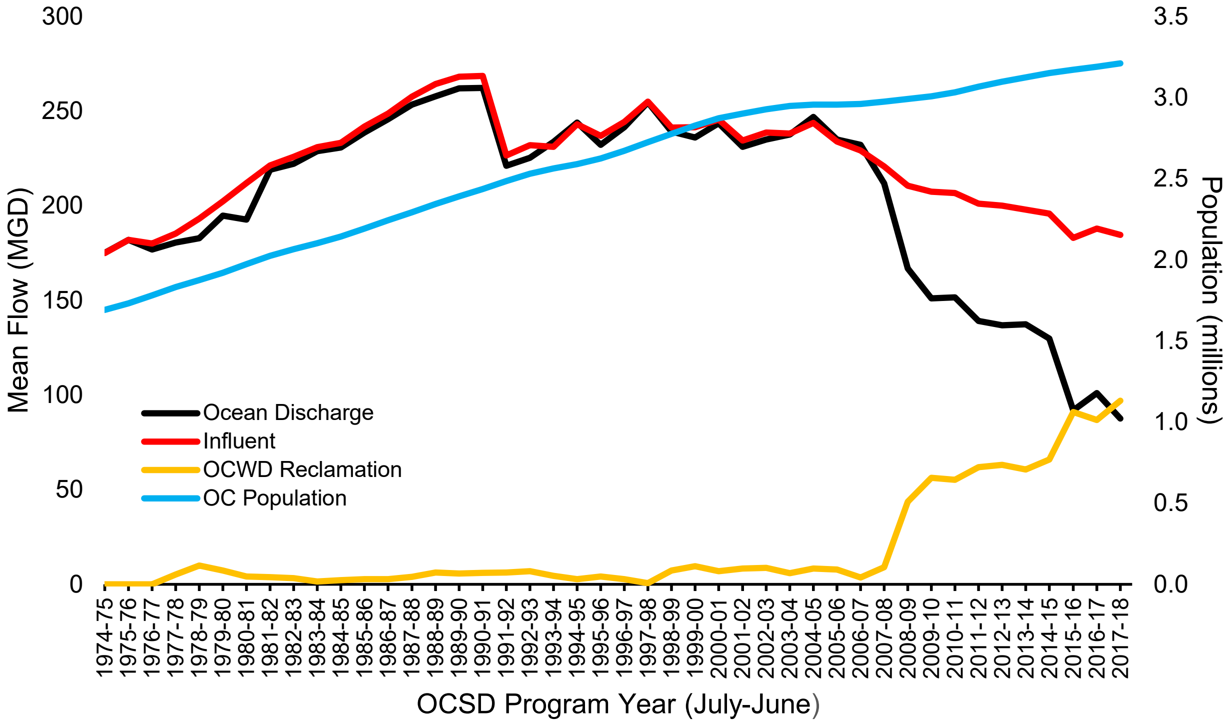

Figure 1–4 OCSD's average annual influent and ocean discharge, OCWD's reclamation, and annual population for Orange County, California, 1974-2018.

Prior to 1990, the annual wastewater discharge volumes increased faster than Orange County population growth (Figure 1-4; CDF 2018). Wastewater flows decreased in 1991-92 due to drought conditions and water conservation measures and then rose at the same rate as the population until the end of the late 1990s. Since then, influent flows have decreased. The combined effect of reduced influent and greater water reclamation flows have dramatically reduced ocean discharge flows.

REGULATORY SETTING FOR THE OCEAN MONITORING PROGRAM

OCSD's NPDES permit includes requirements to monitor influent, effluent, and the receiving water. Effluent flows, constituent concentrations, and toxicity are monitored to determine compliance with permit limits and to provide data for interpreting changes to receiving water conditions. Wastewater impacts to coastal receiving waters are evaluated by OCSD's Ocean Monitoring Program (OMP) based on 3 inter-related components: (1) Core monitoring; (2) Strategic Process Studies (SPS); and (3) Regional monitoring. In addition, OCSD conducts special studies not required under the existing NPDES permit. Information obtained from each of these program components is used to further the understanding of the coastal ocean environment and improve interpretations of the monitoring data. These program elements are summarized below.

The Core monitoring program was designed to measure compliance with permit conditions and for temporal trend analysis. Four major components comprise the program: (1) coastal oceanography and water quality, (2) sediment quality, (3) benthic infaunal community health, and (4) demersal fish and epibenthic macroinvertebrate community assessments, which include fish health and bioaccumulation assessments.

OCSD conducts SPS, as well as other smaller special studies, to provide information about relevant coastal and ecotoxicological processes that are not addressed by Core monitoring. Recent studies have included contributions to the development of ocean circulation and biogeochemical models and fish tracking.

Since 1994, OCSD has participated in 6 regional monitoring studies of environmental conditions within the SCB: 1994 Southern California Bight Pilot Project, Bight'98, Bight'03, Bight'08, Bight'13, and Bight'18. OCSD plays an integral role in these regional projects by leading many of the program design decisions and conducting field sampling, sample analysis, data analysis, and reporting. Results from these efforts provide information that is used by individual dischargers, local, state, and federal resource managers, researchers, and the public to improve understanding of regional environmental conditions. This provides a larger-scale perspective for comparisons with data collected from local, individual point sources. Program documents and reports can be found at the Southern California Coastal Water Research Project's (SCCWRP) website (http://sccwrp.org).

Other collaborative regional monitoring efforts include:

- Participation in the Southern California Bight Regional Water Quality Program (previously known as Central Bight Water Quality Program), a water quality sampling effort with the City of Oxnard, the City of Los Angeles, the County Sanitation Districts of Los Angeles, and the City of San Diego.
- Develop projects to analyze historical data from large publicly owned treatment works (POTWs).
- Supporting and working with the Southern California Coastal Ocean Observing System to upgrade sensors on the Newport Pier Automated Shore Station (http://www.sccoos.org/data/autoss).
- Partnering with the Orange County Health Care Agency and other local POTWs to conduct regional nearshore (aka surfzone) bacterial monitoring used to determine the need for beach postings and/or closure.
- Collaborating on a regional aerial kelp monitoring program.

The complexities of the environmental setting and related difficulties in assigning a cause or source to a pollution event are the rationale for OCSD's extensive OMP. The program has contributed substantially to the understanding of water quality and environmental conditions along Orange County beaches and coastal ocean reach. The large amount of data collected provides a broad understanding of both natural and anthropogenic processes that affect coastal oceanography and marine biology, including the near-coastal ocean ecosystem and its related beneficial uses.

This report presents OMP compliance determinations for data collected from July 2017 through June 2018. Compliance determinations were made by comparing OMP findings to the criteria specified in OCSD's NPDES permit. Any related special studies or regional monitoring efforts are also documented.

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CHAPTER 2
Compliance Determinations

INTRODUCTION

This chapter provides compliance results for the 2017-18 monitoring year for the Orange County Sanitation District's (OCSD) Ocean Monitoring Program (OMP). The program includes sample collection, analysis, and data interpretation to evaluate potential impacts of treated wastewater discharge on the following receiving water characteristics:

- Bacterial
- Physical
- Chemical
- Biological
- Radioactivity

Each of these characteristics have specific criteria (Table 2-1) for which permit compliance must be determined each monitoring year based on the Federal Clean Water Act, the California Ocean Plan (COP), and the Regional Water Quality Control Board Basin Plan.

The Core OMP sampling locations include 28 offshore water quality stations, 68 benthic stations to assess sediment chemistry and bottom-dwelling communities, 14 trawl stations to evaluate demersal fish and macroinvertebrate communities, and 2 rig-fishing zones for assessing human health risk from the consumption of sport fishes (Figures 2-1, 2-2, and 2-3). Monitoring frequencies varied by component and ranged from 2–5 days per week for nearshore (also called surfzone) water quality to annual assessments of fish health and tissue analyses.

WATER QUALITY

Offshore bacteria

For all 3 fecal indicator bacteria (FIB), over 99% of the samples were below their 30-day geomean values (1,000, 200, and 35 MPN/100 mL for total coliform, fecal coliform and enterococci, respectively) with the majority (61-91%) below detection (<10 MPN). The highest density observed for any single sample at any single depth for total coliforms, fecal coliforms, and enterococci was 2613, 493, and 75 MPN/100 mL, respectively. As a result, the majority of the depth-averaged values used for water contact compliance were below detection (Tables B-1, B-2, and B-3). Compliance for all 3 FIB was achieved 100% for both state and federal criteria, indicating no impact of bacteria to offshore receiving waters.

Floating Particulates and Oil and Grease

There were no observations of oil and grease or floating particles of sewage origin at any inshore (Zone A) or offshore (Zone B) station in 2017-18 (Tables B-4 and B-5). Therefore, compliance was achieved.

Table 2–1 Listing of compliance criteria from OCSD's NPDES permit (Order No. R8-2012-0035, NPDES No. CA0110604) and compliance status for each criterion for 2017-18. N/A = Not Applicable.

Criteria	Criteria Met
Bacterial Characteristics	
V.A.1.a. For the Ocean Plan Water-Contact Standards, total coliform density shall not exceed a 30-day Geometric Mean of 1,000 per 100 mL nor a single sample maximum of 10,000 per 100 mL. The total coliform density shall not exceed 1,000 per 100 mL when the single sample maximum fecal coliform/total coliform ratio exceeds 0.1.	Yes
V.A.1.a. For the Ocean Plan Water-Contact Standards, fecal coliform density shall not exceed a 30-day Geometric Mean of 200 per 100 mL nor a single sample maximum of 400 per 100 mL.	Yes
V.A.1.a. For the Ocean Plan Water-Contact Standards, *Enterococcus* density shall not exceed a 30-day Geometric Mean of 35 per 100 mL nor a single sample maximum of 104 per 100 mL.	Yes
V.A.1.b. For the USEPA Primary Recreation Criteria in Federal Waters, *Enterococcus* density shall not exceed a 30 day Geometric Mean (per 100 mL) of 35 nor a single sample maximum (per 100 mL) of 104 for designated bathing beach, 158 for moderate use, 276 for light use, and 501 for infrequent use.	Yes
V.A.1.c. For the Ocean Plan Shellfish Harvesting Standards, the median total coliform density shall not exceed 70 per 100 mL, and not more than 10 percent of the samples shall exceed 230 per 100 mL.	N/A
Physical Characteristics	
V.A.2.a. Floating particulates and grease and oil shall not be visible.	Yes
V.A.2.b. The discharge of waste shall not cause aesthetically undesirable discoloration of the ocean surface.	Yes
V.A.2.c. Natural light shall not be significantly reduced at any point outside the initial dilution zone as a result of the discharge of waste.	Yes
V.A.2.d. The rate of deposition of inert solids and the characteristics of inert solids in ocean sediments shall not be changed such that benthic communities are degraded.	Yes
Chemical Characteristics	
V.A.3.a. The dissolved oxygen concentration shall not at any time be depressed more than 10 percent from that which occurs naturally, as the result of the discharge of oxygen demanding waste materials.	Yes
V.A.3.b. The pH shall not be changed at any time more than 0.2 units from that which occurs naturally.	Yes
V.A.3.c. The dissolved sulfide concentration of waters in and near sediments shall not be significantly increased above that present under natural conditions.	Yes
V.A.3.d. The concentration of substances, set forth in Chapter II, Table 1 (formerly Table B) of the Ocean Plan, in marine sediments shall not be increased to levels which would degrade indigenous biota.	Yes
V.A.3.e. The concentration of organic materials in marine sediments shall not be increased to levels which would degrade marine life.	Yes
V.A.3.f. Nutrient materials shall not cause objectionable aquatic growths or degrade indigenous biota.	Yes
V.A.3.g. The concentrations of substances, set forth in Chapter II, Table 1 (formerly Table B) of the Ocean Plan, shall not be exceeded in the area within the waste field where initial dilution is completed.	Yes
Biological Characteristics	
V.A.4.a. Marine communities, including vertebrate, invertebrate, and plant species, shall not be degraded.	Yes
V.A.4.b. The natural taste, odor, and color of fish, shellfish, or other marine resources used for human consumption shall not be altered.	Yes
V.A.4.c. The concentration of organic materials in fish, shellfish, or other marine resources used for human consumption shall not bioaccumulate to levels that are harmful to human health.	Yes
V.A.5. Discharge of radioactive waste shall not degrade marine life.	Yes

Ocean Discoloration and Transparency

The water clarity standards were met, on average, 100% and 97% of the time for Zone A and B station groups, respectively (Table 2-2). Overall compliance was met 98% of the time for all stations combined. Compliance was essentially the same as the previous year's value of 97.7% and was well within the annual ranges since 1985, ranking 12 of 33 since 1985 (Figure 2-4). All light transmissivity values (Table B-6) were within natural ranges of variability to which marine organisms are exposed (OCSD 1996a). Hence, there were no impacts from the treated wastewater discharge relative to ocean discoloration at any offshore station.

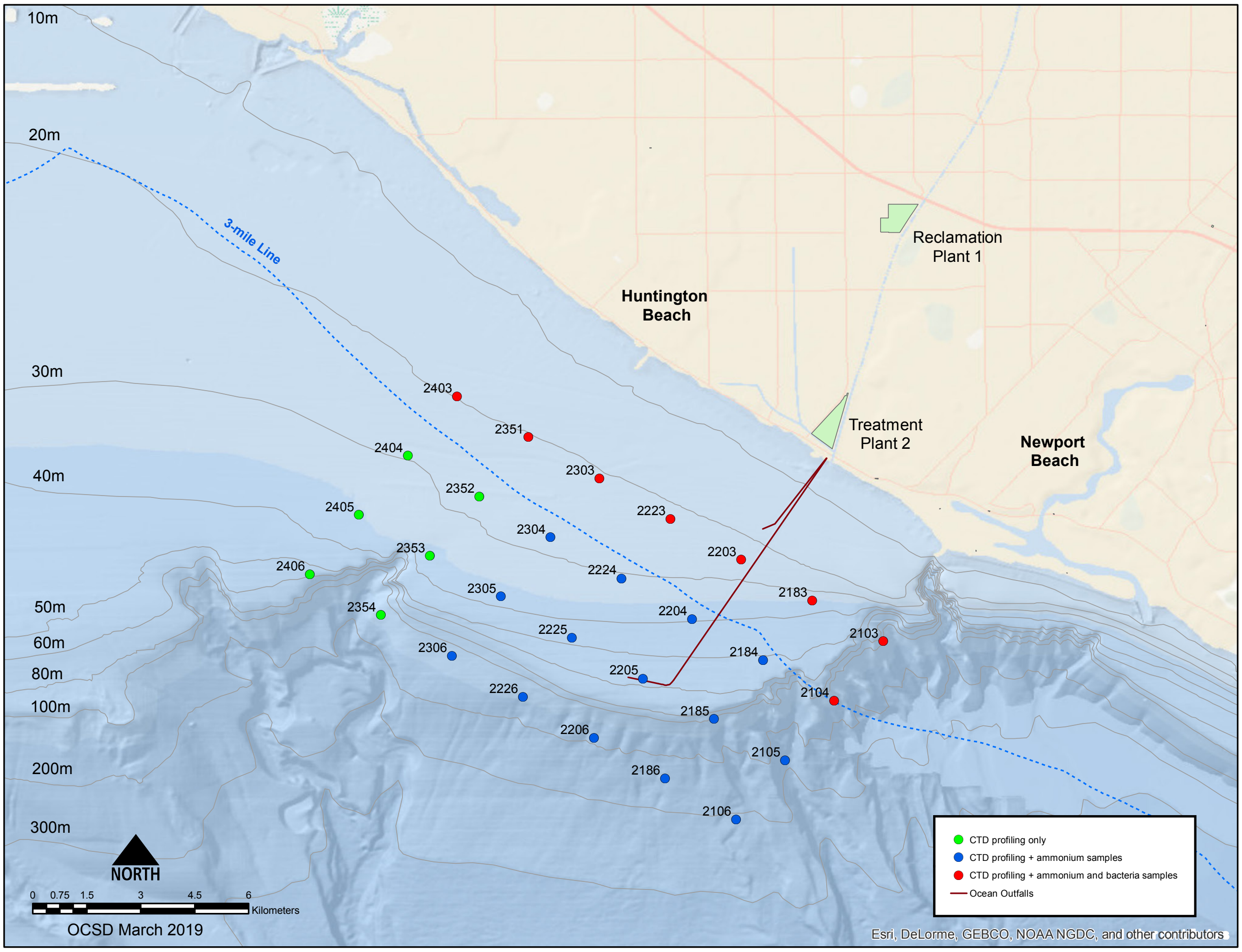

Figure 2–1 Offshore water quality monitoring stations for 2017-18.

Dissolved Oxygen (DO)

In 2017-18, compliance was met, on average, 96.0% for both Zone A and B station groups and for all stations combined (Table 2-2). This represents a decrease in compliance of 1.7% from the 2016-17 monitoring year and rank 24 since 1985 (Figure 2-4). The DO values (Table B-6) were well within the range of long-term monitoring results (OCSD 1996b, 2004). Thus, it was determined that there were no environmentally significant effects to DO from the treated wastewater discharge.

Acidity (pH)

Compliance was met 99% for both zones, separately and combined (Table 2-2; Figure 2-4). There were no environmentally significant effects to pH from the treated wastewater discharge as the measured values (Table B-6) were within the range to which marine organisms are naturally exposed.

Nutrients (Ammonium)

During 2017-18, over 87% of the samples (n=2,572) were below the Reporting Limit (0.02 mg/L). Detectable ammonium concentrations, including estimated values, ranged from 0.011 to 0.198 mg/L (Table B-6). Plume-related changes in ammonium were not considered environmentally significant as maximum values were 20 times less than the chronic (4 mg/L) and 30 times less than the acute (6 mg/L) toxicity standards of the COP (SWRCB 2012). In addition, there were no detectable plankton-associated impacts (i.e., excessive plankton blooms caused by the discharge).

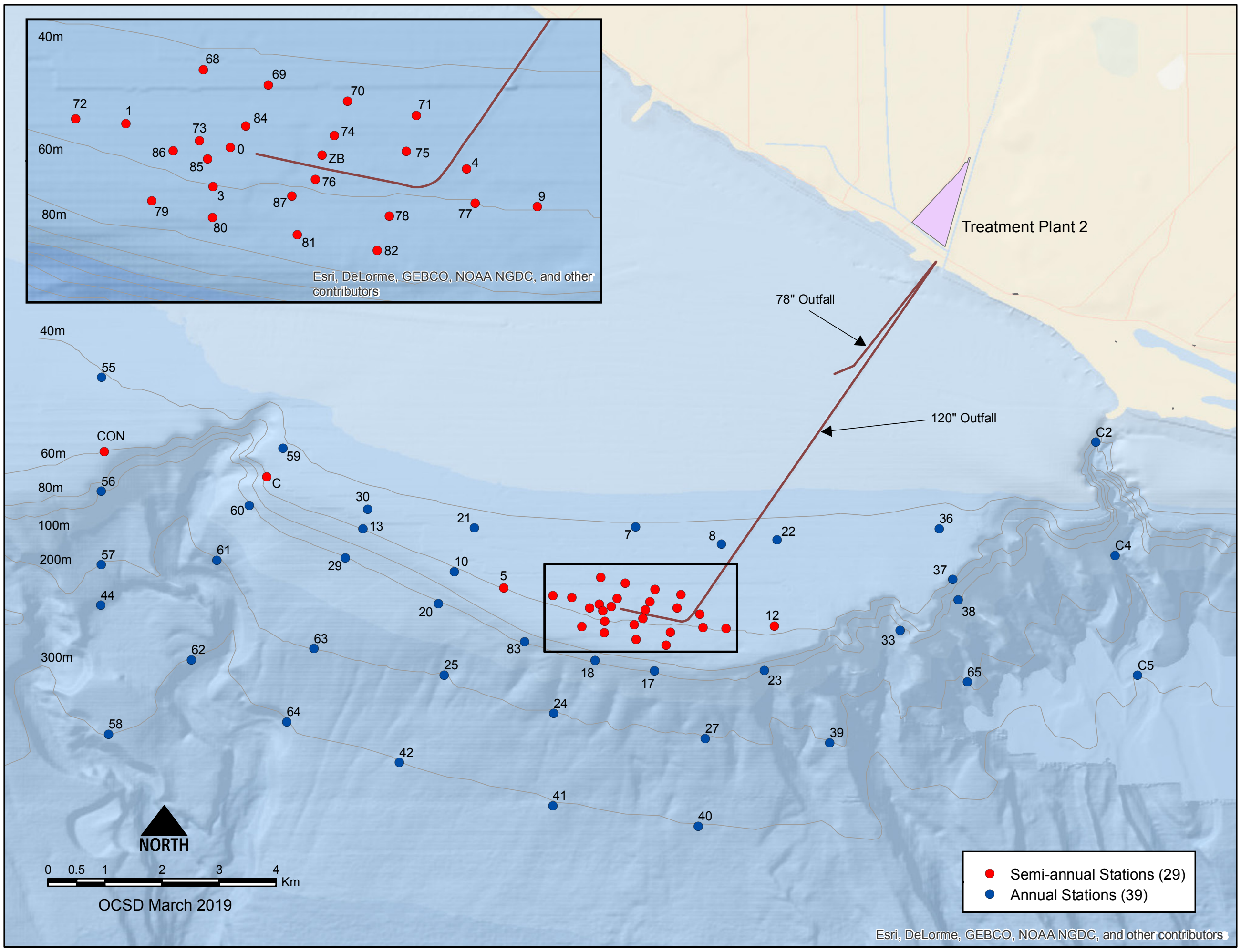

Figure 2–2 Benthic (sediment geochemistry and infauna) monitoring stations for 2017-18.

COP Water Quality Objectives

OCSD's NPDES permit contains 8 constituents from Table 1 (formerly Table B) of the COP that have effluent limitations (see Table 9 of the permit). During the period from July 2017 through June 2018, none of these constituents exceeded their respective effluent limitations, so receiving water compliance was met.

Radioactivity

Pursuant to OCSD's NPDES permit, OCSD measures the influent and the effluent for radioactivity but not the receiving waters. The results of the influent and the effluent analyses during 2017-18 indicated that both state and federal standards were consistently met and are published in OCSD's Discharge Monitoring Reports. As fish and invertebrate communities are diverse and healthy, compliance was met.

Overall Results

Overall, results from OCSD's 2017-18 water quality monitoring program detected minor changes in measured water quality parameters related to the discharge of treated wastewater to the coastal ocean. This is consistent with previously reported results (e.g., OCSD 2017). Plume-related changes in temperature, salinity, DO, pH, and transmissivity were measurable beyond the initial mixing zone during some surveys. This usually extended only into the nearfield stations, typically <2 km

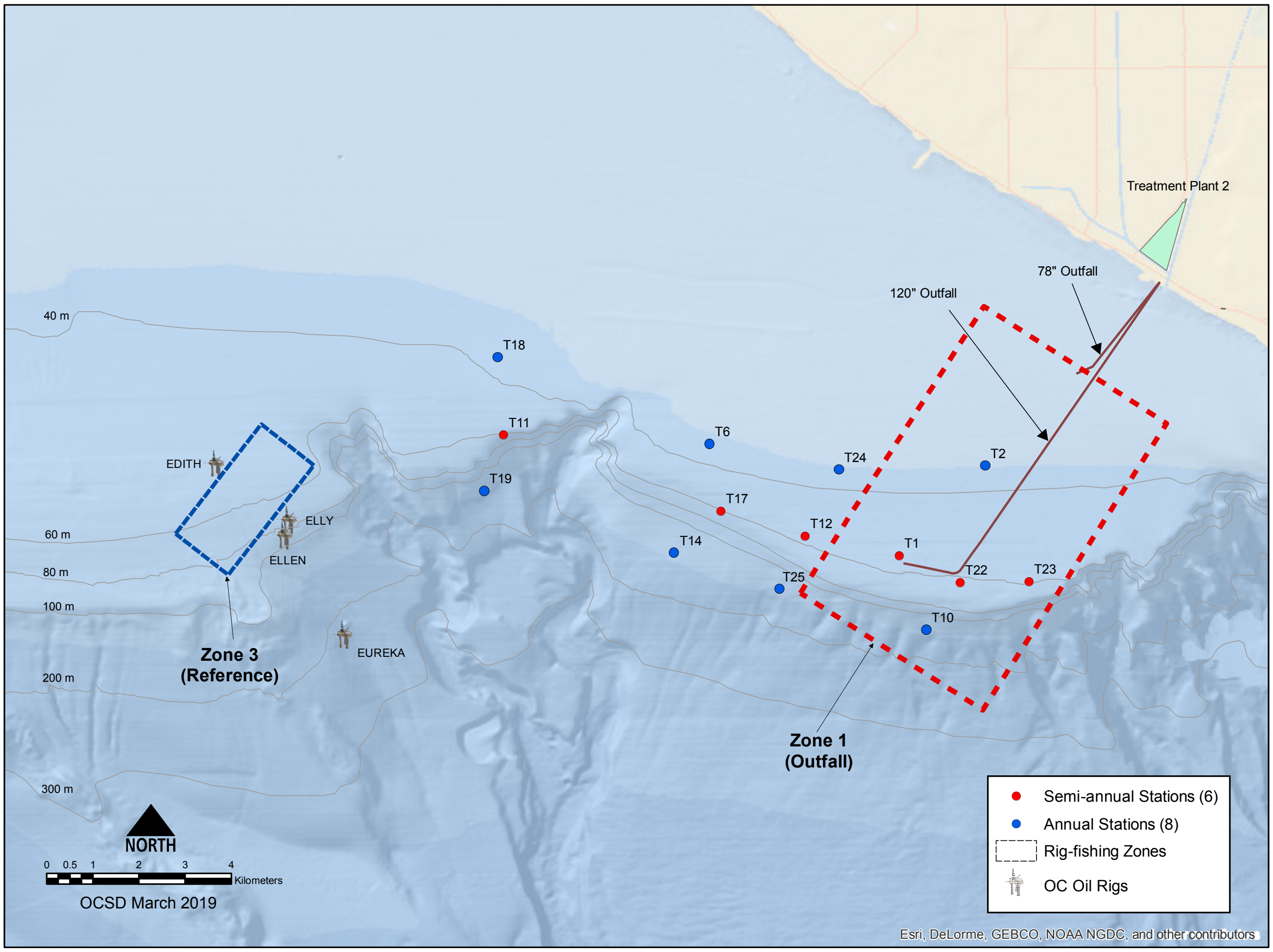

Figure 2–3 Trawl monitoring stations, as well as rig-fishing locations, for 2017-18.

away from the outfall, consistent with past findings. None of these changes were determined to be environmentally significant since they fell within natural ranges to which marine organisms are exposed (OCSD 1996a, 2004; Wilber and Clarke 2001, Chavez et al. 2002, Jarvis et al. 2004, Allen et al. 2005, Hsieh et al. 2005). Overall, the public health risks and measured environmental effects to the receiving water continue to be small. All values were within the ranges of natural variability for the study area and reflected seasonal and yearly changes of large-scale regional influences. The limited observable plume effects occurred primarily at depth, even during the winter

Table 2–2 Summary of offshore water quality compliance testing results for dissolved oxygen, pH, and light transmissivity for 2017-18.

Parameter	Number of Observations	Number of Out-of-Range Occurrences	Percent Out-of-Range Occurrences	Number Out-of-Compliance	Percent Out-of-Compliance
Zone A Stations (Inshore Station Group)					
Dissolved Oxygen	471	49	10%	19	4%
pH	471	33	7%	5	1%
Light Transmissivity	471	144	31%	0	0%
Zone B Stations (Offshore Station Group)					
Dissolved Oxygen	455	45	10%	17	4%
pH	455	10	2%	4	1%
Light Transmissivity	455	76	17%	15	3%
Zone A and Zone B Stations Combined					
Dissolved Oxygen	926	94	10%	36	4%
pH	926	43	5%	9	1%
Light Transmissivity	926	220	24%	15	2%

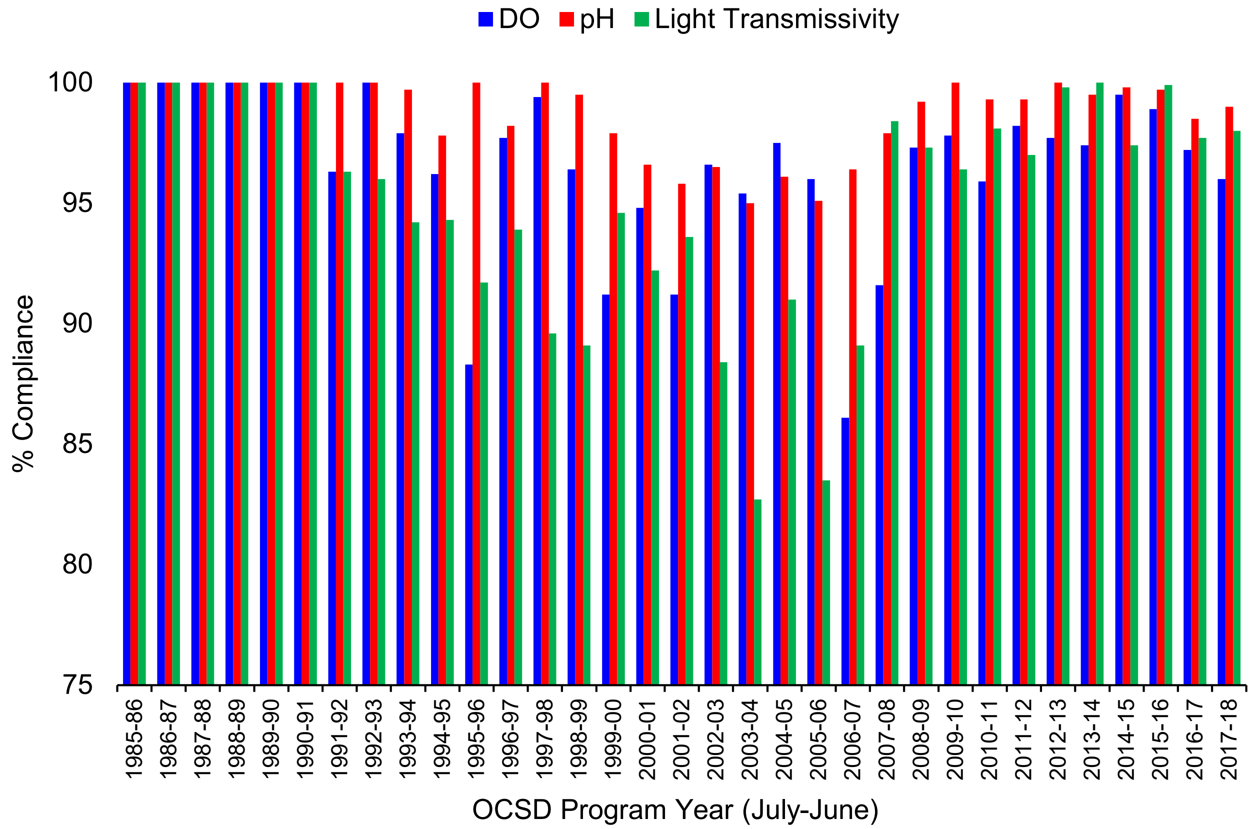

Figure 2–4 Summary of mean percent compliance for dissolved oxygen (DO), pH, and light transmissivity for all compliance stations compared to reference stations, 1985-2018.

when stratification was weakest. In summary, OMP staff concluded that the discharge in 2017-18 did not greatly affect the receiving water environment and that beneficial uses were protected and maintained.

SEDIMENT GEOCHEMISTRY

The mean concentration of most chemical contaminants and metals in 2017-18 were highest in the Upper Slope/Canyon stratum as in previous years (Tables 2-3 and 2-4; OCSD 2016, 2017, 2018). Nearly all chemical contaminant concentrations were well below the Effects Range-Median (ERM) guidelines of biological concern (Tables 2-3, 2-4, 2-5, and 2-6; Long et al. 1995). The single dichlorodiphenyltrichloroethane (DDT) exceedance in the winter survey was not cause for concern as the measured concentration is within historical ranges (OCSD 2010, 2013) and DDT itself is a known legacy contaminant with the Southern California Bight (Schiff 2000). In addition, there was no measurable sediment toxicity at any of the 9 stations monitored in the winter (Table 2-7). As a result, we conclude that compliance was met.

BIOLOGICAL COMMUNITIES

Infaunal Communities

A total of 697 invertebrate taxa comprising 33,266 individuals were collected in the 2017-18 monitoring year. As with previous years (OCSD 2017, 2018), there were noticeable declines in the mean species number (richness) and mean abundance of infauna at stations deeper than 120 m (Table 2-8) and

Table 2–3 Physical properties and chemical contaminant concentrations of sediment samples collected at each semi-annual and annual (*) station in Summer 2017 compared to Effects Range-Median (ERM) and regional values. ND = Not Detected; N/A = Not Applicable.

Station	Depth (m)	Median Phi (ϕ)	Fines (%)	TOC (%)	Sulfides (mg/kg)	Total P (mg/kg)	Total N (mg/kg)	ΣPAH (mg/kg)	ΣDDT (mg/kg)	ΣPest (mg/kg)	ΣPCB (mg/kg)
Middle Shelf Zone 1 (31-50 m)											
7 *	41	3.57	17.1	0.42	2.43	990	390	45.5	2.17	3.99	3.30
8 *	44	3.56	17.4	0.38	7.87	950	390	37.2	4.75	ND	0.86
21 *	44	3.44	16.5	0.40	4.19	1000	390	42.7	11.31	ND	0.40
22 *	45	3.67	20.9	0.38	3.98	1000	380	39.7	2.06	ND	0.19
30 *	46	3.46	18.2	0.39	4.33	1000	440	44.3	22.35	ND	ND
36 *	45	3.28	14.1	0.38	3.09	840	350	40.5	2.36	ND	1.11
55 *	40	2.57	3.2	0.17	1.74	600	210	12.3	ND	ND	ND
59 *	40	2.94	10.2	0.37	1.78	930	410	30.6	ND	ND	ND
	Mean	**3.31**	**14.7**	**0.36**	**3.68**	**914**	**370**	**36.6**	**5.62**	**0.50**	**0.73**
Middle Shelf Zone 2, Within-ZID (51-90 m)											
0	56	3.12	14.6	0.55	5.01	1700	610	344.6	ND	ND	24.75
4	56	3.04	10.8	0.37	2.15	860	520	49.9	ND	ND	0.94
76	58	3.19	12.7	0.34	3.51	1000	340	27.9	ND	2.08	3.50
ZB	56	3.12	9.0	0.38	6.90	970	420	351.8	ND	ND	1.59
	Mean	**3.12**	**11.8**	**0.41**	**4.39**	**1132**	**472**	**193.6**	**ND**	**0.52**	**7.70**
Middle Shelf Zone 2, Non-ZID (51-90 m)											
1	56	3.39	15.0	0.37	2.30	1000	470	56.8	5.52	ND	1.50
3	60	3.14	7.3	0.35	4.26	890	390	240.4	ND	ND	2.73
5	59	3.54	16.7	0.39	1.87	980	500	257.3	ND	ND	0.70
9	59	3.06	12.7	0.35	3.14	910	450	35.1	ND	6.48	ND
10 *	62	3.56	12.7	0.39	3.71	950	370	36.8	ND	ND	3.03
12	58	3.12	16.5	0.33	1.18	800	430	21.8	ND	ND	ND
13 *	59	3.57	17.6	0.39	ND	890	380	59.0	2.89	ND	0.22
37 *	56	2.55	7.5	0.35	10.10	530	480	41.6	ND	ND	ND
68	52	3.39	13.7	0.41	2.64	970	470	40.0	1.94	ND	ND
69	52	3.38	15.5	0.38	4.07	950	520	42.3	ND	ND	ND
70	52	3.22	12.5	0.39	5.29	930	450	31.5	ND	ND	0.52
71	52	3.16	12.8	0.40	2.58	860	350	29.7	1.78	ND	0.30
72	55	3.34	12.8	0.35	3.01	990	380	65.4	ND	ND	1.55
73	55	3.05	7.2	0.42	6.95	1200	420	60.5	2.65	ND	65.39
74	57	3.27	16.5	0.33	2.28	950	450	39.8	ND	ND	ND
75	60	3.07	10.4	0.39	3.85	850	390	210.2	ND	ND	ND
77	60	3.05	9.1	0.38	3.79	1100	390	43.1	ND	ND	ND
78	63	3.12	12.4	0.39	3.28	1100	340	25.5	ND	ND	1.01
79	65	3.28	11.2	0.34	2.82	910	420	39.4	ND	ND	1.17
80	65	3.36	15.2	0.39	3.87	890	370	44.8	ND	ND	1.35
81	65	3.21	10.8	0.35	4.04	940	330	29.6	ND	ND	0.38
82	65	3.18	12.4	0.36	4.79	850	400	25.9	ND	ND	1.25
84	54	3.11	13.3	0.42	5.94	1000	510	155.5	ND	ND	6.98
85	57	3.18	12.3	0.44	9.70	1200	480	261.4	ND	ND	13.19
86	57	3.17	12.5	0.39	7.02	1000	420	284.7	ND	ND	8.29
87	60	3.21	12.2	0.36	4.17	930	410	46.1	ND	ND	0.97
C	56	3.15	11.5	0.33	6.23	910	380	38.9	ND	ND	ND
C2 *	56	5.41	61.6	2.70	33.70	1000	1200	488.8	6.86	ND	70.39
CON	59	3.23	12.2	0.42	7.07	990	420	46.8	2.26	ND	0.43
	Mean	**3.29**	**14.3**	**0.46**	**5.49**	**947**	**447**	**96.5**	**0.82**	**0.22**	**6.25**
Middle Shelf Zone 3 (91-120 m)											
17 *	91	3.11	9.1	0.45	2.58	810	400	19.0	1.77	ND	0.19
18 *	91	3.25	11.4	0.45	ND	860	390	23.1	ND	ND	0.25
20 *	100	3.76	18.5	0.47	6.07	890	460	40.9	2.57	ND	3.67
23 *	100	3.22	15.2	0.38	2.81	830	380	24.6	ND	ND	ND
29 *	100	3.89	22.2	0.56	5.15	950	550	67.2	2.49	ND	3.17
33 *	100	2.57	11.7	0.44	6.33	640	300	25.5	ND	ND	ND
38 *	100	3.52	15.1	0.54	11.20	660	320	80.0	ND	ND	0.33
56 *	100	3.54	17.1	0.51	4.48	990	490	57.0	3.46	ND	3.92
60 *	100	3.92	24.6	0.76	8.09	1000	680	68.9	4.08	ND	2.26
83 *	100	3.38	11.0	0.48	7.49	810	480	31.3	ND	ND	0.90
	Mean	**3.42**	**15.6**	**0.50**	**6.02**	**844**	**445**	**43.8**	**1.44**	**ND**	**1.47**
Outer Shelf (121-200 m)											
24 *	200	4.59	41.7	0.91	4.97	900	790	69.8	7.63	ND	3.02
25 *	200	4.86	48.5	1.16	11.00	850	1100	108.9	8.95	ND	5.85
27 *	200	3.88	26.4	0.75	3.34	970	760	50.4	4.04	ND	1.52
39 *	200	4.66	24.5	0.66	1.79	820	620	73.9	ND	ND	ND
57 *	200	5.36	59.7	1.74	44.40	870	1600	175.5	6.22	ND	11.59
61 *	200	4.78	46.8	1.26	15.70	940	1100	72.4	ND	ND	ND
63 *	200	4.55	40.7	1.01	7.45	920	810	75.2	3.63	ND	1.09
65 *	200	4.43	39.8	0.95	11.10	980	960	70.7	2.10	ND	ND
C4 *	187	5.31	59.5	1.71	23.30	930	1300	272.3	5.99	ND	4.98
	Mean	**4.71**	**43.1**	**1.13**	**13.67**	**909**	**1004**	**107.7**	**4.28**	**ND**	**3.12**

Table 2–3 continues.

Table 2–3 continued.

Station	Depth (m)	Median Phi (ϕ)	Fines (%)	TOC (%)	Sulfides (mg/kg)	Total P (mg/kg)	Total N (mg/kg)	ΣPAH (mg/kg)	ΣDDT (mg/kg)	ΣPest (mg/kg)	ΣPCB (mg/kg)
Upper Slope/Canyon (201-500 m)											
40 *	303	2.19	44.7	1.24	3.17	880	1100	65.9	2.43	ND	0.24
41 *	303	4.74	46.0	1.49	3.83	880	1300	97.3	3.22	ND	0.47
42 *	303	5.48	62.2	1.70	8.13	850	1500	112.9	2.58	ND	0.50
44 *	241	5.67	66.4	2.16	21.60	910	1500	194.6	1.90	ND	1.87
58 *	300	5.74	67.9	2.19	10.30	880	1400	168.5	14.73	ND	6.68
62 *	300	5.58	64.7	2.23	36.90	800	1900	160.0	5.32	ND	4.19
64 *	300	5.51	62.2	1.00	23.10	900	460	58.3	3.65	ND	3.69
C5 *	296	5.76	70.8	2.50	44.60	1000	2300	162.9	4.43	ND	3.12
	Mean	**5.08**	**60.6**	**1.81**	**18.95**	**888**	**1432**	**127.6**	**4.78**	**ND**	**2.60**
Sediment quality guidelines											
ERM		N/A	N/A	N/A	N/A	N/A	N/A	44792.0	46.10	N/A	180.00
Regional summer values (area weighted mean)											
Bight'13 Middle Shelf		N/A	48.0	0.70	N/A	N/A	N/A	55.0	18.00	N/A	2.70
Bight'13 Outer Shelf		N/A	49.0	0.93	N/A	N/A	N/A	92.0	79.00	N/A	4.50
Bight'13 Upper Slope		N/A	75.0	1.90	N/A	N/A	N/A	160.0	490.00	N/A	15.00

Table 2–4 Metal concentrations (mg/kg) in sediment samples collected at each semi-annual and annual (*) station in Summer 2017 compared to Effects Range-Median (ERM) and regional values. ND = Not Detected; N/A = Not Applicable.

Station	Depth (m)	Sb	As	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Zn
Middle Shelf Zone 1 (31-50 m)														
7 *	41	ND	3.54	49.1	0.19	0.12	17.70	8.35	6.98	0.02	8.9	1.26	0.11	37.2
8 *	44	ND	3.50	51.8	0.17	0.16	18.30	8.15	6.85	0.03	9.0	1.35	0.10	39.9
21 *	44	ND	4.06	45.9	0.18	0.10	18.80	8.11	7.27	0.02	8.5	1.55	0.10	40.7
22 *	45	ND	3.93	48.3	0.18	0.13	18.70	8.05	7.17	0.02	9.2	1.47	0.09	42.1
30 *	46	ND	4.12	38.3	0.17	0.10	18.30	7.22	6.67	0.01	8.0	1.06	0.09	36.5
36 *	45	ND	4.41	49.9	0.19	0.13	16.50	7.50	7.10	0.02	8.9	1.20	0.05	40.7
55 *	40	ND	2.33	30.1	0.13	0.04	12.50	3.87	3.81	0.01	6.3	0.66	0.02	24.2
59 *	40	ND	3.08	35.2	0.14	0.06	14.90	5.50	5.21	0.01	7.1	1.14	0.06	30.7
	Mean	**ND**	**3.62**	**43.6**	**0.17**	**0.10**	**16.96**	**7.09**	**6.38**	**0.02**	**8.2**	**1.21**	**0.08**	**36.5**
Middle Shelf Zone 2, Within-ZID (51-90 m)														
0	56	0.69	4.48	60.0	0.21	0.27	41.30	15.00	71.2	0.04	9.5	0.89	0.17	50.8
4	56	ND	3.78	36.9	0.20	0.13	19.20	7.96	5.82	0.01	8.8	1.57	0.06	40.4
76	58	ND	3.40	40.9	0.21	0.14	19.10	8.64	4.98	0.01	8.8	1.49	0.10	41.7
ZB	56	ND	3.00	35.6	0.21	0.23	18.00	8.42	5.33	0.02	8.4	1.70	0.10	42.7
	Mean	**0.17**	**3.66**	**43.4**	**0.21**	**0.19**	**24.40**	**10.00**	**21.83**	**0.02**	**8.9**	**1.41**	**0.11**	**43.9**
Middle Shelf Zone 2, Non-ZID (51-90 m)														
1	56	ND	3.20	39.4	0.20	0.19	19.70	9.38	6.19	0.02	9.0	1.33	0.14	40.2
3	60	ND	2.89	38.2	0.20	0.12	19.40	8.76	5.58	0.02	8.9	1.28	0.12	43.9
5	59	ND	2.89	49.1	0.23	0.17	20.70	10.10	6.59	0.02	10.0	1.36	0.15	45.5
9	59	ND	3.40	36.1	0.21	0.10	18.60	7.54	5.50	0.01	8.7	1.36	0.07	40.0
10 *	62	ND	3.16	48.6	0.18	0.16	20.50	9.51	6.67	0.02	9.8	1.24	0.14	47.8
12	58	ND	2.97	34.1	0.19	0.10	16.60	6.55	5.32	0.01	7.8	1.56	0.07	35.9
13 *	59	ND	3.53	51.5	0.20	0.16	20.50	8.99	6.74	0.01	9.8	1.10	0.10	43.7
37 *	56	ND	2.69	39.4	0.18	0.10	14.10	6.10	4.80	0.01	8.3	1.14	0.04	39.6
68	52	ND	4.01	42.9	0.21	0.15	19.60	8.68	6.44	0.02	9.1	1.71	0.12	41.1
69	52	ND	3.27	43.6	0.20	0.16	19.20	8.87	6.46	0.02	9.1	1.18	0.11	42.1
70	52	ND	3.72	42.3	0.21	0.16	19.40	9.09	6.17	0.01	9.2	1.02	0.10	41.9
71	52	ND	3.71	37.2	0.19	0.16	18.50	7.87	5.72	0.01	8.4	0.92	0.08	40.6
72	55	ND	3.08	39.9	0.19	0.15	19.90	9.58	6.35	0.02	9.3	1.53	0.13	41.5
73	55	ND	4.12	35.9	0.19	0.36	21.70	24.90	7.70	0.05	15.7	1.13	0.17	49.0
74	57	ND	3.56	45.4	0.21	0.20	18.60	8.18	5.59	0.02	8.7	1.46	0.11	40.9
75	60	ND	3.66	40.1	0.21	0.21	19.30	8.44	5.28	0.01	9.1	1.38	0.09	42.6
77	60	ND	3.02	33.9	0.20	0.12	19.50	7.56	5.11	0.02	8.6	1.10	0.09	40.5
78	63	ND	2.86	35.2	0.22	0.10	18.60	7.87	5.02	0.01	8.6	1.67	0.08	40.8
79	65	ND	3.22	38.8	0.21	0.10	19.70	9.25	5.87	0.01	9.3	1.34	0.11	44.3
80	65	ND	3.54	44.1	0.24	0.09	19.20	9.79	5.70	0.01	9.9	1.26	0.08	46.6
81	65	ND	2.64	40.9	0.22	0.09	18.50	7.75	5.24	0.03	8.7	1.10	0.08	40.4
82	65	ND	2.50	41.6	0.23	0.09	19.90	7.99	5.04	0.01	10.1	1.25	0.10	43.2
84	54	ND	3.46	38.0	0.19	0.28	20.10	9.94	7.49	0.03	9.0	1.45	0.13	45.1
85	57	ND	3.49	45.0	0.24	0.08	18.90	9.22	5.76	0.02	9.8	1.72	0.09	47.5
86	57	ND	3.08	36.9	0.19	0.29	19.70	11.80	7.24	0.03	8.5	1.63	0.18	43.6
87	60	ND	2.80	37.2	0.20	0.12	18.80	7.99	5.05	0.01	8.5	1.87	0.13	40.0
C	56	ND	2.97	46.5	0.18	0.10	19.10	7.56	5.79	0.02	9.1	1.47	0.08	40.3
C2 *	56	0.13	8.25	141.0	0.49	0.63	33.00	27.60	21.10	0.04	21.7	3.30	0.17	132
CON	59	ND	2.99	56.7	0.22	0.13	20.20	8.17	6.53	0.02	10.3	1.61	0.10	41.7
	Mean	**0.004**	**3.40**	**44.8**	**0.21**	**0.17**	**19.71**	**9.83**	**6.48**	**0.02**	**9.8**	**1.43**	**0.11**	**45.6**

Tabel 2–4 continues.

Table 2–4 continued.

Station	Depth (m)	Sb	As	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Zn
Middle Shelf Zone 3 (91-120 m)														
17 *	91	ND	2.73	42.4	0.22	0.10	18.40	7.81	5.58	0.01	9.9	1.41	0.06	44.6
18 *	91	ND	2.79	43.5	0.22	0.11	18.70	7.90	5.93	0.01	9.7	1.19	0.07	45.4
20 *	100	ND	3.58	55.6	0.20	0.17	21.70	10.50	7.06	0.02	10.7	1.16	0.14	47.1
23 *	100	ND	2.98	42.0	0.20	0.14	18.00	6.79	5.55	0.04	9.2	1.40	0.05	41.8
29 *	100	ND	2.98	69.6	0.22	0.21	22.90	11.60	7.73	0.02	11.4	1.39	0.33	50.6
33 *	100	ND	3.21	45.3	0.20	0.21	17.60	7.30	5.31	0.01	10.0	1.21	0.06	43.7
38 *	100	ND	3.64	50.4	0.20	0.29	17.00	8.47	6.47	0.02	9.8	1.14	0.09	42.6
56 *	100	ND	2.85	67.1	0.22	0.17	22.70	10.40	7.40	0.02	33.1	1.50	0.14	49.1
60 *	100	ND	3.39	74.8	0.23	0.30	27.20	14.90	9.02	0.03	13.0	1.72	0.23	55.0
83 *	100	ND	2.74	51.4	0.21	0.11	20.20	8.62	6.55	0.01	10.0	1.50	0.09	45.8
	Mean	**ND**	**3.09**	**54.2**	**0.21**	**0.18**	**20.44**	**9.43**	**6.66**	**0.02**	**12.7**	**1.36**	**0.13**	**46.57**
Outer Shelf (121-200 m)														
24 *	200	ND	3.42	93.4	0.26	0.34	26.20	14.30	9.04	0.03	14.0	1.97	0.21	55.9
25 *	200	ND	4.19	127.0	0.28	0.45	32.40	19.60	11.90	0.04	16.8	2.35	0.30	67.6
27 *	200	ND	3.45	68.4	0.23	0.23	23.40	11.50	7.39	0.02	12.9	2.01	0.10	52.1
39 *	200	ND	3.48	55.4	0.24	0.17	21.80	9.21	6.56	0.01	11.5	1.46	0.07	48.3
57 *	200	ND	5.64	155.0	0.39	0.58	39.90	26.60	15.40	0.04	18.8	2.33	0.51	79.9
61 *	200	0.12	5.17	141.0	0.31	0.56	34.00	24.50	14.10	0.04	16.9	2.19	0.44	71.5
63 *	200	ND	3.90	192.0	0.25	0.35	28.90	16.50	10.10	0.03	15.3	2.07	0.24	60.4
65 *	200	ND	4.74	81.7	0.26	0.43	25.90	13.70	9.98	0.02	14.8	1.74	0.15	58.8
C4 *	187	ND	6.56	122.0	0.31	0.36	29.90	17.90	13.90	0.04	17.5	2.32	0.13	85.0
	Mean	**0.01**	**4.51**	**115.1**	**0.28**	**0.39**	**29.16**	**17.09**	**10.93**	**0.03**	**15.4**	**2.05**	**0.24**	**64.39**
Upper Slope/Canyon (201-500 m)														
40 *	303	0.11	3.86	103.0	0.27	0.33	28.70	15.00	8.27	0.02	15.8	2.40	0.14	59.4
41 *	303	ND	3.93	103.0	0.37	0.32	31.30	16.90	10.20	0.02	16.6	2.17	0.16	64.8
42 *	303	0.11	4.90	135.0	0.31	0.44	35.90	20.10	12.50	0.02	18.4	2.55	0.25	72.5
44 *	241	0.12	7.64	212.0	0.57	0.91	49.10	37.80	21.20	0.06	22.3	2.86	0.88	95.3
58 *	300	ND	6.81	211.0	0.45	0.53	45.20	26.80	16.50	0.03	22.0	2.84	0.45	86.0
62 *	300	0.11	5.58	180.0	0.43	0.61	43.00	26.90	16.20	0.03	21.4	3.23	0.39	86.6
64 *	300	0.10	6.99	123.0	0.37	0.30	33.60	22.00	12.20	0.02	21.1	3.17	0.16	75.4
C5 *	296	0.12	6.87	143.0	0.44	0.69	41.30	24.30	15.60	0.03	21.6	3.13	0.30	91.1
	Mean	**0.08**	**5.82**	**151.2**	**0.40**	**0.52**	**38.51**	**23.72**	**14.08**	**0.03**	**19.9**	**2.79**	**0.34**	**78.89**
Sediment quality guidelines														
ERM		N/A	70.00	N/A	N/A	9.60	370.00	270.00	218.00	0.70	51.6	N/A	3.70	410.0
Regional summer values (area weighted mean)														
Bight'13 Middle Shelf		0.90	2.70	130.0	0.21	0.68	30.00	7.90	7.00	0.05	15.0	0.10	0.29	48.0
Bight'13 Outer Shelf		1.10	5.30	130.0	0.36	0.82	37.00	11.00	10.00	0.07	18.0	0.21	0.39	57.0
Bight'13 Upper Slope		1.40	5.40	160.0	0.27	1.50	57.00	21.00	12.00	0.08	30.0	0.89	0.24	88.0

the Annelida (segmented worms) was the dominant taxonomic group at all depth strata (Table B-7). Mean community measure values were comparable between within- and non-ZID stations, and most station values were within regional and OCSD historical ranges in both surveys (Tables 2-8 and 2-9). The infaunal community at within-ZID and non-ZID stations in both surveys can be classified as reference condition based on their low (<25) Benthic Response Index (BRI) values and/or high (>60) Infaunal Trophic Index (ITI) values. The community composition at within-ZID stations was similar to non-ZID stations based on multivariate analyses of the infaunal species and abundances (Figure 2-5). These multiple lines of evidence suggest that the outfall discharge had an overall negligible effect on the benthic community structure within the monitoring area. We conclude, therefore, that the biota was not degraded by the outfall discharge, and as such, compliance was met.

Epibenthic Macroinvertebrate Communities

A total of 45 epibenthic macroinvertebrate (EMI) species, comprising 7,949 individuals and a total weight of 30.4 kg, was collected from 20 trawls conducted in the 2017-18 monitoring period (Tables B-8 and B-9). As with the previous monitoring period, *Ophiura luetkenii* (brittlestar) and *Strongylocentrotus fragilis* (sea urchin) were the most dominant species in terms of abundance (n=4,982; 63% of total) and biomass (12.4 kg; 41% of total), respectively. Among the strata sampled in summer, the average abundance of EMIs was highest at Middle Shelf Zone 2 due to large catches (>1,100) of *Ophiura luetkenii* at Stations T1 and T11 (Tables 2-10, B-8, and B-9). By contrast, the average biomass of EMIs was highest at the Outer Shelf due to large catches of *Strongylocentrotus fragilis* and/or *Sicyonia ingentis* (shrimp) at all stations. Within the Middle Shelf Zone 2 stratum, the overall EMI community composition at the outfall stations was

Table 2–5 Physical properties and chemical concentrations of sediment samples collected at each semi-annual station in Winter 2018 compared to Effects Range-Median (ERM) and regional values. ND = Not Detected; N/A = Not Applicable; * = ERM exceedance.

Station	Depth (m)	Median Phi (ϕ)	Fines (%)	TOC (%)	Sulfides (mg/kg)	Total P (mg/kg)	Total N (mg/kg)	ΣPAH (mg/kg)	ΣDDT (mg/kg)	ΣPest (mg/kg)	ΣPCB (mg/kg)
Middle Shelf Zone 2, Within-ZID (51-90 m)											
0	56	3.05	9.4	0.49	2.01	1400	580	348.1	1.83	ND	27.81
4	56	3.06	7.3	0.31	1.53	900	400	101.5	ND	ND	0.50
76	58	3.09	9.2	0.33	2.11	960	360	69.5	1.77	ND	2.79
ZB	56	3.12	9.4	0.35	3.99	880	390	63.2	58.25 *	ND	7.17
	Mean	**3.08**	**8.8**	**0.37**	**2.41**	**1035**	**432**	**145.6**	**15.46**	**ND**	**9.57**
Middle Shelf Zone 2, Non-ZID (51-90 m)											
1	56	3.22	9.5	0.35	ND	1000	560	63.5	ND	ND	4.80
3	60	3.14	10.5	0.38	ND	1100	440	61.9	ND	ND	7.47
5	59	3.42	10.7	0.40	1.94	1000	370	44.6	ND	ND	2.85
9	59	2.91	7.2	0.34	2.18	850	380	24.1	ND	ND	0.46
12	58	2.79	6.1	0.32	2.00	770	370	24.6	ND	ND	0.16
68	52	3.23	7.8	0.38	1.73	1100	440	39.8	ND	ND	1.79
69	52	3.24	10.7	0.38	2.08	980	500	89.1	ND	ND	2.01
70	52	3.19	11.1	0.36	1.95	950	440	89.9	ND	ND	2.47
71	52	3.00	5.6	0.30	2.83	910	350	99.3	ND	ND	0.49
72	55	3.23	9.1	0.36	2.13	980	420	50.2	ND	ND	63.17
73	55	3.14	10.1	0.43	4.24	1300	410	378.6	2.17	ND	16.89
74	57	3.07	8.9	0.34	3.08	970	380	95.4	ND	ND	0.21
75	60	3.07	10.0	0.32	2.82	930	410	68.9	ND	ND	0.19
77	60	3.03	7.6	0.29	2.37	970	420	27.8	ND	ND	ND
78	63	3.00	6.1	0.29	3.51	920	350	83.6	ND	ND	0.15
79	65	3.20	9.6	0.44	2.43	940	460	39.9	ND	ND	3.72
80	65	3.26	11.1	0.31	1.81	920	380	34.5	ND	ND	ND
81	65	3.19	10.7	0.31	2.25	880	360	32.1	5.37	ND	ND
82	65	3.10	9.6	0.32	3.24	830	380	30.4	3.59	ND	0.23
84	54	3.12	8.1	0.40	3.32	1000	500	80.2	ND	ND	8.51
85	57	3.02	5.6	0.40	3.96	1200	450	177.4	12.93	ND	7.11
86	57	3.14	8.0	0.43	6.59	1100	490	162.3	ND	ND	6.33
87	60	3.03	6.9	0.32	2.54	910	400	56.6	ND	ND	0.73
C	56	3.11	10.4	0.34	4.55	920	410	27.0	ND	ND	0.21
CON	59	3.21	10.9	0.34	3.46	970	440	39.7	1.84	ND	0.17
	Mean	**3.12**	**8.9**	**0.35**	**2.91**	**976**	**420**	**76.9**	**1.04**	**ND**	**5.2**
Sediment quality guidelines											
ERM		N/A	N/A	N/A	N/A	N/A	N/A	44792.0	46.10	N/A	180.00
Regional summer values (area weighted mean)											
Bight'13 Middle Shelf		N/A	48.0	0.70	N/A	N/A	N/A	55.0	18.00	N/A	2.70

similar to those at other non-outfall stations in both Summer and Winter surveys based on the results of the multivariate analyses (cluster and non-metric multidimensional scaling (nMDS) analyses) (Figure 2-6). Furthermore, the community measure values at the outfall stations are within regional and OCSD historical ranges (Table 2-10). These results suggest that the outfall discharge had an overall negligible effect on the EMI community structure within the monitoring area, and as such, we conclude that the EMI communities within the monitoring area were not degraded by the outfall discharge, and consequently, compliance was met.

Fish Communities

A total of 36 fish taxa, comprising 5,081 individuals and a total weight of 109.0 kg, was collected from the monitoring area during the 2017-18 trawling effort (Tables B-10 and B-11). The mean species richness, abundance, biomass, Shannon-Wiener Diversity (H′), and Swartz's 75% Dominance Index (SDI) values of demersal fishes were comparable between outfall and non-outfall stations in both surveys, with values falling within regional and/or OCSD historical ranges (Table 2-11). More importantly, the fish communities at outfall and non-outfall stations were classified as reference condition based on their low (<45) mean Fish Response Index (FRI) values in both surveys. Multivariate analyses (cluster and nMDS) of the demersal fish species and abundance data further demonstrated that the fish communities were similar between the outfall and non-outfall stations regardless of season (Figure 2-7). These results indicate that the outfall discharge had no adverse effect on the demersal fish community structure within the monitoring area. We conclude that the demersal fish communities within the monitoring area were not degraded by the outfall discharge, and thus, compliance was met.

Table 2–6 Metal concentrations (mg/kg) in sediment samples collected at each semi-annual station in Winter 2018 compared to Effects Range-Median (ERM) and regional values. N/A = Not Applicable.

Station	Depth (m)	Sb	As	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Zn
Middle Shelf Zone 2, Within-ZID (51-90 m)														
0	56	0.08	3.97	31.4	0.25	0.35	20.90	12.20	7.94	0.04	8.2	1.62	0.17	42.5
4	56	0.07	3.81	31.6	0.25	0.12	17.60	7.21	5.97	0.02	7.9	1.50	0.08	38.2
76	58	0.08	3.23	34.5	0.28	0.13	17.50	7.81	5.35	0.03	8.0	1.35	0.10	40.4
ZB	56	0.10	3.43	33.8	0.28	0.25	17.10	7.74	5.64	0.02	8.2	1.55	0.12	40.6
	Mean	**0.08**	**3.61**	**32.8**	**0.26**	**0.21**	**18.28**	**8.74**	**6.22**	**0.03**	**8.1**	**1.50**	**0.12**	**40.42**
Middle Shelf Zone 2, Non-ZID (51-90 m)														
1	56	0.07	3.22	34.4	0.25	0.18	17.70	9.04	6.31	0.02	7.9	1.51	0.22	37.7
3	60	0.08	3.75	35.1	0.27	0.14	18.40	8.22	5.98	0.02	7.9	1.55	0.12	41.2
5	59	0.09	3.71	40.3	0.27	0.15	18.60	8.50	6.77	0.03	8.9	1.59	0.13	40.8
9	59	0.08	3.46	32.5	0.26	0.12	17.10	6.78	6.21	0.01	7.8	1.47	0.09	38.0
12	58	0.06	3.42	28.6	0.24	0.09	16.20	6.08	5.71	0.01	7.4	1.52	0.06	34.8
68	52	0.09	3.59	35.2	0.25	0.18	17.70	8.11	6.56	0.03	8.2	1.70	0.13	39.5
69	52	0.08	3.33	36.5	0.25	0.17	18.00	7.90	6.05	0.15	8.5	1.54	0.11	39.4
70	52	0.09	3.88	34.9	0.25	0.16	18.10	8.01	6.51	0.02	8.5	1.50	0.10	40.0
71	52	0.08	3.74	29.6	0.24	0.17	16.30	6.52	5.61	0.02	7.4	1.57	0.10	35.9
72	55	0.07	3.18	34.6	0.25	0.15	17.20	12.90	6.20	0.02	8.3	1.49	0.14	38.0
73	55	0.08	3.68	32.6	0.25	0.36	21.40	13.50	8.25	0.05	7.9	1.66	0.20	44.5
74	57	0.07	2.89	32.0	0.25	0.23	17.40	7.44	5.37	0.03	8.0	1.43	0.10	40.7
75	60	0.08	3.03	35.2	0.26	0.18	16.90	6.89	5.41	0.03	7.8	1.40	0.09	38.7
77	60	0.07	3.13	32.0	0.26	0.12	17.40	6.93	5.72	0.01	7.8	1.44	0.09	39.2
78	63	0.07	3.33	29.4	0.26	0.09	16.20	6.36	4.99	0.01	7.5	1.50	0.07	36.7
79	65	0.08	3.62	35.1	0.28	0.13	17.50	8.28	6.12	0.01	8.3	1.54	0.11	40.2
80	65	0.10	3.24	34.3	0.31	0.11	16.70	7.24	5.51	0.01	8.1	1.51	0.08	40.1
81	65	0.07	3.02	35.9	0.27	0.08	16.70	6.68	5.38	0.01	8.1	1.46	0.08	37.3
82	65	0.07	3.27	35.1	0.28	0.08	17.80	7.08	5.87	0.01	8.7	1.43	0.07	39.9
84	54	0.10	4.86	34.3	0.26	0.20	19.30	10.30	7.27	0.03	8.5	1.64	0.14	41.3
85	57	0.10	3.46	31.3	0.26	0.24	19.30	10.20	6.84	0.05	8.3	1.46	0.15	40.1
86	57	0.09	3.45	32.7	0.25	0.30	18.90	10.50	6.67	0.03	8.0	1.60	0.17	42.0
87	60	0.07	2.97	32.3	0.28	0.11	17.10	7.01	5.22	0.02	7.7	1.45	0.55	39.1
C	56	0.08	3.20	40.9	0.24	0.11	17.70	6.84	6.39	0.02	8.4	1.49	0.07	38.1
CON	59	0.10	2.85	44.8	0.25	0.10	18.10	7.10	6.54	0.02	8.6	1.53	0.08	38.7
	Mean	**0.08**	**3.41**	**34.4**	**0.26**	**0.16**	**17.75**	**8.18**	**6.14**	**0.03**	**8.1**	**1.52**	**0.13**	**39.28**
Sediment quality guidelines														
ERM		N/A	70.00	N/A	N/A	9.60	370.00	270.00	218.00	0.70	51.6	N/A	3.70	410.0
Regional summer values (area weighted mean)														
Bight'13 Middle Shelf		0.90	2.70	130.0	0.21	0.68	30.00	7.90	7.00	0.05	15.0	0.10	0.29	48.0

Table 2–7 Whole-sediment *Eohaustorius estuarius* (amphipod) toxicity test results for 2017-18. The home sediment represents the control; N/A = Not Applicable.

Station	% Survival	% of home	p-value	Assessment
home	100	N/A	N/A	N/A
0	95	95	0.28	Nontoxic
1	99	99	0.75	Nontoxic
4	92	92	0.28	Nontoxic
72	94	94	0.11	Nontoxic
73	97	97	0.52	Nontoxic
76	99	99	0.75	Nontoxic
77	98	98	0.75	Nontoxic
CON	98	98	0.75	Nontoxic
ZB	96	96	0.28	Nontoxic
ZB Dup	95	95	0.28	Nontoxic

Table 2–8 Community measure values for each semi-annual and annual (*) station sampled during the Summer 2017 infauna survey, including regional and historical values. N/A = Not Applicable, NC = Not Calculated.

Station	Depth (m)	Total No. of Species	Total Abundance	H'	SDI	ITI	BRI
Middle Shelf Zone 1 (31-50 m)							
7 *	41	111	588	3.62	28	81	13
8 *	44	102	507	3.75	28	64	17
21 *	44	99	415	3.79	31	82	13
22 *	45	105	504	3.57	29	82	14
30 *	46	105	460	3.66	29	79	17
36 *	45	108	475	3.99	35	84	12
55 *	40	95	441	3.65	26	88	14
59 *	40	95	512	3.64	25	83	13
	Mean	**103**	**488**	**3.71**	**29**	**80**	**14**
Middle Shelf Zone 2, Within-ZID (51-90 m)							
0	56	109	418	3.98	33	74	18
4	56	87	359	3.45	24	69	17
76	58	109	586	3.47	25	74	13
ZB	56	116	456	4.10	38	75	14
	Mean	**105**	**455**	**3.75**	**30**	**73**	**16**
Middle Shelf Zone 2, Non-ZID (51-90 m)							
1	56	85	373	3.39	22	80	13
3	60	82	437	3.27	19	72	15
5	59	80	360	3.26	21	79	19
9	59	114	560	3.64	28	77	12
10 *	62	72	298	3.25	21	88	13
12	58	107	478	3.83	31	76	12
13 *	59	86	338	3.39	24	81	17
37 *	56	92	300	4.05	35	77	14
68	52	107	590	3.54	23	74	15
69	52	100	500	3.76	27	78	16
70	52	109	518	3.71	25	73	16
71	52	116	433	4.04	39	80	16
72	55	99	453	3.61	25	73	17
73	55	102	559	3.37	23	65	19
74	57	93	395	3.78	27	78	15
75	60	94	285	3.86	34	86	15
77	60	81	336	3.38	23	82	14
78	63	122	573	3.72	27	78	13
79	65	105	469	3.76	33	76	12
80	65	92	375	3.57	26	88	10
81	65	91	361	3.70	27	85	12
82	65	79	388	3.58	21	79	11
84	54	110	596	3.60	23	78	15
85	57	103	477	3.82	31	71	19
86	57	102	505	3.43	25	80	16
87	60	101	407	3.55	29	88	15
C	56	94	355	3.87	30	82	16
C2 *	56	20	115	2.27	6	40	45
CON	59	122	635	3.66	30	74	17
	Mean	**95**	**430**	**3.57**	**26**	**77**	**16**
Middle Shelf Zone 3 (91-120 m)							
17 *	91	83	378	3.68	23	87	11
18 *	91	72	380	3.59	22	84	10
20 *	100	83	398	3.72	25	86	12
23 *	100	69	350	3.57	21	77	13
29 *	100	69	319	3.61	21	83	18
33 *	100	102	416	3.90	33	80	15
38 *	100	65	320	3.58	19	68	26
56 *	100	65	214	3.65	25	86	19
60 *	100	80	278	4.00	34	81	23
83 *	100	58	238	3.41	19	80	10
	Mean	**75**	**329**	**3.67**	**24**	**81**	**16**
Outer Shelf (121-200 m)							
24 *	200	33	74	3.22	16	54	30
25 *	200	39	86	3.37	18	67	26
27 *	200	44	116	3.31	18	69	20
39 *	200	53	228	3.25	17	49	21
57 *	200	19	38	2.69	10	60	32
61 *	200	28	59	3.06	15	54	35
63 *	200	34	83	3.13	14	73	21
65 *	200	38	80	3.32	20	61	24
C4 *	187	42	231	2.85	9	66	34
	Mean	**37**	**111**	**3.13**	**15**	**61**	**27**

Table 2–8 continues.

Table 2–8 continued.

Station	Depth (m)	Total No. of Species	Total Abundance	H'	SDI	ITI	BRI
			Upper Slope/Canyon (201-500 m)				
40 *	303	38	70	3.41	21	N/A	N/A
41 *	303	37	81	3.29	17	N/A	N/A
42 *	303	30	61	3.13	15	N/A	N/A
44 *	241	17	30	2.68	10	N/A	N/A
58 *	300	24	38	2.98	15	N/A	N/A
62 *	300	17	30	2.71	10	N/A	N/A
64 *	300	21	37	2.93	13	N/A	N/A
C5 *	296	27	54	2.96	14	N/A	N/A
	Mean	**26**	**50**	**3.01**	**14**	**N/A**	**N/A**
			Regional summer values [mean (range)]				
Bight'13 Middle Shelf		90 (45-171)	491 (142-2718)	3.60 (2.10-4.10)	NC	NC	18 (7-30)
Bight'13 Outer Shelf		66 (24-129)	289 (51-1492)	3.40 (2.30-4.10)	NC	NC	18 (8-28)
Bight'13 Upper Slope		30 (6-107)	96 (12-470)	2.70 (0.60-3.90)	NC	N/A	N/A
			OCSD historical summer values (2007-2017 Fiscal Years) [mean (range)]				
Middle Shelf Zone 1		105 (7-157)	395 (12-820)	3.95 (1.59-4.46)	35 (4-51)	85 (67-98)	16 (8-21)
Middle Shelf Zone 2, Within-ZID		88 (33-138)	498 (212-1491)	3.37 (0.36-4)	22 (1-35)	56 (1-91)	26 (13-52)
Middle Shelf Zone 2, Non-ZID		94 (29-142)	407 (90-785)	3.71 (2.29-4.43)	28 (5-52)	77 (1-94)	18 (10-57)
Middle Shelf Zone 3		92 (45-146)	434 (177-807)	3.74 (3.06-4.23)	27 (15-43)	82 (65-94)	18 (9-26)
Outer Shelf		43 (19-78)	125 (38-367)	3.26 (2.33-3.74)	18 (8-30)	69 (42-91)	24 (14-39)
Upper Slope/Canyon		25 (13-38)	56 (22-106)	2.86 (2.29-3.30)	12 (6-19)	N/A	N/A

Table 2–9 Community measure values for each semi-annual station sampled during the Winter 2018 infauna survey, including regional and historical values. NC = Not Calculated.

Station	Depth (m)	Total No. of Species	Total Abundance	H'	SDI	ITI	BRI
			Middle Shelf Zone 2, Within-ZID (51-90 m)				
0	56	85	294	4.03	32	81	14
4	56	93	307	3.93	33	85	11
76	58	54	134	3.55	23	89	15
ZB	56	88	446	3.45	19	73	20
	Mean	**80**	**295**	**3.74**	**27**	**82**	**15**
			Middle Shelf Zone 2, Non-ZID (51-90 m)				
1	56	90	459	3.76	24	73	13
3	60	87	455	3.53	21	75	13
5	59	77	263	3.79	29	79	12
9	59	83	226	4.01	33	75	12
12	58	85	341	3.75	26	79	13
68	52	90	329	3.83	28	76	14
69	52	87	460	3.38	21	68	19
70	52	98	592	3.62	23	71	17
71	52	71	288	3.59	22	82	16
72	55	70	228	3.71	25	78	14
73	55	94	379	3.91	30	78	13
74	57	105	623	3.37	21	69	19
75	60	73	227	3.76	24	84	11
77	60	61	269	2.99	13	73	20
78	63	53	136	3.54	23	83	14
79	65	76	318	3.80	25	82	12
80	65	89	411	3.90	30	78	9
81	65	100	575	3.78	24	73	14
82	65	78	375	3.69	22	78	14
84	54	102	580	3.83	27	72	13
85	57	127	523	4.08	35	77	15
86	57	96	363	3.69	30	75	11
87	60	80	338	3.73	24	80	12
C	56	68	211	3.78	25	74	16
CON	59	76	239	3.76	28	77	13
	Mean	**85**	**368**	**3.70**	**25**	**76**	**14**
			Regional summer values [mean (range)]				
Bight'13 Middle Shelf		90 (45-171)	491 (142-2718)	3.60 (2.10-4.10)	NC	NC	18 (7-30)
			OCSD historical winter values (2007-2017 Fiscal Years) [mean (range)]				
Middle Shelf Zone 2, Within-ZID		81 (35-135)	384 (88-1230)	3.42 (0.89-4.68)	24 (1-76)	56 (3-89)	25 (9-45)
Middle Shelf Zone 2, Non-ZID		86 (45-142)	325 (96-634)	3.75 (2.87-4.32)	29 (9-48)	79 (47-95)	17 (9-46)

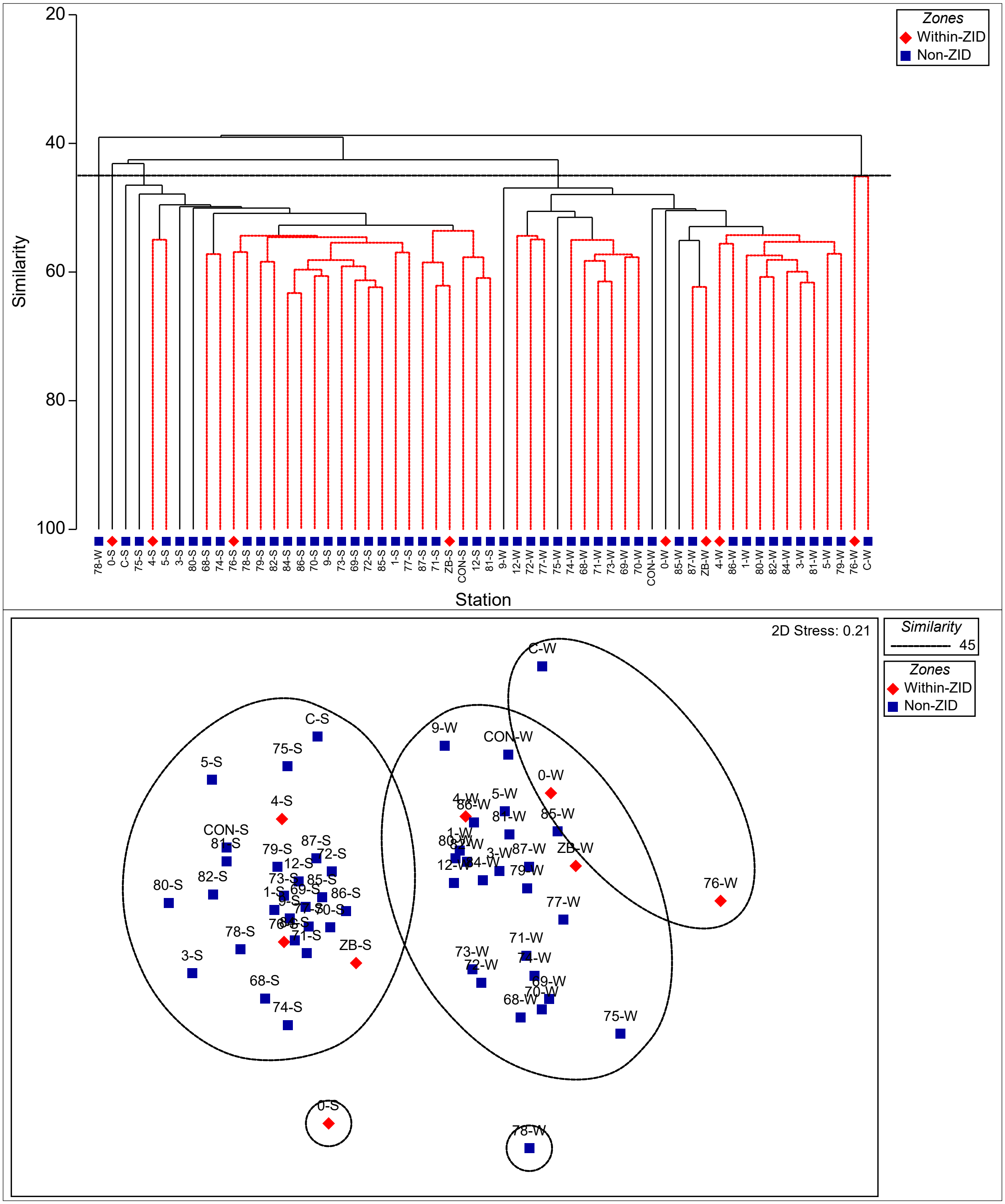

Figure 2–5 Dendrogram (top panel) and non-metric multidimensional scaling plot (bottom panel) of the infauna collected at within- and non-ZID stations along the Middle Shelf Zone 2 stratum for the Summer 2017 (S) and Winter 2018 (W) benthic surveys. Stations connected by red dashed lines in the dendrogram are not significantly differentiated based on the SIMPROF test. The 5 main clusters formed at a 45% similarity on the dendrogram are superimposed on the nMDS plot.

Table 2–10 Summary of epibenthic macroinvertebrate community measures for each semi-annual and annual (*) station sampled during the Summer 2017 and Winter 2018 trawl surveys, including regional and OCSD historical values. NC = Not Calculated.

Quarter	Station	Nominal Depth (m)	Total No. of Species	Total Abundance	Biomass (kg)	H'	SDI
				Middle Shelf Zone 1 (31-50 m)			
Summer	T2 *	35	11	459	0.52	0.36	1
	T24 *	36	15	837	1.10	1.28	2
	T6 *	36	18	624	0.78	1.16	2
	T18 *	36	8	59	0.05	1.08	2
		Mean	**13**	**495**	**0.61**	**0.97**	**2**
				Middle Shelf Zone 2, Outfall (51-90 m)			
	T22	60	10	152	0.13	1.81	4
	T1	55	11	1251	2.10	0.55	1
		Mean	**11**	**702**	**1.11**	**1.18**	**3**
				Middle Shelf Zone 2, Non-outfall (51-90 m)			
	T23	58	14	122	0.36	1.90	4
	T12	57	12	96	0.24	2.00	5
	T17	60	12	146	0.62	1.68	3
	T11	60	12	2408	2.90	0.19	1
		Mean	**13**	**693**	**1.03**	**1.44**	**3**
				Outer Shelf (121-200 m)			
	T10 *	137	7	132	5.74	0.60	1
	T25 *	137	6	131	5.66	0.85	2
	T14 *	137	10	166	2.36	0.62	1
	T19 *	137	11	310	5.59	0.78	1
		Mean	**9**	**185**	**4.84**	**0.71**	**1**
				Middle Shelf Zone 2, Outfall (51-90 m)			
Winter	T22	60	13	210	0.36	1.38	3
	T1	55	11	254	0.29	1.82	4
		Mean	**12**	**232**	**0.32**	**1.60**	**4**
				Middle Shelf Zone 2, Non-outfall (51-90 m)			
	T23	58	11	223	0.60	1.11	2
	T12	57	11	162	0.30	2.07	5
	T17	60	9	77	0.27	1.59	3
	T11	60	13	130	0.39	2.10	5
		Mean	**11**	**148**	**0.39**	**1.72**	**4**
				Regional summer values [area-weighted mean (range)]			
Bight'13 Middle Shelf			12 (3-23)	1093 (19-17973)	5 (0.31-36)	1.11 (0.09-2.49)	NC
Bight'13 Outer Shelf			15 (3-29)	728 (4-5160)	27 (0.39-83)	1.26 (0.10-2.39)	NC
				OCSD historical values (2007-2017 Fiscal Years) [mean (range)]			
Middle Shelf Zone 1			11 (2-18)	435 (2-2592)	0.80 (0.00-3.44)	1.31 (0.01-2.22)	3 (1-5)
Middle Shelf Zone 2, Outfall			12 (7-18)	292 (49-1436)	1.54 (0.08-5.67)	1.39 (0.22-2.15)	3 (1-5)
Middle Shelf Zone 2, Non-outfall			11 (5-19)	344 (12-2498)	1.69 (0.04-11.16)	1.31 (0.06-2.43)	3 (1-9)
Outer Shelf			10 (3-15)	168 (26-548)	3.73 (0.09-19.31)	1.07 (0.15-2.12)	2 (1-8)

FISH BIOACCUMULATION AND HEALTH

Demersal Fish Tissue Chemistry

Muscle and liver contaminant concentrations in Hornyhead Turbot and English Sole were generally similar between outfall and non-outfall stations (Table 2-12). Only 1 English Sole individual was collected at the outfall from 7 hauls. All mean contaminant concentration values for muscle and liver tissues were within OCSD historical ranges within the monitoring area.

Sport Fish Muscle Chemistry

Muscle tissue contaminant concentrations were generally similar in sport fishes collected at the outfall and non-outfall zones (Table 2-13). More importantly, all muscle tissue contaminant levels at both zones were well below federal and/or state human consumption guidelines. These results indicate there is little risk from consuming fish from the monitored areas and compliance was achieved.

Fish Health

Fishes appeared normal in both color and odor in 2017-18, thus compliance was met. Furthermore, no external parasites were observed and less than 1% of all fishes collected showed evidence of morphological irregularities.

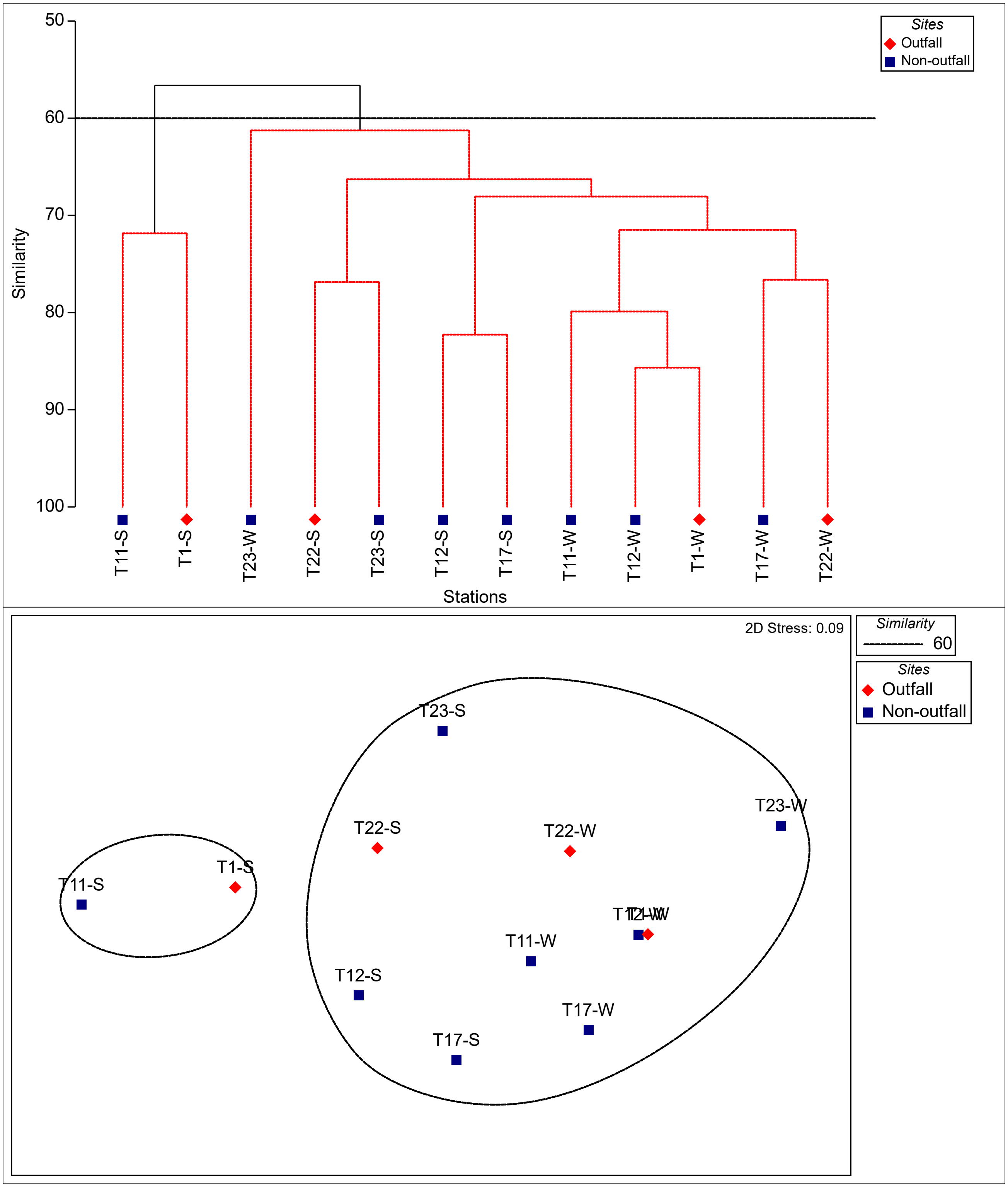

Figure 2–6 Dendrogram (top panel) and non-metric multidimensional scaling plot (bottom panel) of the epibenthic macroinvertebrates collected at outfall and non-outfall stations along the Middle Shelf Zone 2 stratum for the Summer 2017 (S) and Winter 2018 (W) trawl surveys. Stations connected by red dashed lines in the dendrogram are not significantly differentiated based on the SIMPROF test. The 2 main clusters formed at a 60% similarity on the dendrogram are superimposed on the nMDS plot.

Table 2–11 Summary of demersal fish community measures for each semi-annual and annual (*) station sampled during the Summer 2017 and Winter 2018 trawl surveys, including regional and OCSD historical values. NC = Not Calculated.

Quarter	Station	Nominal Depth (m)	Total No. of Species	Total Abundance	Biomass (kg)	H'	SDI	FRI
				Middle Shelf Zone 1 (31-50 m)				
Summer	T2 *	35	9	87	4.82	1.67	3	19
	T24 *	36	10	134	2.16	1.70	3	23
	T6 *	36	8	138	0.85	1.57	3	19
	T18 *	36	8	114	0.76	1.33	3	20
		Mean	**9**	**118**	**2.15**	**1.57**	**3**	**20**
				Middle Shelf Zone 2, Outfall (51-90 m)				
	T22	60	9	110	2.47	1.79	4	22
	T1	55	12	129	2.61	1.87	4	16
		Mean	**11**	**120**	**2.54**	**1.83**	**4**	**19**
				Middle Shelf Zone 2, Non-outfall (51-90 m)				
	T23	58	8	45	1.43	1.48	3	25
	T12	57	9	131	4.56	1.51	3	16
	T17	60	9	152	3.96	1.84	4	12
	T11	60	11	101	1.25	1.61	3	17
		Mean	**9**	**107**	**2.80**	**1.61**	**3**	**18**
				Outer Shelf (121-200 m)				
	T10 *	137	19	717	15.76	1.61	3	19
	T25 *	137	14	546	12.21	1.53	3	27
	T14 *	137	12	461	9.10	1.48	2	27
	T19 *	137	16	732	10.30	1.79	4	37
		Mean	**15**	**614**	**11.84**	**1.60**	**3**	**28**
				Middle Shelf Zone 2, Outfall (51-90 m)				
Winter	T22	60	10	216	7.39	1.94	5	14
	T1	55	10	222	6.05	1.85	4	13
		Mean	**10**	**219**	**6.72**	**1.90**	**5**	**13**
				Middle Shelf Zone 2, Non-outfall (51-90 m)				
	T23	58	10	116	3.95	1.76	3	17
	T12	57	12	192	4.08	1.81	4	15
	T17	60	9	91	4.40	1.95	5	16
	T11	60	15	647	10.88	1.98	5	20
		Mean	**12**	**262**	**5.83**	**1.88**	**4**	**17**
				Regional summer values [area-weighted mean (range)]				
Bight'13 Middle Shelf			15 (5-24)	506 (12-2446)	12 (0.70-64.20)	1.65 (0.67-2.35)	NC	28 (17-61)
Bight'13 Outer Shelf			14 (2-21)	790 (2-3088)	16 (0.20-54.50)	1.35 (0.59-2.01)	NC	20 (-1-51)
				OCSD historical values (2007-2017 Fiscal Years) [mean (range)]				
Middle Shelf Zone 1			11 (2-16)	247 (83-470)	5.24 (1.16-11.86)	1.59 (0.69-2.20)	3 (2-5)	22 (17-26)
Middle Shelf Zone 2, Outfall			13 (2-18)	463 (147-3227)	19.64 (4.34-78.72)	1.63 (0.39-2.14)	3 (1-6)	24 (18-33)
Middle Shelf Zone 2, Non-outfall			15 (3-25)	607 (41-12274)	14.04 (1.01-135.64)	1.73 (0.14-2.22)	4 (1-6)	23 (13-34)
Outer Shelf			15 (2-22)	630 (260-1610)	16.07 (2.60-54.92)	1.38 (0.65-1.91)	3 (1-5)	15 (4-41)

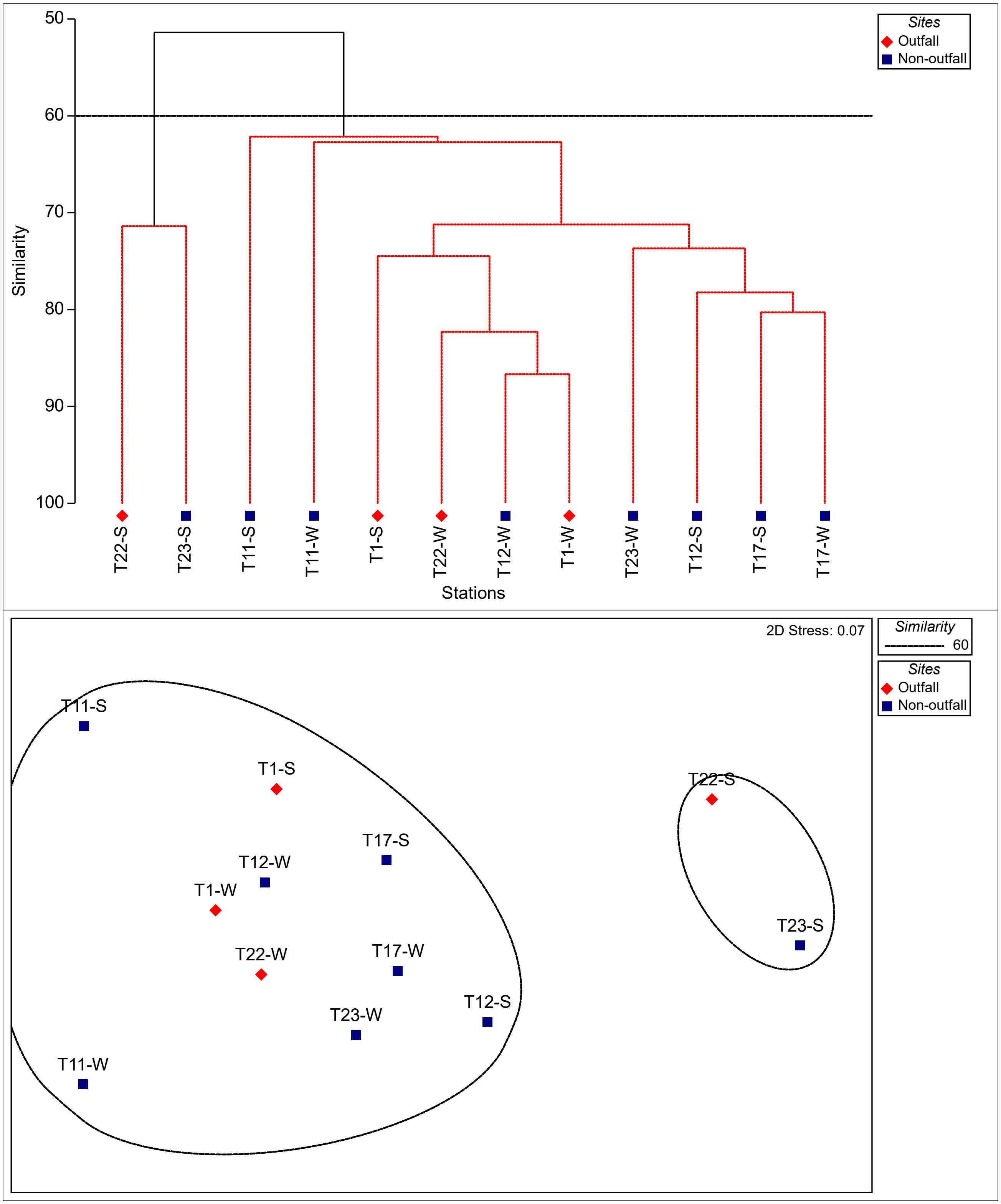

Figure 2–7 Dendrogram (top panel) and non-metric multidimensional scaling plot (bottom panel) of the demersal fishes collected at outfall and non-outfall stations along the Middle Shelf Zone 2 stratum for the Summer 2017 (S) and Winter 2018 (W) trawl surveys. Stations connected by red dashed lines in the dendrogram are not significantly differentiated based on the SIMPROF test. The 2 main clusters formed at a 60% similarity on the dendrogram are superimposed on the nMDS plot.

Table 2–12 Means and ranges of tissue contaminant concentrations in selected flatfishes collected by trawling in 2017-18 at Stations T1 (Outfall) and T11 (Non-outfall), as well as historical values. ND = Not Detected.

Species	Tissue	Station	n	Standard Length (mm)	Percent Lipid	Mercury (mg/kg)	ΣDDT (µg/kg)	ΣPCB (µg/kg)	ΣChlordane (µg/kg)	Dieldrin (µg/kg)
OCSD 2017-2018 values										
Pleuronichthys verticalis (Hornyhead Turbot)	Muscle	Non-outfall	6	160 (150-178)	ND (All ND)	0.06 (0.03-0.12)	1.87 (0-9.68)	ND (All ND)	ND (All ND)	ND (All ND)
		Outfall	10	153 (119-190)	ND (All ND)	0.05 (0.01-0.10)	1.79 (0-4.22)	ND (All ND)	ND (All ND)	ND (All ND)
	Liver	Non-outfall	6	160 (150-178)	1.97 (0.98-3.98)	0.26 (0.19-0.34)	135.20 (43.20-368.10)	6.70 (0-40.20)	ND (All ND)	ND (All ND)
		Outfall	10	153 (119-190)	5.67 (2.06-18)	0.14 (0.06-0.31)	174.48 (75.60-503)	ND (All ND)	ND (All ND)	ND (All ND)
Parophrys vetulus (English Sole)	Muscle	Non-outfall	10	194 (168-268)	0.63 (0-1.39)	0.07 (0.04-0.11)	62.28 (7.85-282.99)	8.20 (0-38.83)	ND (All ND)	ND (All ND)
		Outfall	1	217	ND	0.09	14.8	2.53	ND	ND
	Liver	Non-outfall	10	194 (168-268)	8.94 (2.95-22.40)	0.07 (0.03-0.16)	927.83 (96.20-3567.30)	199.65 (9.40-1131.20)	ND (All ND)	ND (All ND)
		Outfall	1	217	2.75	0.14	201.1	38.9	ND	ND
OCSD historical values (2007-2017 Fiscal Years)										
Pleuronichthys verticalis (Hornyhead Turbot)	Muscle	Non-outfall	62	151 (98-217)	0.18 (0-0.68)	0.05 (0.01-0.30)	11.64 (0-38.75)	2.76 (0-18.36)	0.07 (0-1.45)	ND (All ND)
		Outfall	91	160 (110-204)	0.15 (0-0.77)	0.08 (0.01-0.42)	7.75 (0-54.50)	1.71 (0-12.57)	0.01 (0-0.71)	0.20 (0-12.70)
	Liver	Non-outfall	62	156 (98-217)	6.41 (0.42-30.40)	0.20 (0.05-0.79)	608.42 (0-2100)	51.14 (0-432.59)	ND (All ND)	ND (All ND)
		Outfall	91	158 (110-204)	8.73 (0-24.60)	0.18 (0.02-0.59)	545.02 (0-1822.70)	118.28 (0-457.80)	4.14 (0-81.70)	ND (All ND)
Parophrys vetulus (English Sole)	Muscle	Non-outfall	89	182 (124-247)	0.81 (0-6.22)	0.05 (0.01-0.12)	75.75 (0-524.30)	8.21 (0-61.20)	ND (All ND)	0.05 (0-4.45)
		Outfall	87	183 (136-290)	1.09 (0-8.23)	0.05 (0.01-0.11)	107.86 (3.97-633.46)	14.53 (0-130.90)	ND (All ND)	ND (All ND)
	Liver	Non-outfall	89	181 (124-247)	10.12 (1.93-26.80)	0.06 (0.02-0.19)	1384.92 (71.10-14300)	171.08 (0-1694.70)	0.09 (0-5.27)	ND (All ND)
		Outfall	87	182 (136-290)	11.31 (0-27.10)	0.06 (0.02-0.16)	1559.02 (95.70-20967)	207.16 (0-1627.29)	1.27 (0-30.80)	ND (All ND)

Table 2–13 Means and ranges of muscle tissue contaminant concentrations in selected scorpaenid fishes collected by rig-fishing in September 2017 at Zones 1 (Outfall) and 3 (Non-outfall), as well as historical values and state and federal tissue thresholds. ND = Not Detected; N/A = Not Applicable.

Zone	Species	n	Standard Length (mm)	Percent Lipid	Mercury (mg/kg)	Arsenic (mg/kg)	Selenium (mg/kg)	ΣDDT (µg/kg)	ΣPCB (µg/kg)	ΣChlordane (µg/kg)	Dieldrin (µg/kg)
OCSD 2017-2018 values											
Non-outfall	*Sebastes caurinus* (Copper Rockfish)	3	267 (243-282)	0.86 (0.55-1.08)	0.11 (0.06-0.18)	1.12 (0.52-2.16)	0.30 (0.16-0.40)	6.50 (5.61-7.97)	ND (All ND)	ND (All ND)	ND (All ND)
Non-outfall	*Sebastes miniatus* (Vermilion Rockfish)	7	243 (228-255)	0.81 (0.36-1.28)	0.07 (0.05-0.10)	2.09 (1.07-3.24)	0.18 (0.07-0.31)	9.55 (4-16)	ND (All ND)	ND (All ND)	ND (All ND)
Outfall	*Sebastes caurinus* (Copper Rockfish)	2	305 (285-325)	1.00 (0.79-1.21)	0.11 (0.09-0.13)	1.80 (1.73-1.86)	0.58 (0.57-0.58)	10.29 (8.38-12.20)	0.74 (0-1.49)	ND (All ND)	ND (All ND)
Outfall	*Sebastes miniatus* (Vermilion Rockfish)	8	285 (265-315)	1.29 (0.42-3.82)	0.06 (0.05-0.07)	3.02 (2.19-4.67)	0.35 (0.17-0.60)	11.48 (4.78-35.10)	0.43 (0-3.41)	ND (All ND)	ND (All ND)
OCSD historical values (2007-2017 Fiscal Years)											
Non-outfall	*Sebastes caurinus* (Copper Rockfish)	7	329 (225-780)	0.57 (0-0.97)	0.12 (0.07-0.19)	1.86 (1.49-2.21)	0.85 (0.42-1.64)	21.33 (6.05-43)	2.29 (0-7.60)	ND (All ND)	ND (All ND)
Non-outfall	*Sebastes miniatus* (Vermilion Rockfish)	11	246 (215-295)	0.62 (0.34-1.26)	0.08 (0.05-0.20)	3.41 (1.84-10.30)	1.05 (0.68-1.54)	25.37 (6.91-99.20)	0.63 (0-2.46)	ND (All ND)	ND (All ND)
Outfall	*Sebastes caurinus* (Copper Rockfish)	15	277 (223-320)	0.61 (0-2)	0.11 (0.05-0.16)	1.64 (0.93-3.13)	0.84 (0.51-1.01)	9.95 (5.21-20.77)	3.55 (0-6.14)	ND (All ND)	ND (All ND)
Outfall	*Sebastes miniatus* (Vermilion Rockfish)	35	261 (149-317)	1.17 (0-3.67)	0.05 (0.02-0.08)	2.60 (0.68-5.89)	0.59 (0.23-0.88)	13.53 (0-58.30)	2.32 (0-17.24)	0.29 (0-8.80)	ND (All ND)
Tissue Thresholds											
	CA Advisory Tissue Level		N/A	N/A	0.44	N/A	15	2100	120	560	46
	Federal Action Level for edible tissue		N/A	N/A	1	N/A	N/A	5000	2000	300	300

Liver Histopathology

No histopathology analysis was conducted for the 2017-18 monitoring period (see Appendix A).

CONCLUSIONS

COP criteria for water quality were met, and state and federal bacterial standards were also met at offshore stations. Sediment quality was not affected as evidenced by the generally low concentration of chemical contaminants, the absence of sediment toxicity in controlled laboratory tests, and the presence of normal infaunal communities throughout the monitoring area. Fish and trawl invertebrate communities in the monitoring area were also diverse and healthy, and federal and state fish consumption guidelines were met. These results suggest that the receiving environment was not degraded by the discharge of treated wastewater, and as such, all permit compliance criteria were met in 2017-18 and environmental and human health were protected.

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CHAPTER 3
Regional Monitoring and Special Studies

INTRODUCTION

The Orange County Sanitation District (OCSD) operates under the requirements of a National Pollutant Discharge Elimination System (NPDES) permit issued jointly by the United States Environmental Protection Agency and the State of California Regional Water Quality Control Board (RWQCB) (Order No. R8-2012-0035, NPDES No. CA0110604) in June 2012. To document the effectiveness of its source control and wastewater treatment operations in protecting the coastal ocean, OCSD conducts an Ocean Monitoring Program (OMP) that includes Strategic Process Studies (SPS) and regional monitoring programs. In addition, OCSD performs special studies, which are generally less involved than SPS and have no regulatory requirement for prior approval or level of effort.

SPS are designed to address unanswered questions raised by the Core monitoring program results and focus on issues of interest to OCSD and its regulators, such as the effect of contaminants of emerging concern on local fish populations. SPS are proposed and must be approved by RWQCB to ensure appropriate focus and level of effort. For the 2017-18 program year, no SPS were conducted.

Regional monitoring studies focus on the larger areas of the Southern California Bight (SCB). These may include the "Bight" studies coordinated by the Southern California Coastal Water Research Project (SCCWRP) or studies conducted in coordination with other public agencies and/or non-governmental organizations in the region. Examples include the Central Region Kelp Survey Consortium and the Southern California Bight Regional Water Quality Program.

This chapter provides overviews of recently completed and ongoing studies and regional monitoring efforts. Unlike other chapters in this report, these summaries are not restricted to the most recent program year (i.e., July 2017-June 2018) and include the most recent information available to date. When appropriate, this information is also incorporated into other report chapters to supplement Core monitoring results. Links to final study reports, if available, are listed under each section below.

REGIONAL MONITORING

Regional Nearshore (Surfzone) Bacterial Sampling

OCSD partners with the Orange County Health Care Agency (OCHCA), the South Orange County Wastewater Authority, and the Orange County Public Works in the Ocean Water Protection Program, a regional bacterial sampling program that samples 126 stations along 42 miles (68 km) of coastline (from Seal Beach to San Clemente State Beach) and 70 miles (113 km) of harbor and bay frontage. OCSD samples 38 stations along 19 miles (31 km) of beach from Seal Beach to Crystal Cove State Beach (Figure 3-1).

OCHCA reviews bacteriological data to determine whether a station meets Ocean Water-Contact Sports Standards (i.e., Assembly Bill 411; AB411), and uses these results as the basis for health

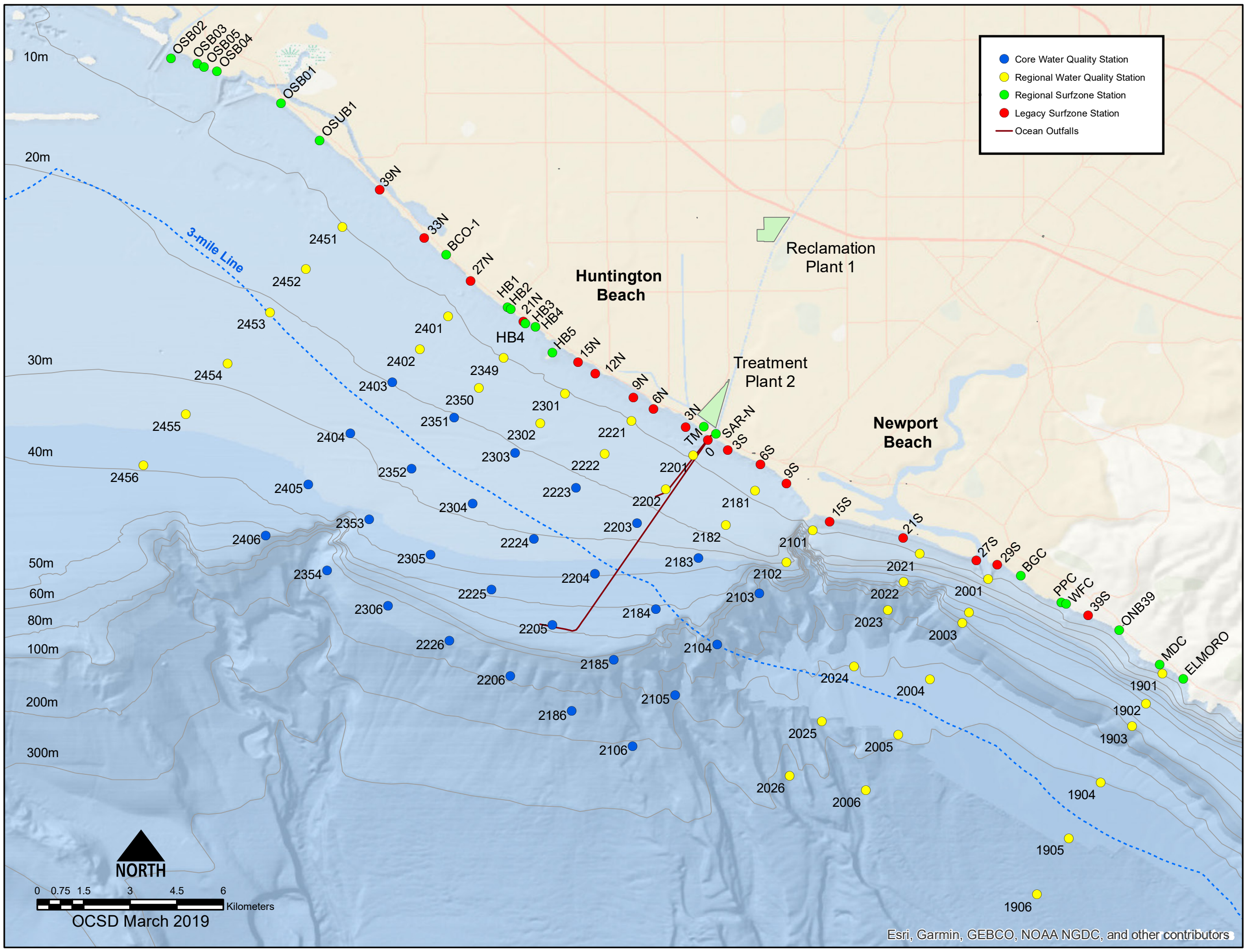

Figure 3–1 Offshore and nearshore (surfzone) water quality monitoring stations for 2017-18.

advisories, postings, or beach closures. In 2018, there were similar numbers of postings as in 2017 (88 versus 86), but a drop in the beach-mile days[1] (7.1 versus 11.5) (OCHCA 2018). Overall, since 2000, the area sampled by OCSD has seen a significant drop in both beach postings and beach-mile days (Figure 3-2).

Of the 38 OCSD-sampled regional surfzone stations, 18 are legacy (Core) stations sampled since the 1970s (Figure 3-1). For 2017-18, these stations (Table B-12) were analyzed separately from OCSD's regional surfzone stations (Table B-13). Results for the 18 legacy stations were similar to those of previous years (OCSD 2017, 2018) with fecal indicator counts varying by season, location, and bacteria type. A general spatial pattern was associated with the mouth of the Santa Ana River. Seasonal geomeans peaked near the river mouth and tapered off upcoast and downcoast.

Southern California Bight Regional Water Quality Program

OCSD is a member of a regional cooperative sampling effort known as the Southern California Bight Regional Water Quality Program (SCBRWQP; previously known as the Central Bight Regional Water Quality Monitoring Program) with the City of Oxnard, City of Los Angeles, the County Sanitation Districts of Los Angeles, and the City of San Diego. Each quarter, the participating agencies sample 301 stations that cover the coastal waters from Ventura County to Crystal Cove State Beach and from Point Loma to the United States–Mexico Border (Figure 3-3). The participants use comparable

[1] Beach-Mile Days = number of days x number of miles posted or closed.

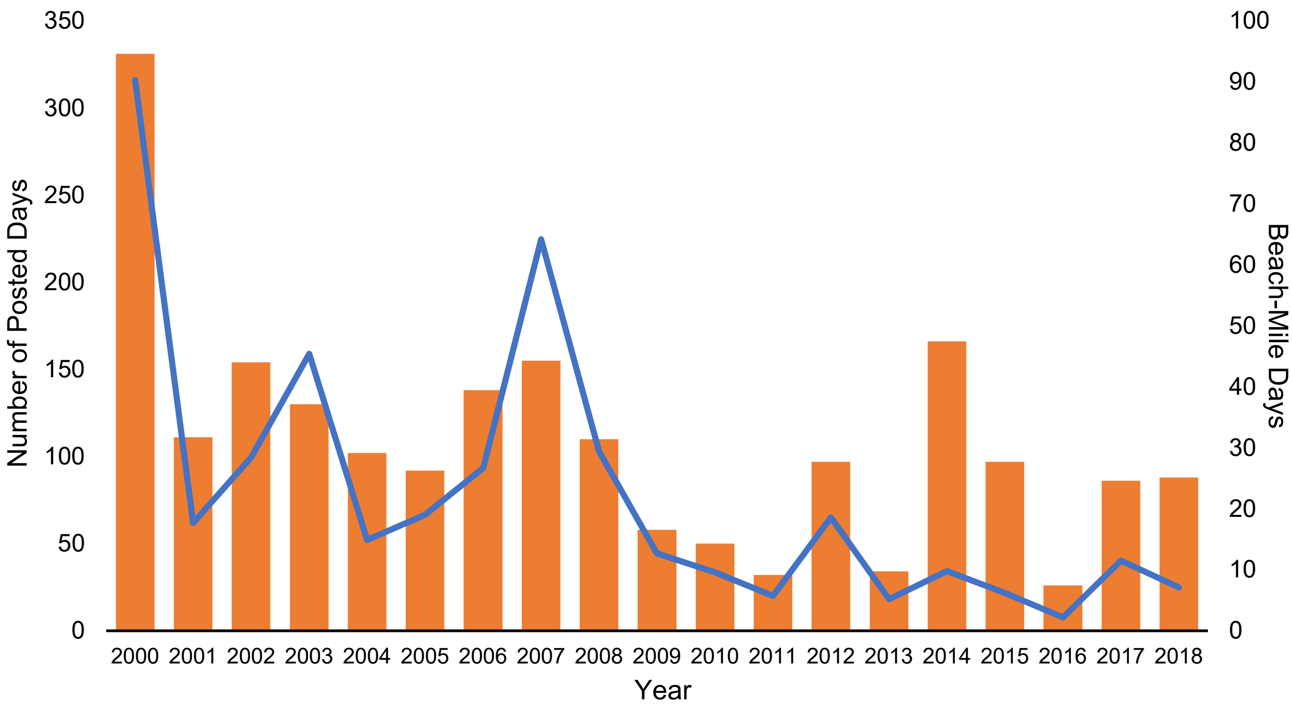

Figure 3–2 Annual (April 1-October 1) Posted Days (orange bars) and Beach-Mile Days (blue line) from Seal Beach to Crystal Cove State Beach, California (2000-2018).

conductivity-temperature-depth (aka CTD) profiling systems and field sampling methods. OCSD samples 66 stations, which includes the 28 Core water quality program stations, as part of this program (Figure 3-1). The SCBRWQP monitoring provides regional data that enhances the evaluation of water quality changes due to natural (e.g., upwelling) or anthropogenic discharges (e.g., outfalls and stormwater flows) and provides a regional context for comparisons with OCSD's monitoring results. The SCBRWQP serves as the basis for SCCWRP's Bight water quality sampling (see section below). Additionally, the group has been evaluating the establishment of data quality assurance guidelines and data quality flags for submitting data to the Southern California Coastal Ocean Observing System in order to comply with national Integrated Ocean Observing System guidelines.

Bight Regional Monitoring

Since 1994, OCSD has participated in 5 regional monitoring studies of environmental conditions within the SCB: 1994 Southern California Bight Pilot Project, Bight'98, Bight'03, Bight'08, and Bight'13. OCSD has played a considerable role in all aspects of these regional projects, including program design, sampling, quality assurance, data analysis, and reporting. Results from these efforts provide information that is used by individual dischargers, resource managers, and the public to improve region-wide understanding of environmental conditions and to provide a regional perspective for comparisons with data collected from individual point sources. During the summer of 2013, OCSD staff conducted field operations, ranging from Orange County south to Camp Pendleton in northern San Diego County and west to the southern end of Santa Catalina Island, as part of the Bight'13 sampling effort. Subsequent project activities included sample analysis, data quality review, data analysis, reporting, and designing the next Bight'18 regional program. Detailed project information and documentation are available on SCCWRP's website (http://www.sccwrp.org/about/research-areas/regional-monitoring/).

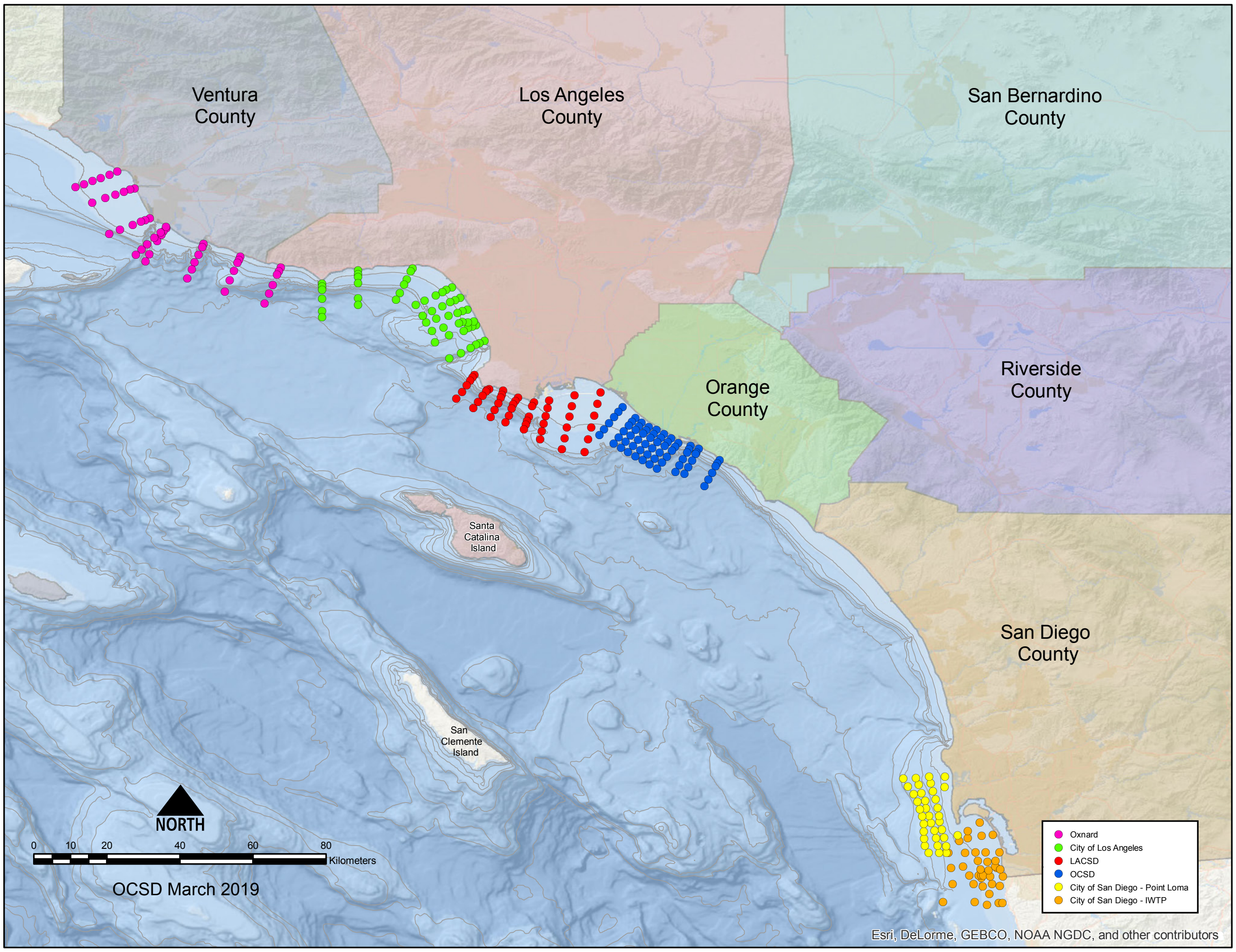

Figure 3–3 Southern California Bight Regional Water Quality Program monitoring stations for 2017-18.

Regional Kelp Survey Consortium – Central Region

OCSD is a member of the Central Region Kelp Survey Consortium (CRKSC), which was formed in 2003 to map giant kelp (*Macrocystis pyrifera*) beds off Ventura, Los Angeles, and Orange Counties via aerial photography. The program is modeled after the San Diego Regional Water Quality Control Board, Region Nine Kelp Survey Consortium, which began in 1983. Both consortiums sample quarterly to count the number of observable kelp beds and calculate maximum kelp canopy coverage. Combined, the CRKSC and San Diego aerial surveys provide synoptic coverage of kelp beds along approximately 81% of the 270 miles (435 km) of the southern California mainland coast from northern Ventura County to the United States–Mexico Border. Survey results are published and presented annually by MBC Applied Environmental Sciences (MBC 2018) to both consortium groups, regulators, and the public. Reports are available on SCCWRP's website (http://kelp.sccwrp.org/reports.html).

2017 CRKSC Results

While the total combined kelp surface canopy increased slightly (by 1.9%) in 2017, more individual beds decreased in size. Of the 26 beds, 10 exceeded 40% of their historical maximum size, including 3 that reached maximum levels recorded. Six beds declined to less than 10% of their maximum size. Overall, total kelp coverage has been at or above the long-term average every year for the past

10 years, although for the past 3 years it has been 18 to 27% below the peak 2009 coverage (6.406 km^2).

For the 4 survey areas nearest to OCSD's outfall, 3 (Horseshoe Kelp, Huntington Flats, and Huntington Flats to Newport Harbor) continued to show no surface canopy. The Newport/Irvine Coast beds showed a 1-year decrease of 8.3% in 2017 (0.036 km^2 to 0.033 km^2). It represented only 7.9% of the maximum canopy area recorded in 2011.

There was no evidence of any adverse effects on giant kelp resources from any of the region's dischargers. Rather, the regional kelp surveys continue to demonstrate that most kelp bed dynamics in the Central region are influenced by the large-scale oceanographic environment and micro-variations in local topography and currents that can cause anomalies in kelp bed performances.

Ocean Acidification Mooring

OCSD's Ocean Acidification Mooring was deployed for just over 7 months during the program year; routine service and maintenance, vessel scheduling, and technical issues with a telemetry modem prevented continuous deployment. During the course of the year, a second mooring was procured to address the primary issues of non-deployment status. Rotating the 2 moorings—swapping one with the other—should improve deployment and recovery schedules while allowing for routine maintenance and repairs of sensors on the off-cycle mooring.

SPECIAL STUDIES

California Ocean Plan Compliance Determination Method Comparison

Southern California ocean dischargers maintain extensive monitoring programs to assess their effects on ambient receiving water quality and to determine compliance with California Ocean Plan (COP) standards. However, historically each agency used a different approach for analyzing these data and determining COP compliance. In 2009, in collaboration with Southern California ocean dischargers, the State Water Resources Control Board and SCCWRP began developing a new method to establish an out-of-range occurrence (ORO) for dissolved oxygen (DO), pH, and light transmissivity. Appendix A contains the steps on how the comparison was compiled.

For 2017-18, the SCCWRP approach identified greater numbers of reference stations and fewer stations that did not meet COP criteria (Table 3-1). The probable source of these differences is the different approaches used in identifying reference stations, out-of-range values and statistical significance testing, and subsequently out-of-compliance (OOC). OCSD uses multiple parameters and contextual information (e.g., Is the station up-current of the outfall? Was there a large phytoplankton bloom?) and divides up the stations into 2 zones with one reference station per zone. SCCWRP's approach identifies plume impacted stations using CDOM only and compares those stations to a larger set of reference stations. As a result, SCCWRP can identify stations "impacted" due to natural variability. For example, in May 2018 SCCWRP identified an out-of-range value at a station 5 miles (8 km) up-current of the outfall.

One benefit of using the SCCWRP approach is its ability to be standardized among agencies. A disadvantage is disregarding plume transport by currents and changes due to natural variability. OCSD's approach identified a greater number of OROs/OOCs but it involved significant staff effort to interpret OROs, which would be harder to replicate across agencies.

Fish Tracking Study

Background

OCSD's OMP assesses discharge effects on marine communities, including bioaccumulation analyses of contaminants in tissue samples of flatfishes (predominantly Hornyhead Turbot and

Table 3–1 Number of stations comparison using OCSD and SCCWRP California Ocean Plan compliance determinations methodologies for dissolved oxygen, pH, and light transmissivity for 2017-18.

Survey	Plume Impacted		Reference		Out-of-Range		Out-of-Compliance	
	OCSD	SCCWRP	OCSD	SCCWRP	OCSD	SCCWRP	OCSD	SCCWRP
				Dissolved Oxygen				
Jul 2017	N/A	4	2	12	8	2	4	2
Aug 2017	N/A	4	2	13	12	0	5	0
Sep 2017	N/A	5	2	12	0	0	0	0
Oct 2017	N/A	4	2	11	2	0	1	0
Nov 2017	N/A	4	2	13	3	0	1	0
Dec 2017	N/A	4	2	15	0	0	0	0
Jan 2018	N/A	5	2	10	8	0	4	0
Feb 2018	N/A	3	2	16	0	0	0	0
Mar 2018	N/A	5	2	12	7	0	3	0
Apr 2018	N/A	4	2	16	1	0	1	0
May 2018	N/A	6	2	11	17	0	5	0
Jun 2018	N/A	5	2	13	11	2	3	2
				pH				
Jul 2017	N/A	4	2	12	1	0	0	0
Aug 2017	N/A	4	2	13	4	0	2	0
Sep 2017	N/A	5	2	12	0	0	0	0
Oct 2017	N/A	4	2	11	0	0	0	0
Nov 2017	N/A	4	2	13	0	0	0	0
Dec 2017	N/A	4	2	15	1	0	0	0
Jan 2018	N/A	5	2	10	2	0	1	0
Feb 2018	N/A	3	2	16	11	0	0	0
Mar 2018	N/A	5	2	12	4	0	2	0
Apr 2018	N/A	4	2	16	2	0	0	0
May 2018	N/A	6	2	11	3	0	1	0
Jun 2018	N/A	5	2	13	6	0	1	0
				Light Transmissivity				
Jul 2017	N/A	4	2	12	7	3	1	3
Aug 2017	N/A	4	2	13	7	1	0	0
Sep 2017	N/A	5	2	12	14	0	0	0
Oct 2017	N/A	4	2	11	3	1	0	1
Nov 2017	N/A	4	2	13	3	1	0	1
Dec 2017	N/A	4	2	15	18	0	1	0
Jan 2018	N/A	5	2	10	16	1	0	1
Feb 2018	N/A	3	2	16	18	0	0	0
Mar 2018	N/A	5	2	12	12	0	0	0
Apr 2018	N/A	4	2	16	25	0	9	0
May 2018	N/A	6	2	11	5	2	0	2
Jun 2018	N/A	5	2	13	3	3	0	3

N/A = Not Applicable.

English Sole; occasionally Pacific Sanddab) and rockfishes relative to background levels and human health consumption guidelines. In making these comparisons it is assumed that the location of capture is also the location of exposure. However, little is known about the movement patterns of sentinel fish species within OCSD's monitoring area. As such, OCSD contracted Professor Chris Lowe from California State University, Long Beach to conduct a fish tracking study using passive acoustic telemetry from 2017-2018 to understand the site fidelity and potential risk exposure of sentinel fishes at the outfall and a reference area.

<u>Methods</u>

Study area and instrumentation

Vemco Ltd. VR2W automated, omnidirectional acoustic receivers and 69 kHz Vemco Ltd. sync transmitters were deployed together in a grid at depths ranging from 35-65 m in January 2017 at the outfall and an upcoast reference area (Figure 3-4). The receivers and transmitters were moored together using 2 biodegradable sand bags and cotton rope fitted with a Sub Sea Sonics AR-50 underwater acoustic release. Four of these moorings also contained temperature loggers to aid in positional rendering of fish locations.

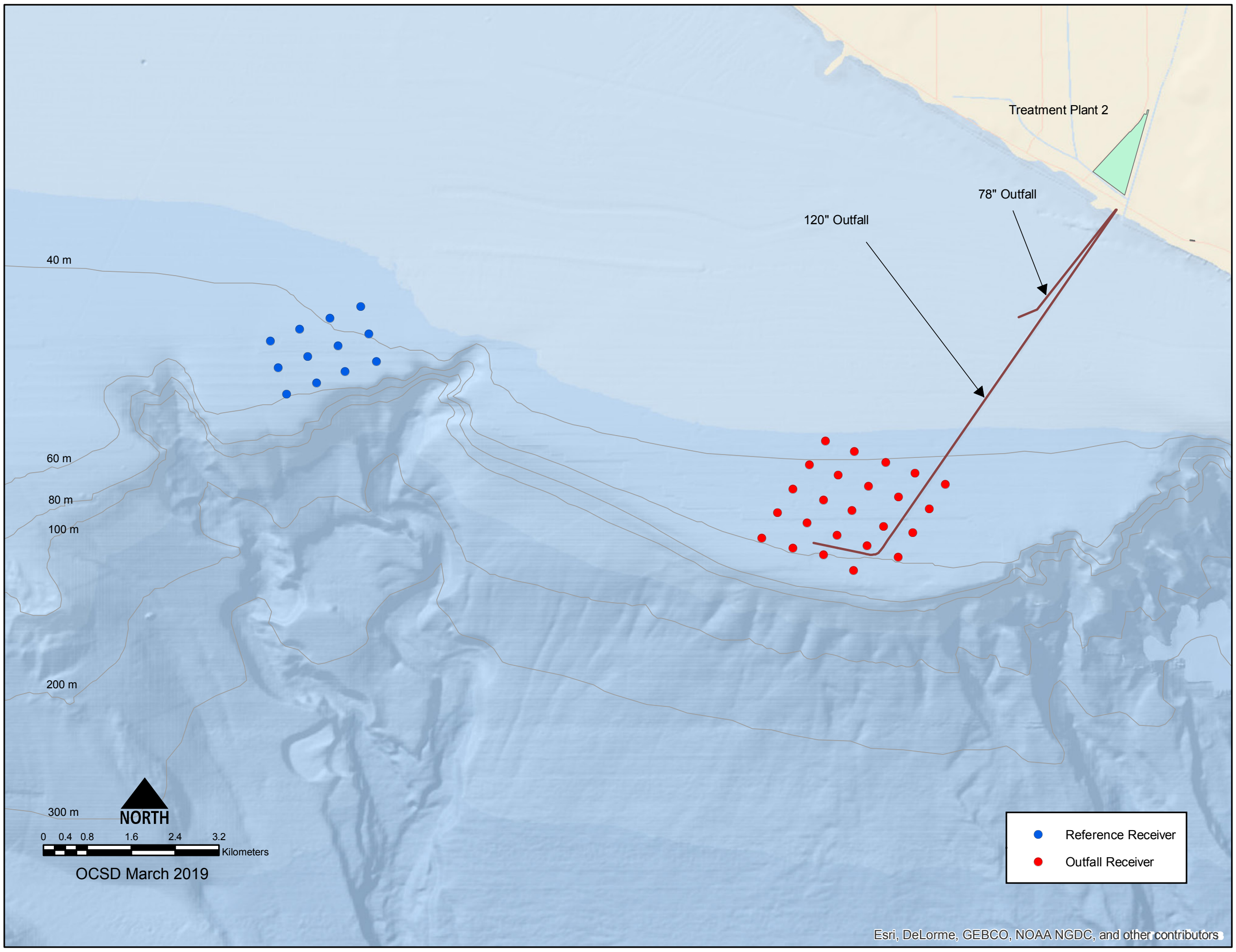

Figure 3–4 Acoustic receiver locations for OCSD's fish tracking study.

Fish collection and tagging

A total of 149 fishes were internally (i.e., California Scorpionfish and Vermilion Rockfish) or externally (i.e., English Sole, Hornyhead Turbot, and Pacific Sanddab) fitted with a Vemco Ltd. V9 coded tag (Table 3-2). Fish samples were caught either by trawls or rig fishing from OCSD's M/V *Nerissa* at the outfall and reference area between January 2017 and August 2018. Twenty Pacific Sanddab were tagged at the outfall but were subsequently released at the reference area; all other fish samples were released at the site of capture.

Table 3–2 Number of fishes tagged at the outfall and reference area for OCSD's fish tracking study.

Study area	Fish Family	Fish Species	Common Name	Number Tagged
Outfall	Paralichthyidae	*Citharichthys sordidus*	Pacific Sanddab	54 *
	Pleuronectidae	*Parophrys vetulus*	English Sole	6
		Pleuronichthys verticalis	Hornyhead Turbot	15
	Scorpaenidae	*Scorpaena guttata*	California Scorpionfish	2
		Sebastes miniatus	Vermilion Rockfish	55
			Total	**132**
Reference	Paralichthyidae	*Citharichthys sordidus*	Pacific Sanddab	5
	Pleuronectidae	*Parophrys vetulus*	English Sole	7
		Pleuronichthys verticalis	Hornyhead Turbot	2
	Scorpaenidae	*Scorpaena guttata*	California Scorpionfish	0
		Sebastes miniatus	Vermilion Rockfish	3
			Total	**17**

* Twenty of the 54 Pacific Sanddab tagged at the outfall were translocated to the reference area.

Data collection and analyses

Acoustic receivers were recovered in May 2017, October 2017, and March 2018 at the outfall and in April 2017, October 2017, and February 2018 at the reference area. Receivers were redeployed immediately after data from the receivers were downloaded to a laptop on the boat. Receiver data, tag information, and water temperature data were sent to Vemco Ltd. for position rendering after each download. Rendered fish positions were layered over detailed habitat maps (i.e., bathymetry and sediment parameters) in a geographic information system (aka GIS) for movement analysis. Preliminary calculations included: Euclidean distance measurements and selectivity indices to examine site selectivity, Brownian Bridge Kernel Utilization Distributions at 50% and 95% to examine area use on a variety of scales (i.e. entire track duration, each 24-hour period, each daylight period, each night period), and contaminant exposure calculations based on sediment-bound organochlorine concentrations gathered from OCSD's Core sediment geochemistry monitoring.

Results

Of the 149 fishes tagged, 145 were able to be positioned by VPS rendering. Ninety-five individuals were positioned in the outfall array only, 23 individuals were positioned in the reference array only, and 27 individuals were positioned in both arrays.

Preliminary data suggest that flatfishes are not appropriate indicator species of contaminant exposure. Individuals moved large distances and used different habitats each day (Figures 3-5 to 3-7). In addition, most individuals left receiver range within 2 months of tagging. The movement patterns that these species exhibit suggest a low likelihood of prolonged sediment-bound contaminant exposure at areas surrounding the outfall.

Rockfishes, on the other hand, are appropriate indicator species to monitor effluent effects because they used the same areas daily (Figures 3-8 and 3-9). These "resident" individuals spent the majority of their time within 150 m of the outfall diffuser section, which suggests that these individuals have a high probability of being persistently exposed to the effluent and the relatively higher sediment-bound contaminants in the outfall area.

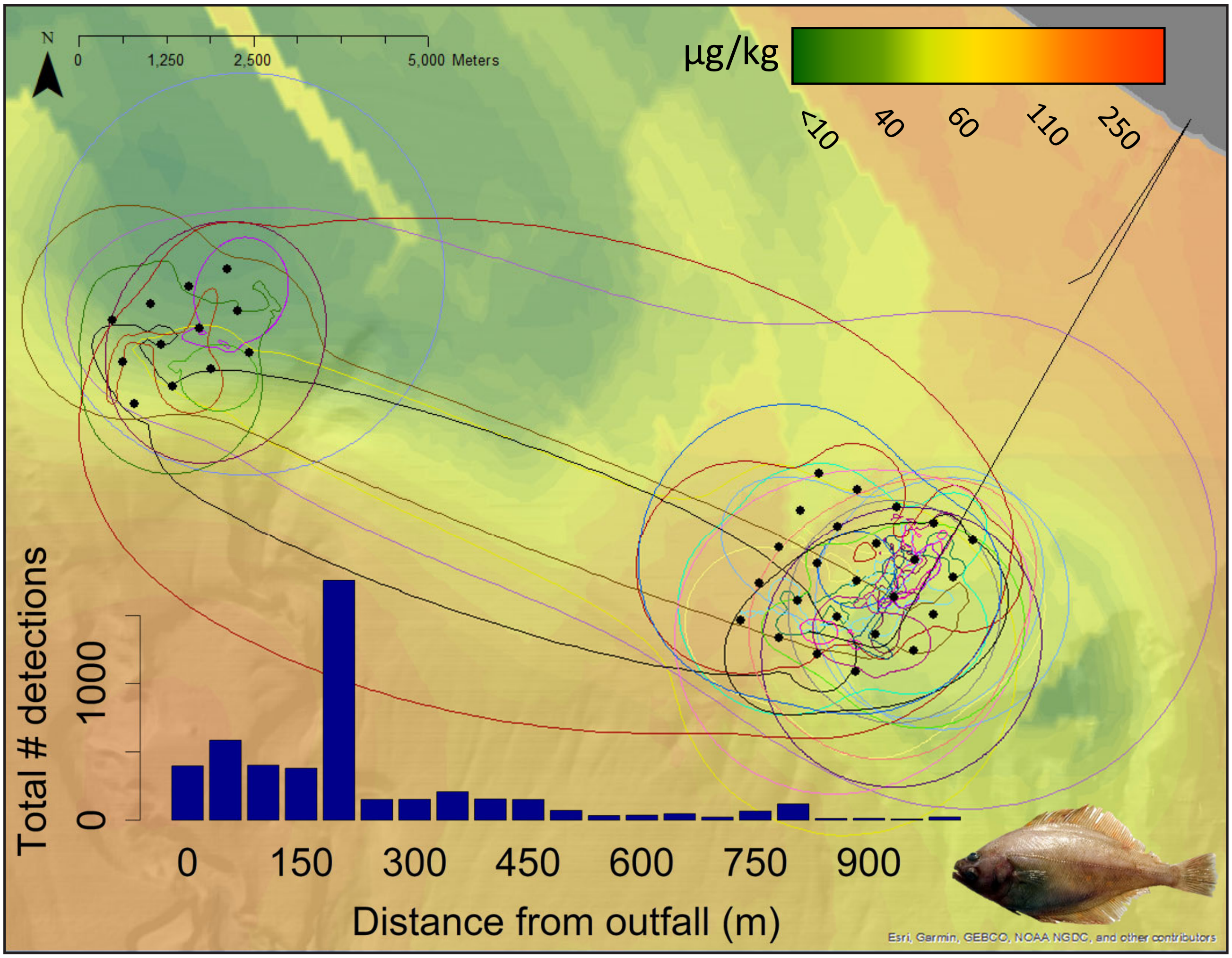

Figure 3–5 Euclidean distance measurement distributions for *Citharichthys sordidus* (Pacific Sanddab; n=34) displayed over a base map of total observed sediment organochlorine concentrations (total PCB, total DDT, and total PAH in µg/kg). Colored rings represent the areas in which a single individual spent 95% of its time while detected. Individuals tagged in the outfall array were detected for an average of 29.0±56.7 (SD) days before they left the array.

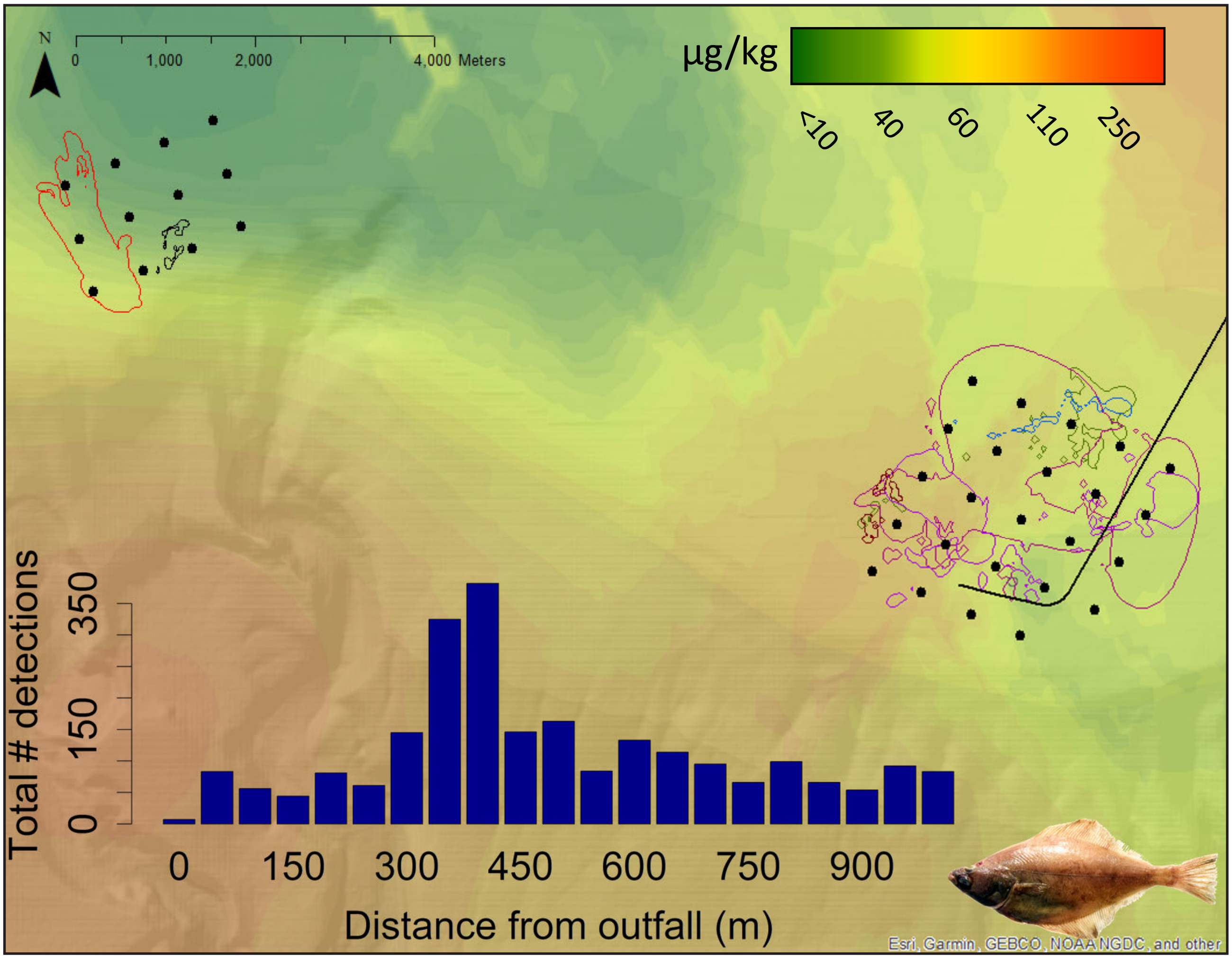

Figure 3–6 Euclidean distance measurement distributions for *Parophrys vetulus* (English Sole; n=6) displayed over a base map of total observed sediment organochlorine concentrations (total PCB, total DDT, and total PAH in µg/kg). Colored rings represent the areas in which a single individual spent 95% of its time while detected. Individuals tagged in the outfall array were detected for an average of 38.0±27.6 (SD) days before they left the array.

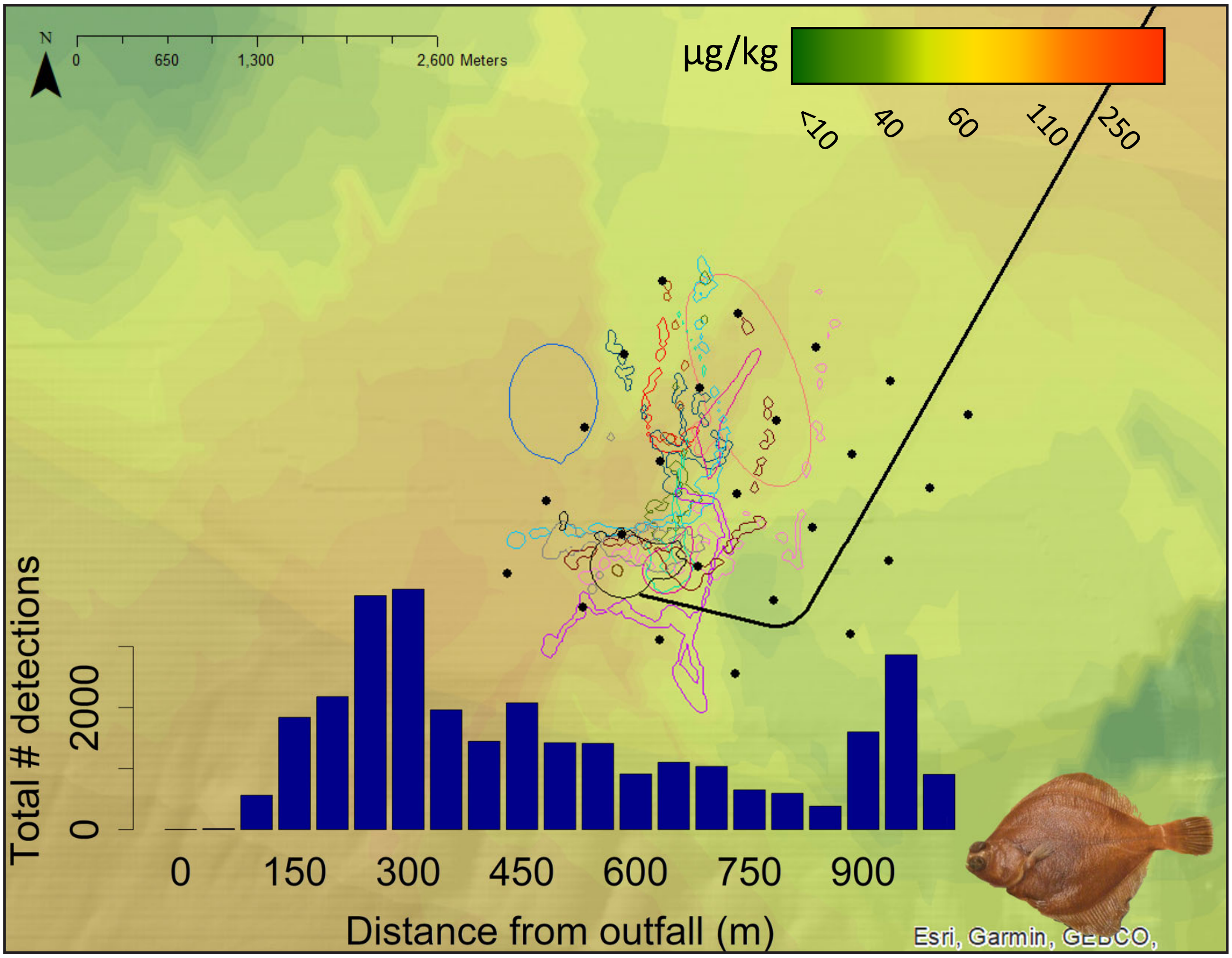

Figure 3–7 Euclidean distance measurement distributions for *Pleuronichthys verticalis* (Hornyhead Turbot; n=15) displayed over a base map of total observed sediment organochlorine concentrations (total PCB, total DDT, and total PAH in µg/kg). Colored rings represent the areas in which a single individual spent 95% of its time while detected. Individuals tagged in the outfall array were detected for an average of 46.5±35.6 (SD) days before they left the array.

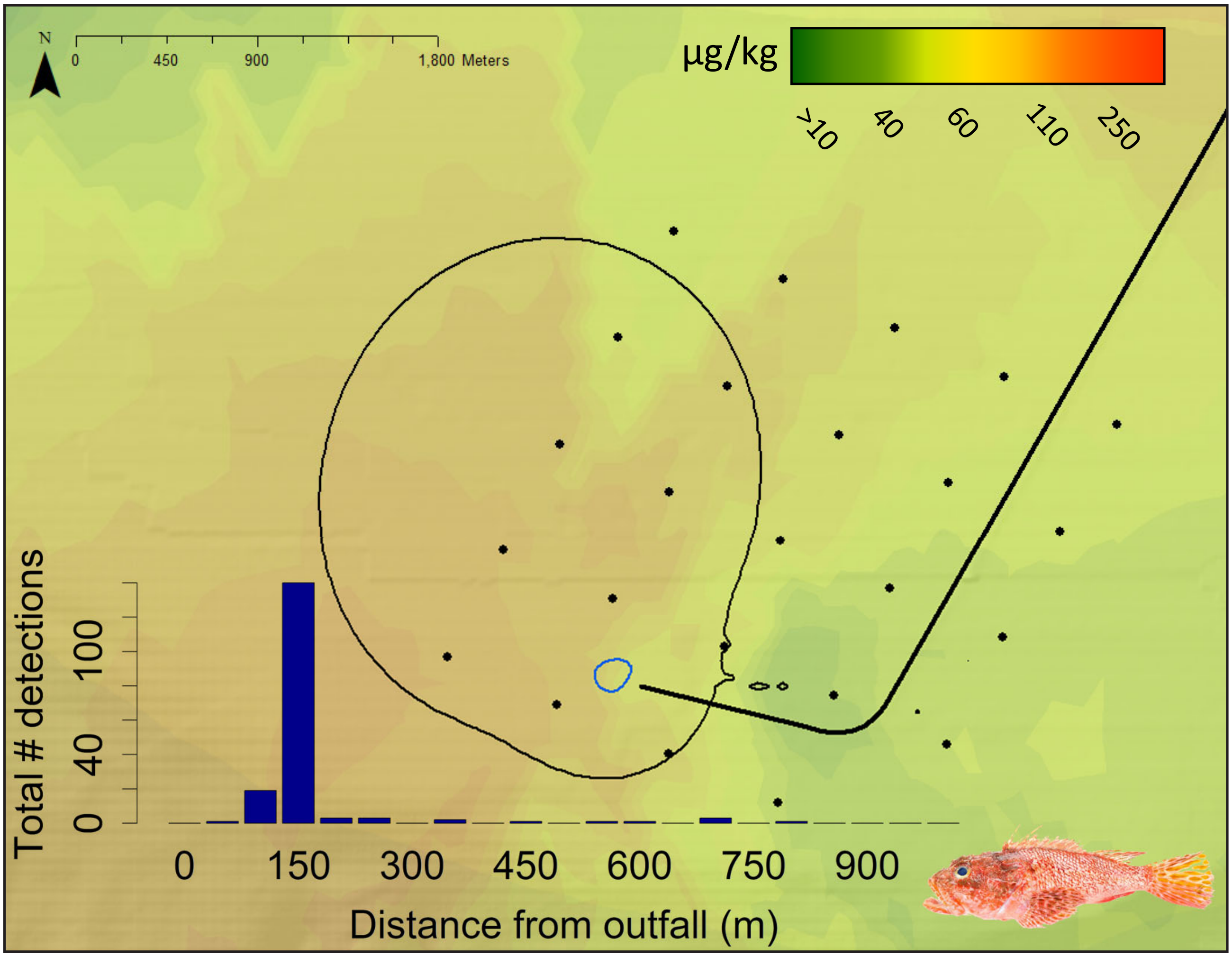

Figure 3–8 Euclidean distance measurement distributions for *Scorpaena guttata* (California Scorpionfish; n=2) displayed over a base map of total observed sediment organochlorine concentrations (total PCB, total DDT, and total PAH in µg/kg). Colored rings represent the areas in which a single individual spent 95% of its time while detected. Individuals tagged in the outfall array were detected for an average of 8.0 days before they left the array.

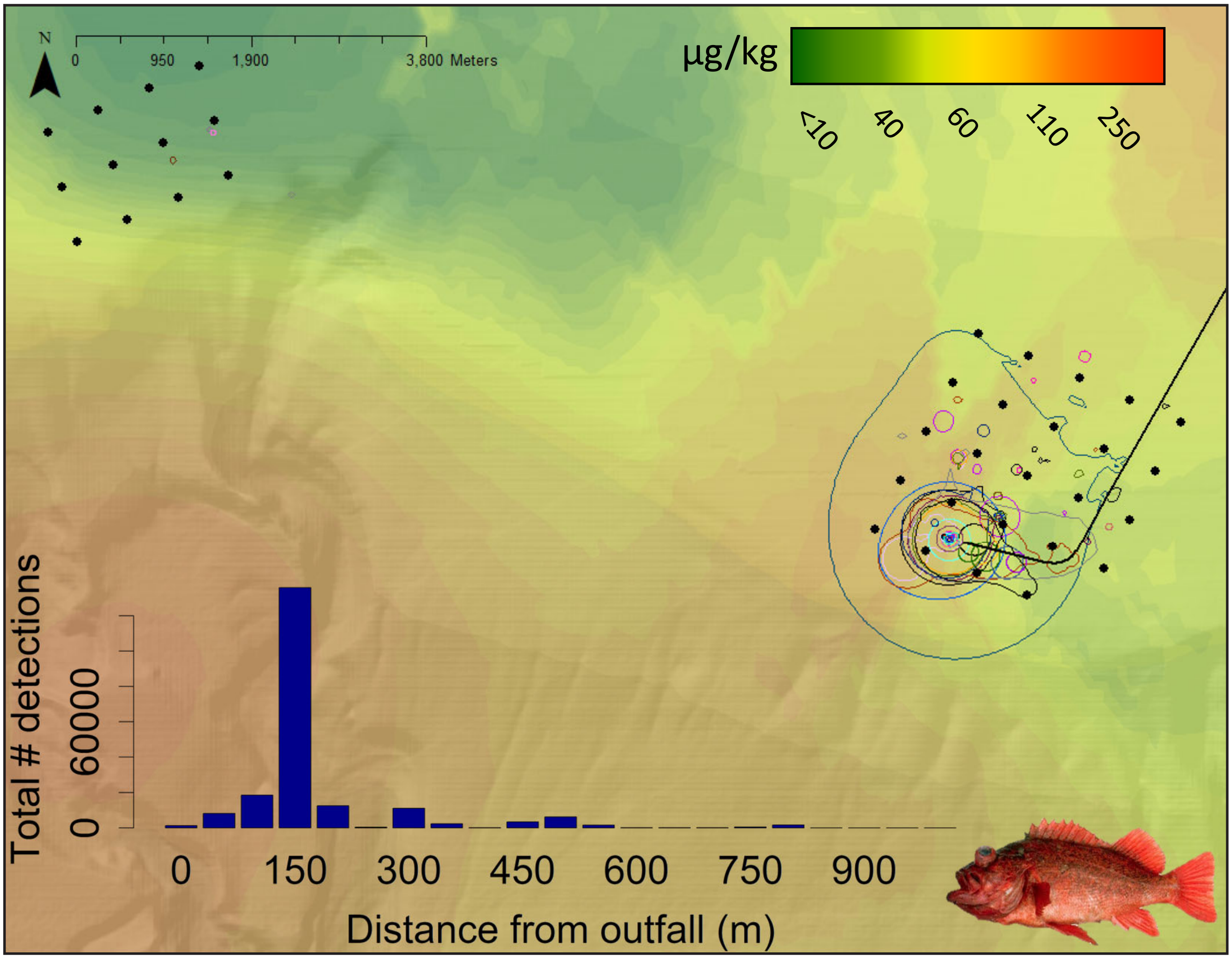

Figure 3–9 Euclidean distance measurement distributions for *Sebastes miniatus* (Vermilion Rockfish; n=55) displayed over a base map of total observed sediment organochlorine concentrations (total PCB, total DDT, and total PAH in µg/kg). Colored rings represent the areas in which a single individual spent 95% of its time while detected. Individuals tagged in the outfall array were detected for an average of 151.1±104.0 (SD) days before they left the array.

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APPENDIX A
Methods

INTRODUCTION

This appendix contains a summary of the field sampling, laboratory testing, and data analysis methods used for the Ocean Monitoring Program (OMP) at the Orange County Sanitation District (OCSD). The methods also include calculations of water quality compliance with California Ocean Plan (COP) criteria.

WATER QUALITY MONITORING

Field Methods

Offshore Zone

Permit-specified water quality monitoring was conducted 3 times per quarter at 28 stations (Figure 2-1). Eight stations located inshore of the 3-mile line of the coast are designated as areas used for water contact sports by the Regional Water Quality Control Board (i.e., waters designated as REC-1), and were sampled an additional 3 days per quarter for 3 fecal indicator bacteria (FIB), total and fecal coliform and enterococci. The additional surveys were conducted in order to calculate a 30-day geometric mean.

Each survey included measurements of pressure (from which depth is calculated), temperature, conductivity (from which salinity is calculated), dissolved oxygen (DO), acidity/alkalinity (pH), water clarity (light transmissivity, beam attenuation coefficient [beam-c], and photosynthetically active radiation [PAR]), chlorophyll-*a* fluorescence, and colored dissolved organic matter (CDOM). Measurements were conducted using a Sea-Bird Electronics SBE911 plus conductivity-temperature-depth (CTD) profiling system deployed from the M/V *Nerissa*. Profiling was conducted at each station from 1 m below the surface to 2 m above the bottom or to a maximum depth of 75 m when water depths exceeded 75 m. SEASOFT V2 (2017a) software was used for data acquisition, data display, and sensor calibration. PAR was measured in conjunction with chlorophyll-*a* because of the positive linkage between light intensity and photosynthesis per unit chlorophyll (Hardy 1993). Wind condition, sea state, and visual observations of floatable materials or grease that might be of sewage origin were also noted. Discrete water samples were collected using a Sea-Bird Electronics Carousel Water Sampler (SBE32) equipped with Niskin bottles for ammonium (NH3-N; for all 6 surveys per quarter) and FIB (for 5 of 6 surveys per quarter) analyses at specified stations and depths. All discrete samples were kept on wet ice in coolers and transported to OCSD's laboratory within 6 hours of collection. A summary of the sampling and analysis methods is presented in Table A-1.

Table A–1 Water quality sample collection and analysis methods by parameter for 2017-18.

Parameter	Sampling Method	Method Reference	Preservation	Container	Holding Time	Sampling Depth	Field Replicates
Nearshore (Surfzone)							
Total Coliforms Fecal Coliforms Enterococci	grab	Standard Methods 9222 B ** Standard Methods 9222 D ** EPA Method 1600 ***	Ice (<6 °C)	125 mL HDPE (Sterile container)	8 hrs. (field + lab)	Ankle-deep water	at least 10% of samples
Offshore							
Temperature [1]	*in-situ* probe	LMC SOP 1500.1 - CTD Operations	not applicable	not applicable	not applicable	every 1 m *	at least 10% of stations
Salinity (conductivity) [2]	*in-situ* probe	LMC SOP 1500.1 - CTD Operations	not applicable	not applicable	not applicable	every 1 m *	at least 10% of stations
pH [3]	*in-situ* probe	LMC SOP 1500.1 - CTD Operations	not applicable	not applicable	not applicable	every 1 m *	at least 10% of stations
Dissolved Oxygen [4]	*in-situ* probe	LMC SOP 1500.1 - CTD Operations	not applicable	not applicable	not applicable	every 1 m *	at least 10% of stations
Light Transmissivity [5]	*in-situ* probe	LMC SOP 1500.1 - CTD Operations	not applicable	not applicable	not applicable	every 1 m *	at least 10% of stations
Photosynthetically Active Radiation (PAR) [6]	*in-situ* probe	LMC SOP 1500.1 - CTD Operations	not applicable	not applicable	not applicable	every 1 m *	at least 10% of stations
Chlorophyll-*a* fluorescence [6]	*in-situ* probe	LMC SOP 1500.1 - CTD Operations	not applicable	not applicable	not applicable	every 1 m *	at least 10% of stations
Color Dissolved Organic Matter (CDOM) [6]	*in-situ* probe	LMC SOP 1500.1 - CTD Operations	not applicable	not applicable	not applicable	every 1 m *	at least 10% of stations
Ammonium (NH3-N)	Niskin	LMC SOP 4500-NH3.G, Rev. J **	Ice (<6 °C)	125 mL HDPE	28 days	Surface, 10m, 20m, 30m, 40m, 50m, 60m, Bottom	at least 10% of samples
Total Coliforms and *Escherichia coli* [7]	Niskin	Standard Methods 9223 C **	Ice (<6 °C)	125 mL HDPE (Sterile container)	8 hrs (field + lab)	Surface, 10m, 20m, 30m, 40m, 50m, 60m, Bottom	at least 10% of samples
Enterococci	Niskin	Standard Methods 9230 D	Ice (<6 °C)	125 mL HDPE (Sterile container)	8 hrs (field + lab)	Surface, 10m, 20m, 30m, 40m, 50m, 60m, Bottom	at least 10% of samples
Surface Observations	visual observations	Permit specs.	not applicable	not applicable	not applicable	surface	not applicable

[1] Calibrated to reference cells (0.0005 °C accuracy) annually.
[2] Calibrated to IAPSO Standard and Guildline 8400B Autosal annually.
[3] Referenced and calibrated to NIST buffers of pH 7, 8, and 9 prior to every survey.
[4] Referenced and calibrated each survey by comparison with the lab DO probe, which is calibrated daily.
[5] Referenced and calibrated to known transmittance in air.
[6] Factory calibrated annually.
[7] Fecal coliform count calculation: (*Escherichia coli* MPN/100mL x 1.1)
* Sampled continuously at 24 scans/second but data processed to 1 m intervals.
** APHA (2012).
*** Available online at: www.epa.gov.

Southern California Bight Regional Water Quality

An expanded grid of water quality stations was sampled quarterly as part of the Southern California Bight Regional Water Quality monitoring program. These 38 stations were sampled by OCSD in conjunction with the 28 Core water quality stations (Figure 3-1) and those of the County Sanitation Districts of Los Angeles, the City of Los Angeles, the City of Oxnard, and the City of San Diego. The total sampling area extends from the Ventura River in the north to the U.S./Mexico Border in the south, with a significant spatial gap between Crystal Cove State Beach and Mission Bay (Figure 3-3). Data were collected using CTDs within a fixed-grid pattern comprising 304 stations during a targeted period of 3–4 days. Parameters measured included pressure, water temperature, conductivity, DO, pH, chlorophyll-*a*, CDOM, and water clarity. Profiling was conducted from the surface to 2 m from the bottom or to a maximum depth of 100 m. OCSD's sampling and analytical methods were the same as those presented in Table A-1.

Nearshore Zone

Regional nearshore (also referred to as "surfzone") FIB samples were collected 1–2 days per week at a total of 38 stations (Figure 3-1). When creek/storm drain stations flowed to the ocean, 3 bacteriological samples were collected at the source, 25 yards downcoast, and 25 yards upcoast. When flow was absent, a single sample was collected 25 yards downcoast.

Samples were collected in ankle-deep water, with the mouth of the sterile bottle facing an incoming wave but away from both the sampler and ocean bottom. After the sample was taken, the bottle was tightly capped and promptly stored on ice in the dark. The occurrence and size of any grease particles at the high tide line were also recorded. Laboratory analysis of FIB samples began within 6 hours of collection.

Laboratory Methods

Laboratory analyses of NH3-N and bacteriology samples followed methods listed in Table A-1. Quality assurance/quality control procedures included analysis of laboratory blanks and duplicates. All data underwent at least 3 separate reviews prior to being included in the final database used for statistical analysis, comparison to standards, and data summaries.

Data Analyses

Raw CTD data were processed using both SEASOFT (2017b) and third party (IGODS 2012) software. The steps included retaining downcast data and removing potential outliers (i.e., data that exceeded specific sensor response criteria limits). Flagged data were removed if they were considered to be due to instrument failures, electrical noise (e.g., large data spikes), or physical interruptions of sensors (e.g., by bubbles) rather than by actual oceanographic events. After outlier removal, averaged 1 m depth values were prepared from the downcast data; if there were any missing 1 m depth values, then the upcast data were used as a replacement. CTD and discrete data were then combined to create a single data file that contained all sampled stations for each survey day.

Compliance Determinations

COP compliance was assessed based on: (1) specific numeric criteria for DO, pH, and FIB (Rec-1 zone only); and (2) narrative (non-numeric) criteria for transmissivity, floating particulates, oil and grease, water discoloration, beach grease, and excess nutrients.

Dissolved Oxygen, pH, and Transmissivity

Station locations were defined as either Zone A (inshore) or Zone B (offshore) as shown in Figure A-1. Compliance evaluations for DO, pH, and transmissivity were based on statistical comparisons to the corresponding Zone A or Zone B reference station located upcurrent of the outfall (OCSD 1999). For each survey, the depth of the pycnocline layer, if present, was calculated for each

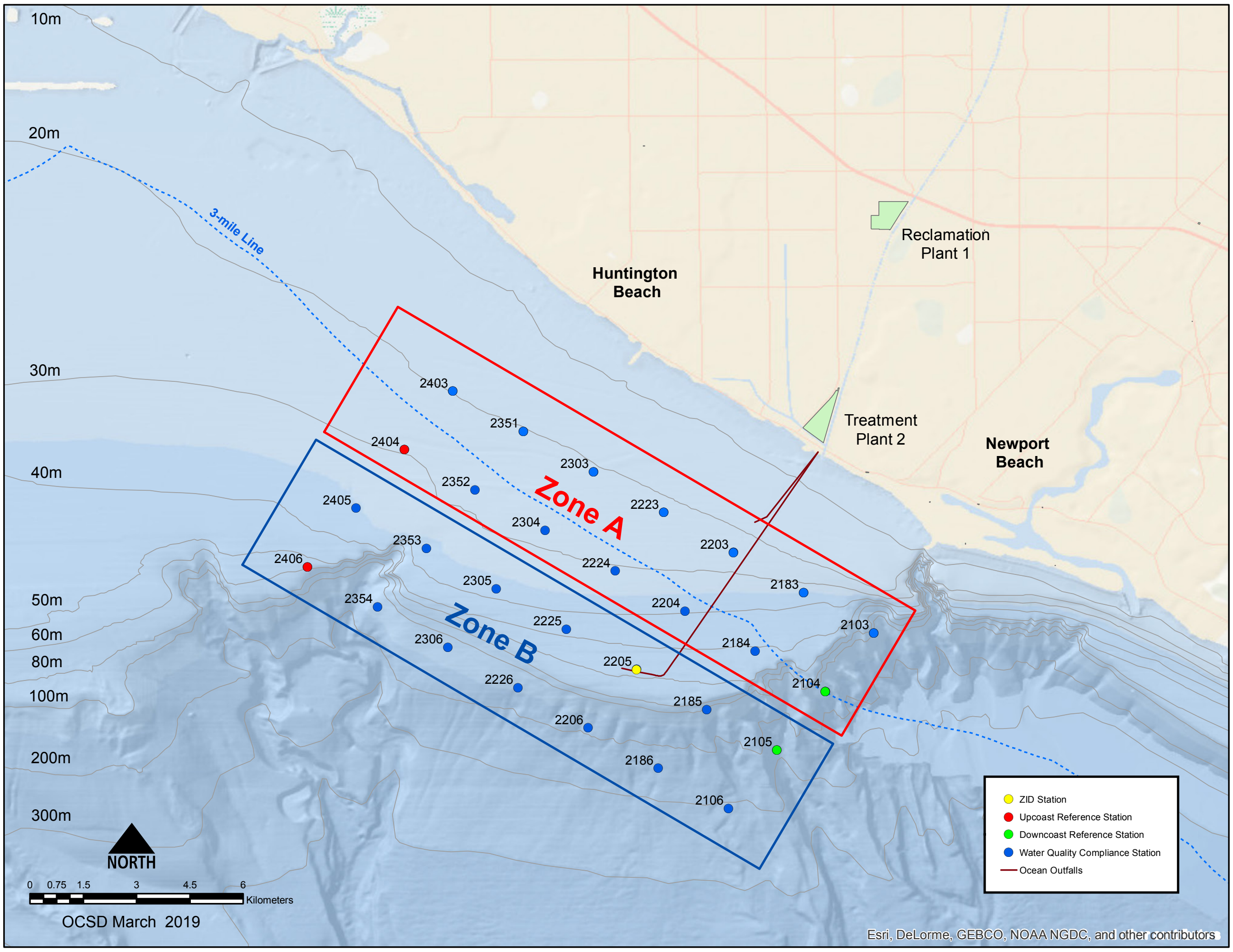

Figure A–1 Offshore water quality monitoring stations and zones used for compliance determinations.

station using density data. The pycnocline is defined as the depth layer where stability is greater than 0.05 kg/m^3 (Officer 1976). Data for each station and numeric compliance parameter (transmissivity, DO, and pH) were binned by water column stratum: above, within, or below the pycnocline. When a pycnocline was absent, data were binned into the top, middle, or bottom third of the water column for each station. Mean values for each parameter were calculated by stratum and station. The number of observations usually differed from station to station and survey to survey due to different water and pycnocline depths. The selection of appropriate reference stations (i.e., upcoast or downcoast) for each survey day were determined based on available current measurements and the presence or absence of typical plume "signals" (e.g., NH3-N, FIB, and CDOM). If the choice of a reference station was indeterminate, then the data were analyzed twice using both upcoast and downcoast reference stations. Once reference stations were determined, the data were analyzed using in-house MATLAB (2007) routines to calculate Out-of-Range occurrences (OROs) for each sampling date and parameter. These OROs were based on comparing the mean data by stratum and station with the corresponding reference station data to determine whether the following criteria were exceeded:

- Dissolved oxygen: cannot be depressed >10% below the mean;
- pH: cannot exceed ±0.2 pH units of the mean; and
- Natural light (defined as transmissivity): shall not be significantly reduced, where statistically different from the mean is defined as the lower 95% confidence limit.

In accordance with permit specifications, the outfall station (2205) was not included in the comparisons because it is within the zone of initial dilution (ZID).

To determine whether an ORO was Out-of-Compliance (OOC), distributional maps were created that identified the reference stations for each sampling date and location of each ORO, including which stratum was out of range. Each ORO was then evaluated to determine if it represented a logical OOC event. These evaluations were based on: (A) evaluation of the wastewater plume location relative to depth using a combination of temperature, density, salinity, CDOM, and when available, FIB and NH3-N; (B) evaluation of features in the water column relative to naturally occurring events (i.e., high chlorophyll-*a* due to phytoplankton); and (C) unique characteristics of some stations that may not be comparable with permit-specified reference stations (2104/2105 or 2404/2406) due to differences in water depth and/or variable oceanographic conditions. For example, some Zone A stations (e.g., 2403) are located at shallower depths than reference Station 2104. Waves and currents can cause greater mixing and resuspension of bottom sediments at shallower stations under certain conditions (e.g., winter storm surges). This can result in naturally decreased water clarity (transmissivity) that is unrelated to the wastewater discharge. An ORO can be in-compliance if, for example, a downcurrent station is different from the reference, but no intermediate (e.g., nearfield) stations exhibited OROs.

Once the total number of OOC events was summed by parameter, the percentage of OROs and OOCs were calculated according to the total number of observations. In a typical year, Zone A has a total of 468 possible comparisons if 13 stations (not including the reference station) and 3 strata over 12 survey dates per year are used. For Zone B, 432 comparisons are possible from 12 stations (not including the reference and outfall stations), 3 strata, and 12 sampling dates. The total combined number of ORO and OOC events was then determined by summing the Zone A and Zone B results. When all of the strata are not present (e.g., below thermocline at shallow stations) or additional surveys are conducted, the total number of comparisons in the analysis may be more or less than the target number of comparisons possible (900).

Compliance was also calculated using a method developed by Southern California Coastal Water Research Project (SCCWRP) in conjunction with its member agencies and the State Water Resources Control Board. The methodology involves 4 steps: (A) identification of the stations affected by effluent wastewater using CDOM, (B) selection of reference sampling sites representing "natural" conditions, (C) a per meter comparison between water quality profiles in the reference and plume-affected zones, and (D) calculation of maximum delta and comparison to COP standards to determine ORO_{SCCWRP}. Reference sites were selected from the areas around the outfalls, excluding the sites affected by the effluent. Reference density profiles are calculated and the profiles in the plume zone are compared to the reference profiles and a maximum difference value is used to establish the number of ORO_{SCCWRP}. Detailed methodology, as applied to dissolved oxygen, can be found in Nezlin et al. (2016).

The 2 methods differ in their approach to establishing OROs and the SCCWRP methodology does not calculate OOCs, therefore the following steps were taken to make the output of both approaches more comparable.

(1) The SCCWRP approach identifies a varying number of "plume impacted" and reference stations per survey while the OCSD method does not explicitly identify stations impacted by the plume and uses only 2 predetermined reference stations. For this analysis, only the number of reference stations can be directly compared.

(2) SCCWRP methodology compares only those values located below the mixed layer while the OCSD method includes surface values. For this comparison, all ORO_{OCSD} found in the upper part of the water column (i.e., Strata 1) were not considered.

(3) Under the OCSD approach, a station may have multiple ORO and/or OOC values on a given survey, while the SCCWRP approach identifies a single maximum difference value per station. Therefore, monthly station ORO_{OCSD} were recalculated as presence/absence when multiple ORO_{OCSD} occurred at a station.

(4) Unlike the OCSD method, the SCCWRP method does not provide a path to evaluate whether an ORO did or did not constitute an OOC. For this comparison, it was assumed that an ORO_{SCCWRP} was equivalent to the OOC_{OCSD} if it was located downcurrent from the outfall.

(5) SCCWRP methodology does not exclude the outfall station (2205) which is located within the ZID. For this analysis, any ORO_{SCCWRP} associated with Station 2205 was not included.

(6) SCCWRP methodology currently does not distinguish between positive and negative significant differences. For those instances when an ORO_{SCCWRP} was positive when the applicable COP criteria is relative to a negative impact, these OROs were not included.

Fecal Indicator Bacteria (FIB)

FIB compliance used corresponding bacterial standards at each REC-1 station and for stations outside the 3-mile state limit. FIB counts at individual REC-1 stations were averaged per survey and compliance for each FIB was determined using the following COP criteria (SWRCB 2010):

30-day Geometric Mean

- Total coliform density shall not exceed 1,000 per 100 mL.
- Fecal coliform density shall not exceed 200 per 100 mL.
- Enterococci density shall not exceed 35 per 100 mL.

Single Sample Maximum

- Total coliform density shall not exceed 10,000 per 100 mL.
- Fecal coliform density shall not exceed 400 per 100 mL.
- Enterococci density shall not exceed 104 per 100 mL.
- Total coliform density shall not exceed 1,000 per 100 mL when the fecal coliform/total coliform ratio exceeds 0.1.

Determinations of fecal coliform compliance were accomplished by multiplying *E. coli* data by 1.1 to obtain a calculated fecal coliform value.

There are no compliance criteria for FIB at the nearshore stations. Nevertheless, FIB data were given to the Orange County Health Agency (which follows State Department of Health Service AB411 standards) for the Ocean Water Protection Program (http://ocbeachinfo.com/) and are briefly discussed in Chapter 3.

Nutrients and Aesthetics

These compliance determinations were done based on presence/absence and level of potential effect at each station. Station groupings are shown in Table B-4 and are based on relative distance and direction from the outfall. Compliance for the floating particulates, oil and grease, and water discoloration were determined based on presence/absence at the ocean surface for each station. Compliance with the excess nutrient criterion was based on evaluation of NH3-N compared to COP objectives for chronic (4 mg/L) and acute (6 mg/L) toxicity to marine organisms. Compliance was also evaluated by looking at potential spatial relationships between NH3-N distribution and phytoplankton (using chlorophyll-*a* fluorescence).

SEDIMENT GEOCHEMISTRY MONITORING

Field Methods

Sediment samples were collected for geochemistry analyses from 29 semi-annual stations in July 2017 (summer) and in January 2018 (winter), as well as from 39 annual stations in July 2017 (Figure 2-2). In addition, 2–3 L of sediment was collected from Stations 0, 1, 4, 72, 73, 76, 77, CON, and ZB in January 2018 for sediment toxicity testing. Each station was assigned to 1 of 6 station groups: (1) Middle Shelf Zone 1 (31–50 m); (2) Middle Shelf Zone 2, within-ZID (51–90 m); (3) Middle Shelf Zone 2, non-ZID (51–90 m); (4) Middle Shelf Zone 3 (91–120 m); (5) Outer Shelf (121–200 m); and (6) Upper Slope/Canyon (201–500 m). In Chapter 2, the Middle Shelf Zone 2, within- and non-ZID station groups are simply referred to as within-ZID and non-ZID stations, respectively.

A single sample was collected at each station using a paired 0.1 m^2 Van Veen grab sampler deployed from the M/V *Nerissa*. All sediment samples were qualitatively and quantitatively assessed for acceptability prior to processing. Samples were deemed acceptable if they had a minimum depth of 5 cm. However, if 3 consecutive sediment grabs each yielded a depth of <5 cm at a station, then the depth threshold was lowered to ≤4 cm. The top 2 cm of the sample was transferred into containers using a stainless steel scoop (Table A-2). The sampler and scoop were rinsed thoroughly with filtered seawater prior to sample collection. All sediment samples were transported on wet ice to the laboratory. Sample storage and holding times followed specifications in OCSD's Laboratory, Monitoring, and Compliance Standard Operating Procedures (LMC SOP) (Table A-2; OCSD 2016).

Table A–2 Sediment collection and analysis summary for 2017-18.

Parameter	Container	Preservation	Holding Time	Method
Dissolved Sulfides	HDPE container	Freeze	6 months	LMC SOP 4500-S G Rev. B
Grain Size	Plastic bag	4 °C	6 months	Plumb (1981)
Mercury	Amber glass jar	Freeze	6 months	LMC SOP 245.1B Rev. G
Metals	Amber glass jar	Freeze	6 months	LMC SOP 200.8B_SED Rev. F
Sediment Toxicity	HDPE container	4 °C	2 months	LMC SOP 8810
Total Chlorinated Pesticides (ΣPest)	Glass jar	Freeze	6 months	LMC SOP 8000-SPP
Total DDT (ΣDDT)	Glass jar	Freeze	6 months	LMC SOP 8000-SPP
Total Nitrogen (TN)	Glass jar	Freeze	6 months	EPA 351.2M and 353.2M *
Total Organic Carbon (TOC)	Glass jar	Freeze	6 months	ASTM D4129-05 *
Total Phosphorus (TP)	Glass jar	Freeze	6 months	EPA 6010B *
Total Polychlorinated Biphenyls (ΣPCB)	Glass jar	Freeze	6 months	LMC SOP 8000-SPP
Total Polycyclic Aromatic Hydrocarbons (ΣPAH)	Glass jar	Freeze	6 months	LMC SOP 8000-PAH

* Available online at: www.epa.gov.

Laboratory Methods

Sediment grain size, total organic carbon, total nitrogen, and total phosphorus samples were subsequently transferred to local and interstate laboratories for analysis (see Appendix C). Sample transfers were conducted and documented using required chain of custody protocols through the Laboratory Information Management Systems software. All other analyses were conducted by OCSD lab staff.

Sediment chemistry and grain size samples were processed and analyzed using the methods listed in Table A-2. The measured sediment chemistry parameters are listed in Table A-3. Method blanks, analytical quality control samples (duplicates, matrix spikes, and blank spikes), and standard reference materials were prepared and analyzed with each sample batch. Total polychlorinated biphenyls (ΣPCB) and total polycyclic aromatic hydrocarbons (ΣPAH) were calculated by summing the measured value of each respective constituent listed in Table A-3. Total dichlorodiphenyltrichloroethane (ΣDDT) represents the summed values of 4,4'-DDMU and the 2,4- and 4,4'-isomers of DDD, DDE, and DDT, and total chlorinated pesticides (ΣPest) represents the summed values of 13 chlordane derivative compounds plus dieldrin.

Table A–3 Parameters measured in sediment samples for 2017-18.

		Metals	
Antimony	Cadmium	Lead	Selenium
Arsenic	Chromium	Mercury	Silver
Barium	Copper	Nickel	Zinc
Beryllium			
		Organochlorine Pesticides	
		Chlordane Derivatives and Dieldrin	
Aldrin	Endosulfan-alpha	*gamma*-BHC	Hexachlorobenzene
cis-Chlordane	Endosulfan-beta	Heptachlor	Mirex
trans-Chlordane	Endosulfan-sulfate	Heptachlor epoxide	*trans*-Nonachlor
Dieldrin	Endrin		
		DDT Derivatives	
2,4’-DDD	2,4’-DDE	2,4’-DDT	4,4’-DDMU
4,4’-DDD	4,4’-DDE	4,4’-DDT	
		Polychlorinated Biphenyl (PCB) Congeners	
PCB 18	PCB 81	PCB 126	PCB 170
PCB 28	PCB 87	PCB 128	PCB 177
PCB 37	PCB 99	PCB 138	PCB 180
PCB 44	PCB 101	PCB 149	PCB 183
PCB 49	PCB 105	PCB 151	PCB 187
PCB 52	PCB 110	PCB 153/168	PCB 189
PCB 66	PCB 114	PCB 156	PCB 194
PCB 70	PCB 118	PCB 157	PCB 201
PCB 74	PCB 119	PCB 167	PCB 206
PCB 77	PCB 123	PCB 169	
		Polycyclic Aromatic Hydrocarbon (PAH) Compounds	
Acenaphthene	Benzo[g,h,i]perylene	Fluoranthene	1-Methylnaphthalene
Acenaphthylene	Benzo[k]fluoranthene	Fluorene	2-Methylnaphthalene
Anthracene	Biphenyl	Indeno[1,2,3-c,d]pyrene	2,6-Dimethylnaphthalene
Benz[a]anthracene	Chrysene	Naphthalene	1,6,7-Trimethylnaphthalene
Benzo[a]pyrene	Dibenz[a,h]anthracene	Perylene	2,3,6-Trimethylnaphthalene
Benzo[b]fluoranthene	Dibenzothiophene	Phenanthrene	1-Methylphenanthrene
Benzo[e]pyrene		Pyrene	
		Other Parameters	
Dissolved Sulfides	Total Nitrogen	Total Organic Carbon	Total Phosphorus
Grain Size			

Sediment toxicity was conducted using the 10-day *Eohaustorius estuarius* amphipod survival test (EPA 1994). Amphipods were exposed to test and home (control) sediments, and the percent survival in each was determined.

Data Analyses

All analytes that were undetected (i.e., value below the method detection limit) are reported as not detected (ND). Further, an ND value was treated as zero for calculating a mean analyte concentration; however, if a station group contained all ND for a particular analyte, then the mean analyte concentration is reported as ND. Sediment contaminant concentrations were evaluated against sediment quality guidelines known as Effects Range-Median (ERM) (Long et al. 1998). The ERM guidelines were developed for the National Oceanic and Atmospheric Administration National Status and Trends Program (NOAA 1993) as non-regulatory benchmarks to aid in the interpretation of sediment chemistry data and to complement toxicity, bioaccumulation, and benthic community assessments (Long and MacDonald 1998). The ERM is the 50th percentile sediment concentration above which a toxic effect frequently occurs (Long et al. 1995), and as such, an ERM exceedance is considered a significant potential for adverse biological effects. Bight’13 sediment geochemistry data (Dodder et al. 2016) were also used as benchmarks. Data analysis consisted of summary statistics and qualitative comparisons only.

Toxicity threshold criteria applied in this report were consistent with those of the Water Quality Control Plan for Enclosed Bays and Estuaries – Part 1 Sediment Quality (Bay et al. 2009, SWRCB 2009). Stations with statistically different ($p<0.05$) survival rates when compared to the control, determined by a two-sample t-test, were categorized as nontoxic when survival was 90–100% of the control, lowly toxic when survival was 82–89% of the control, and moderately toxic when survival was

59–81% of the control. Stations with no statistically different (p>0.05) survival rates when compared to the control were categorized as nontoxic when survival was 82–100% of the control and lowly toxic when survival was 59–81% of the control. Any station exhibiting survival less than 59% of the control was categorized as highly toxic.

BENTHIC INFAUNA MONITORING

Field Methods

A paired, 0.1 m^2 Van Veen grab sampler deployed from the M/V *Nerissa* was used to collect a sediment sample from 29 semi-annual stations in July 2017 (summer) and in January 2018 (winter), as well as from 39 annual stations in July 2017 (Figure 2-2). The purpose of the semi-annual surveys was to determine long-term trends and potential effects along the 60-m depth contour, while the annual survey was conducted primarily to assess the spatial extent of the influence of the effluent discharge. Each station was assigned to 1 of 6 depth categories as described above in the sediment geochemistry field methods section.

All sediment samples were qualitatively and quantitatively assessed for acceptability prior to processing as described above in the sediment geochemistry field methods section. At each station, acceptable sediment in the sampler was emptied into a 63.5 cm × 45.7 cm × 20.3 cm (25 in × 18 in × 8 in) plastic tray and then decanted onto a sieving table whereupon a hose with a fan spray nozzle was used to gently wash the sediment with filtered seawater through a 40.6 cm × 40.6 cm (16 in × 16 in), 1.0 mm sieve. Organisms retained on the sieve were rinsed with 7% magnesium sulfate anesthetic into one or more 1 L plastic containers and then placed in a cooler containing ice packs. After approximately 30 minutes in the anesthetic, animals were fixed by adding full strength buffered formaldehyde to the container to achieve a 10%, by volume, solution. Samples were transported to OCSD's laboratory for further processing.

Laboratory Methods

After 3–10 days in formalin, samples were rinsed with tap water and then transferred to 70% ethanol for long-term preservation. Samples were sent to Marine Taxonomic Services, Inc. (San Marcos, CA) and Aquatic Bioassay and Consulting Laboratories, Inc. (Ventura, CA), where they were sorted to 5 major taxonomic groups (aliquots): Annelida (worms), Mollusca (snails, clams, etc.), Arthropoda (shrimps, crabs, etc.), Echinodermata (sea stars, sea urchins, etc.), and miscellaneous phyla (Cnidaria, Nemertea, etc.). Removal of organisms was monitored to ensure that at least 95% of all organisms were successfully separated from the sediment matrix (see Appendix C). Upon completion of sample sorting, the major taxonomic groups were distributed for identification and enumeration (Table A-4). Taxonomic differences were resolved and the database

Table A–4 Benthic infauna taxonomic aliquot distribution for 2017-18.

Quarter	Survey (No. of samples)	Taxonomic Aliquots	Contractor	OCSD
Summer 2017	Annual (39)	Annelida	10	29
		Arthropoda	0	39
		Echinodermata	0	39
		Mollusca	19	20
		Miscellaneous Phyla	0	39
	Semi-annual (29)	Annelida	9	20
		Arthropoda	0	29
		Echinodermata	29	0
		Mollusca	15	14
		Miscellaneous Phyla	0	29
Winter 2018	Semi-annual (29)	Annelida	29	0
		Arthropoda	29	0
		Echinodermata	29	0
		Mollusca	15	14
		Miscellaneous Phyla	29	0
		Totals	**213**	**272**

was edited accordingly (see Appendix C). Species names used in this report follow those given in Cadien and Lovell (2016).

Data Analyses

Infaunal community data were analyzed to determine if populations outside the ZID were affected by the outfall discharge. Six community measures were used to assess infaunal community health and function: (1) total number of species (richness), (2) total number of individuals (abundance), (3) Shannon-Wiener Diversity (H′), (4) Swartz's 75% Dominance Index (SDI), (5) Infaunal Trophic Index (ITI), and (6) Benthic Response Index (BRI). H′ was calculated using $\log_e$ (Zar 1999). SDI was calculated as the minimum number of species with combined abundance equal to 75% of the individuals in the sample (Swartz 1978). SDI is inversely proportional to numerical dominance, thus a low index value indicates high dominance (i.e., a community dominated by a few species). The ITI was developed by Word (1978, 1990) to provide a measure of infaunal community "health" based on a species' mode of feeding (e.g., primarily suspension vs. deposit feeder). ITI values greater than 60 are considered indicative of a "normal" community, while 30–60 represent a "changed" community, and values less than 30 indicate a "degraded" community. The BRI measures the pollution tolerance of species on an abundance-weighted average basis (Smith et al. 2001). This measure is scaled inversely to ITI with low values (<25) representing reference conditions and high values (>72) representing defaunation or the exclusion of most species. The intermediate value range of 25–34 indicates a marginal deviation from reference conditions, 35–44 indicates a loss of biodiversity, and 45–72 indicates a loss of community function. The ITI and BRI were not calculated for stations >200 m in depth following recommendations provided by Word (1978) and Ranasinghe et al. (2012), respectively. The BRI was used to determine compliance with NPDES permit conditions, as it is a commonly used Southern California benchmark for infaunal community structure and was developed with the input of regulators (Ranasinghe et al. 2007, 2012). OCSD's historical infauna data from the past 10 monitoring periods, as well as Bight'13 infauna data (Gillett et al. 2017), were also used as benchmarks.

The presence or absence of certain indicator species (pollution sensitive and pollution tolerant) was also determined for each station. The presence of pollution sensitive species, i.e., *Amphiodia urtica* (brittlestar) and amphipod crustaceans in the genera *Ampelisca* and *Rhepoxynius*, typically indicates the existence of a healthy environment, while the occurrence of large numbers of pollution tolerant species, i.e., *Capitella capitata* Cmplx (polychaete), may indicate stressed or organically enriched environments. Patterns of these species were used to assess the spatial and temporal influence of the wastewater discharge in the receiving environment.

PRIMER v7 (2015) multivariate statistical software was also used to examine the spatial patterns of infaunal invertebrate communities at the Middle Shelf Zone 2 stations. The other stations were excluded from the analyses, as Clarke and Warwick (2014) advocated that clustering is less useful and may be misleading where there is a strong environmental forcing, such as depth. Analyses included (1) hierarchical clustering with group-average linking based on Bray-Curtis similarity indices and similarity profile (SIMPROF) permutation tests of the clusters and (2) ordination of the same data using non-metric multidimensional scaling (nMDS) to confirm hierarchical clustering. Prior to the calculation of the Bray-Curtis indices, the data were fourth root transformed in order to down-weight the highly abundant species and to incorporate the less common species (Clarke and Warwick 2014).

TRAWL COMMUNITIES MONITORING

Field Methods

Demersal fishes and epibenthic macroinvertebrates (EMIs) were collected by trawling in August 2017 (summer) and in January 2018 (winter). Sampling was conducted at 15 stations: Inner Shelf

(18 m) Station T0; Middle Shelf Zone 1 (36 m) Stations T2, T24, T6, and T18; Middle Shelf Zone 2 (60 m) Stations T23, T22, T1, T12, T17, and T11; and Outer Shelf (137 m) Stations T10, T25, T14, and T19 (Figure 2-3). Only Middle Shelf Zone 2 stations were sampled in both summer and winter; the remaining stations were sampled in summer only. Station T0 was sampled to maintain the long-term abundance records of fishes and EMIs at this site, but data for this historical station are not discussed in this report.

OCSD's trawl sampling protocols are based upon regionally developed sampling methods (Kelly et al. 2013). These methods require that a portion of the trawl track must pass within a 100 m radius of the nominal station position and be within 10% of the station's nominal depth. In addition, the speed of the trawl should range from 0.77 to 1.0 m/s (1.5 to 2.0 kts). Since 1985, OCSD has trawled a set bottom distance of 450 m ±10%, which contrasts with the regional standard of using time on the bottom (8-15 min) rather than distance. A minimum of 1 trawl was conducted from the M/V *Nerissa* at each station using a 7.6 m (25 ft) wide, Marinovich, semi-balloon otter trawl (2.54 cm mesh) with a 0.64 cm mesh cod-end liner, an 8.9 m chain-rigged foot rope, and 23 m long trawl bridles following regionally adopted methodology (Mearns and Allen 1978). The trawl wire scope varied from a ratio of approximately 5:1 at the shallowest station to approximately 3:1 at the deepest station. To minimize catch variability due to weather and current conditions, which may affect the bottom-time duration of the trawl, trawls generally were taken along a constant depth and usually in the same direction at each station. Station locations and trawling speeds and paths were determined using Global Positioning System navigation. Trawl depths were determined using a Sea-Bird Electronics SBE 39 pressure sensor attached to one of the trawl boards.

Upon retrieval of the trawl net, the contents (fishes and EMIs) were emptied into a large flow-through water tank and then sorted by species into separate containers. Fish bioaccumulation specimens were counted, recorded, and removed for processing (see Fish Bioaccumulation Monitoring and Fish Health Monitoring sections below). The remaining fish specimens were processed as follows: (1) a minimum of 15 arbitrarily selected specimens of each species were weighed to the nearest gram and measured individually to the nearest millimeter (standard length for most species; total length for a few species); and (2) if a haul sample contained substantially more than 15 individuals of a species, then the excess specimens were enumerated in 1 cm size classes and a bulk weight was recorded. All fish specimens were examined for abnormalities such as external tumors, lesions, parasites, and skeletal deformities. EMIs were sorted to species, counted, and batch weighed. For each invertebrate species with large abundances (n>100), 100 individuals were counted and batch weighed; the remaining individuals were batch weighed and enumerated later by back calculating using the weight of the first 100 individuals. EMI specimens that could not be identified in the field were preserved in 10% buffered formalin for subsequent laboratory analysis.

Laboratory Methods

After 3–10 days in formalin, the EMI specimens retained for further taxonomic scrutiny were rinsed with tap water and then transferred to 70% ethanol for long-term preservation. These EMIs were identified using relevant taxonomic keys and, in some cases, were compared to voucher specimens housed in OCSD's Taxonomy Lab. Species and common names used in this report follow those given in Page et al. (2013) and Cadien and Lovell (2016).

Data Analyses

Total number of species, total abundance, biomass, H′, and SDI were calculated for both fishes and EMIs at each station. Fish biointegrity in OCSD's monitoring area was assessed using the Fish Response Index (FRI). The FRI is a multivariate weighted-average index produced from an ordination analysis of calibrated species abundance data (Allen et al. 2001, 2006). FRI scores less than 45 are classified as reference (normal) and those greater than 45 are non-reference (abnormal or disturbed). OCSD's historical trawl EMI and fish data from the past 10 monitoring periods, as well as Bight'13 trawl data (Walther et al. 2017), were also used as benchmarks.

PRIMER v.7 (2015) multivariate statistical software was used to examine the spatial patterns of the fish and EMI assemblages at the Middle Shelf Zone 2 stations. The other stations were excluded from the analyses, as Clarke and Warwick (2014) advised that clustering is less useful and may be misleading where there is a strong environmental forcing, such as depth. Analyses included (1) hierarchical clustering with group-average linking based on Bray-Curtis similarity indices and SIMPROF permutation tests of the clusters and (2) ordination of the same data using nMDS to confirm hierarchical clustering. Prior to the calculation of the Bray-Curtis indices, the data were fourth root transformed in order to down-weight the highly abundant species and incorporate the importance of the less common species (Clarke and Warwick 2014).

Middle Shelf Zone 2 stations were grouped into the following categories to assess spatial, outfall-related patterns: "outfall" (Stations T22 and T1) and "non-outfall" (Stations T23, T12, T17, and T11).

FISH BIOACCUMULATION MONITORING

Two demersal fish species, English Sole (*Parophrys vetulus*) and Hornyhead Turbot (*Pleuronichthys verticalis*), were targeted for analysis of muscle and liver tissue chemistry. Muscle tissue was analyzed because contaminants may bioaccumulate in this tissue and can be transferred to higher trophic levels. Liver tissue was analyzed because it typically has higher lipid content than muscle tissue and thus bioaccumulates relatively higher concentrations of lipid-soluble contaminants that have been linked to pathological conditions as well as immunological or reproductive impairment (Arkoosh et al. 1998).

Demersal fishes in the families Scorpaenidae (e.g., California Scorpionfish and Vermilion Rockfish) and Serranidae (e.g., Kelp Bass and Sand Bass) were targeted, as they are frequently caught and consumed by recreational anglers. As such, contaminants in the muscle tissue of these fishes were analyzed to gauge human health risk.

Field Methods

The sampling objective for bioaccumulation analysis was to collect 10 individuals each of English Sole and Hornyhead Turbot at outfall (T1) and non-outfall (T11) stations during the 2017-18 monitoring period. Five hauls were conducted at each station in August 2017, while 2 and 3 hauls were conducted at Stations T1 and T11, respectively, in January 2018. Ten individuals in total of scorpaenid and serranid fishes were targeted at the outfall (Zone 1) and non-outfall (Zone 3) areas using hook-and-line fishing gear ("rig-fishing") in September 2017 (Figure 2-3).

Each fish collected for bioaccumulation analysis was weighed to the nearest gram and its standard length measured to the nearest millimeter; placed in pre-labelled, plastic, re-sealable bags; and stored on wet ice in an insulated cooler. Bioaccumulation samples were subsequently transported under chain of custody protocols to OCSD's laboratory. Sample storage and holding times for bioaccumulation analyses followed specifications in OCSD's LMC SOP (Table A-5; OCSD 2016).

Table A–5 Fish tissue handling and analysis summary for 2017-18.

Parameter	Container	Preservation	Holding Time	Method
Arsenic and Selenium	Ziplock bag	Freeze	6 months	LMC SOP 200.8B SED Rev. F
Organochlorine Pesticides	Ziplock bag	Freeze	6 months	NS&T (NOAA 1993); EPA 8270 *
DDTs	Ziplock bag	Freeze	6 months	NS&T (NOAA 1993); EPA 8270 *
Lipids	Ziplock bag	Freeze	N/A	EPA 9071 *
Mercury	Ziplock bag	Freeze	6 months	LMC SOP 245.1B Rev. G
Polychlorinated Biphenyls	Ziplock bag	Freeze	6 months	NS&T (NOAA 1993); EPA 8270 *

* Available online at: www.epa.gov; N/A = Not Applicable.

Laboratory Methods

Individual fish were dissected in the laboratory under clean conditions. Muscle and liver tissues were analyzed for various parameters listed in Table A-6 using methods shown in Table A-5. Method blanks, analytical quality control samples (duplicates, matrix spikes, and blank spikes), and standard reference materials were prepared and analyzed with each sample batch. All reported concentrations are on a wet weight basis.

ΣDDT and ΣPCB were calculated as described in the sediment geochemistry section. Total chlordane (ΣChlordane) represents the sum of 7 derivative compounds (*cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, heptachlor, heptachlor epoxide, and oxychlordane). Organic contaminant data were not lipid normalized.

Table A–6 Parameters measured in fish tissue samples for 2017-18.

	Metals	
Arsenic *	Mercury	Selenium *
	Organochlorine Pesticides	
	Chlordane Derivatives and Dieldrin	
cis-Chlordane	Dieldrin	*cis*-Nonachlor
trans-Chlordane	Heptachlor	*trans*-Nonachlor
Oxychlordane	Heptachlor epoxide	
	DDT Derivatives	
2,4'-DDD	2,4'-DDE	2,4'-DDT
4,4'-DDD	4,4'-DDE	4,4'-DDT
		4,4'-DDMU
	Polychlorinated Biphenyl (PCB) Congeners	
PCB 18	PCB 101	PCB 156
PCB 28	PCB 105	PCB 157
PCB 37	PCB 110	PCB 167
PCB 44	PCB 114	PCB 169
PCB 49	PCB 118	PCB 170
PCB 52	PCB 119	PCB 177
PCB 66	PCB 123	PCB 180
PCB 70	PCB 126	PCB 183
PCB 74	PCB 128	PCB 187
PCB 77	PCB 138	PCB 189
PCB 81	PCB 149	PCB 194
PCB 87	PCB 151	PCB 201
PCB 99	PCB 153/168	PCB 206
	Other Parameter	
	Lipids	

* Analyzed only in rig-fish specimens.

Data Analyses

All analytes that were undetected (i.e., value below the method detection limit) are reported as ND. Further, an ND value was treated as zero for calculating a mean analyte concentration; however, if fish tissue samples had all ND for a particular analyte, then the mean analyte concentration is reported as ND. Data analysis consisted of summary statistics (i.e., means and ranges) and qualitative comparisons only.

The U.S. Food and Drug Administration action levels and the State of California Office of Environmental Health Hazard Assessment advisory tissue levels for ΣDDT, ΣPCB, methylmercury, dieldrin and ΣChlordane were used to assess human health risk in rig-caught fish (Klasing and Brodberg 2008, FDA 2011).

Analysis of bioaccumulation data consisted of summary statistics and qualitative comparisons only.

FISH HEALTH MONITORING

Assessment of the overall health of fish populations is also required by the NPDES permit. This entails documenting physical symptoms of disease in fish samples collected during each monitoring period, as well as conducting liver histopathology analysis once every 5 years (starting from June 15, 2012, the issue date of the current NPDES permit).

Field Methods

All trawl fish samples collected during the 2017-18 monitoring period were visually inspected for lesions, tumors, large, non-mobile external parasites, and other signs (e.g., skeletal deformities) of disease. Any atypical odor and coloration of fish samples were also noted. No fish samples were collected for liver histopathology analysis, as this analysis was conducted during the 2015-16 monitoring period (OCSD 2017).

Data Analyses

Analysis of fish disease data consisted of qualitative comparisons only.

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APPENDIX B
Supporting Data

Table B–1 Depth-averaged total coliform bacteria (MPN/100 mL) collected in offshore waters and used for comparison with California Ocean Plan Water-Contact (REC-1) compliance criteria for 2017-18.

Station	Date					Meets 30-day Geometric Mean of ≤1000/100mL	Meets Single Sample Standard of ≤10,000/100mL	Meets Single Sample Standard of ≤1000/100mL *
	7/25/2017	**7/26/2017**	**7/27/2017**	**8/2/2017**	**8/3/2017**			
2103	<10	<10	<10	<10	25	YES	YES	YES
2104	<10	15	18	<10	15	YES	YES	YES
2183	<10	<10	<10	17	33	YES	YES	YES
2203	<10	<10	<10	12	16	YES	YES	YES
2223	<10	<10	<10	16	15	YES	YES	YES
2303	<10	<10	<10	<10	<10	YES	YES	YES
2351	<10	<10	<10	<10	15	YES	YES	YES
2403	<10	<10	<10	13	29	YES	YES	YES
	10/24/2017	**10/25/2017**	**10/26/2017**	**11/6/2017**	**11/7/2017**			
2103	14	16	12	15	13	YES	YES	YES
2104	11	20	15 **	22	13	YES	YES	YES **
2183	27	66	29	29	71	YES	YES	YES
2203	12	32	<10	87	62	YES	YES	YES
2223	<10	25	<10	112	18	YES	YES	YES
2303	14	14	<10	132	71	YES	YES	YES
2351	<10	10	<10	88	65	YES	YES	YES
2403	<10	<10	<10	159	129	YES	YES	YES
	1/16/2018	**1/17/2018**	**1/18/2018**	**2/5/2018**	**2/6/2018**			
2103	35	33	36	<10	<10	YES	YES	YES
2104	26	113 **	70 **	<10	<10	YES	YES	YES **
2183	19	18	29	<10	<10	YES	YES	YES
2203	16	13	24	<10	<10	YES	YES	YES
2223	11	12	<10	<10	<10	YES	YES	YES
2303	25	<10	<10	<10	<10	YES	YES	YES
2351	<10	<10	<10	<10	<10	YES	YES	YES
2403	12	<10	<10	<10	<10	YES	YES	YES
	4/17/2018	**4/18/2018**	**4/26/2018**	**5/7/2018**	**5/8/2018**			
2103	13	12	19	12	10	YES	YES	YES
2104	10	<10	14	15	13	YES	YES	YES
2183	21	17	11	14	<10	YES	YES	YES
2203	33	16	13	<10	13	YES	YES	YES
2223	16	10	<10	<10	<10	YES	YES	YES
2303	<10	<10	<10	<10	<10	YES	YES	YES
2351	<10	<10	<10	<10	<10	YES	YES	YES
2403	<10	<10	<10	<10	<10	YES	YES	YES

* Standard is based on when the single sample maximum fecal coliform/total coliform ratio >0.1.
** Depths combined, meet single sample standard (10/26/17, 1/17/18, 1/18/18).

Table B–2 Depth-averaged fecal coliform bacteria (MPN/100 mL) collected in offshore waters and used for comparison with California Ocean Plan Water-Contact (REC-1) compliance criteria for 2017-18.

Station	Date					Meets 30-day Geometric Mean ≤200/100mL	Meets single sample standard of ≤400/100mL
	7/25/2017	**7/26/2017**	**7/27/2017**	**8/2/2017**	**8/3/2017**		
2103	<10	<10	<10	<10	<10	YES	YES
2104	<10	12	11	<10	<10	YES	YES
2183	<10	<10	<10	<10	<10	YES	YES
2203	<10	<10	<10	<10	<10	YES	YES
2223	<10	<10	<10	<10	<10	YES	YES
2303	<10	<10	<10	<10	<10	YES	YES
2351	<10	<10	<10	<10	<10	YES	YES
2403	<10	<10	<10	<10	<10	YES	YES
	10/24/2017	**10/25/2017**	**10/26/2017**	**11/6/2017**	**11/7/2017**		
2103	12	11	10	<10	<10	YES	YES
2104	<10	11	13	<10	<10	YES	YES
2183	10	18	16	<10	<10	YES	YES
2203	<10	11	<10	<10	<10	YES	YES
2223	<10	<10	<10	<10	<10	YES	YES
2303	<10	<10	<10	<10	<10	YES	YES
2351	<10	<10	<10	<10	<10	YES	YES
2403	<10	<10	<10	<10	<10	YES	YES
	1/16/2018	**1/17/2018**	**1/18/2018**	**2/5/2018**	**2/6/2018**		
2103	13	13	17	<10	<10	YES	YES
2104	17	36 *	29	<10	<10	YES	YES *
2183	<10	11	12	<10	<10	YES	YES
2203	10	<10	15	<10	<10	YES	YES
2223	<10	<10	<10	<10	<10	YES	YES
2303	<10	<10	<10	<10	<10	YES	YES
2351	<10	<10	<10	<10	<10	YES	YES
2403	<10	<10	<10	<10	<10	YES	YES
	4/17/2018	**4/18/2018**	**4/26/2018**	**5/7/2018**	**5/8/2018**		
2103	<10	<10	15	<10	<10	YES	YES
2104	<10	<10	11	11	11	YES	YES
2183	10	11	<10	10	<10	YES	YES
2203	13	<10	<10	<10	<10	YES	YES
2223	<10	<10	<10	<10	<10	YES	YES
2303	<10	<10	<10	<10	<10	YES	YES
2351	<10	<10	<10	<10	<10	YES	YES
2403	<10	<10	<10	<10	<10	YES	YES

* Depths combined, meet single sample standard (1/17/18).

Table B–3 Depth-averaged enterococci bacteria (MPN/100mL) collected in offshore waters and used for comparison with California Ocean Plan Water-Contact (REC-1) compliance criteria and EPA Primary Recreation Criteria in Federal Waters for 2017-18.

Station	Date					Meets COP 30-day Geometric Mean of ≤35/100 mL	Meets COP single sample standard of ≤104/100 mL
	7/25/2017	**7/26/2017**	**7/27/2017**	**8/2/2017**	**8/3/2017**		
2103	<10	<10	<10	<10	<10	YES	YES
2104	<10	<10	<10	<10	<10	YES	YES
2183	<10	<10	<10	<10	<10	YES	YES
2203	<10	<10	<10	<10	<10	YES	YES
2223	<10	<10	<10	<10	<10	YES	YES
2303	<10	<10	<10	<10	<10	YES	YES
2351	<10	<10	<10	11	<10	YES	YES
2403	<10	<10	<10	<10	<10	YES	YES
	10/24/2017	**10/25/2017**	**10/26/2017**	**11/6/2017**	**11/7/2017**		
2103	<10	<10	<10	<10	<10	YES	YES
2104	<10	<10	10	<10	<10	YES	YES
2183	<10	<10	10	<10	<10	YES	YES
2203	<10	<10	<10	<10	<10	YES	YES
2223	<10	<10	<10	<10	<10	YES	YES
2303	10	<10	<10	<10	<10	YES	YES
2351	<10	<10	<10	<10	12	YES	YES
2403	<10	<10	<10	<10	<10	YES	YES
	1/16/2018	**1/17/2018**	**1/18/2018**	**2/5/2018**	**2/6/2018**		
2103	<10	<10	<10	<10	<10	YES	YES
2104	<10	15	12	<10	<10	YES	YES
2183	<10	<10	<10	<10	<10	YES	YES
2203	<10	<10	<10	<10	<10	YES	YES
2223	<10	<10	<10	<10	<10	YES	YES
2303	<10	<10	<10	<10	<10	YES	YES
2351	<10	<10	<10	<10	<10	YES	YES
2403	<10	<10	<10	<10	<10	YES	YES
	4/17/2018	**4/18/2018**	**4/26/2018**	**5/7/2018**	**5/8/2018**		
2103	<10	<10	<10	<10	<10	YES	YES
2104	<10	<10	<10	<10	<10	YES	YES
2183	11	<10	<10	<10	<10	YES	YES
2203	<10	<10	10	<10	<10	YES	YES
2223	<10	<10	<10	<10	<10	YES	YES
2303	<10	<10	<10	<10	<10	YES	YES
2351	<10	<10	<10	<10	<10	YES	YES
2403	<10	<10	<10	<10	10	YES	YES

Table B–4 Summary of floatable material by station group observed during the 28-station grid water quality surveys for 2017-18. Total number of station visits = 336.

Surface Observation	Station Group							Totals
	Upcoast Offshore	Upcoast Inshore	Infield Offshore	Within-ZID	Infield Inshore	Downcoast Offshore	Downcoast Inshore	
	2225, 2226 2305, 2306 2353, 2354 2405, 2406	2223, 2224 2303, 2304 2351, 2352 2403, 2404	2206	2205	2203, 2204	2105, 2106 2185, 2186	2103, 2104 2183, 2184	
Oil and Grease	0	0	0	0	0	0	0	0
Trash/Debris	0	2	1	0	1	1	0	5
Biological Material (kelp)	0	0	0	0	0	1	0	1
Material of Sewage Origin	0	0	0	0	0	0	0	0
Totals	0	2	1	0	1	2	0	6

Table B–5 Summary of floatable material by station group observed during the REC-1 water quality surveys for 2017-18. Total number of station visits = 105.

Surface Observation	Station Groups				Totals
	Upcoast Inshore	Within-ZID	Infield Inshore	Downcoast Inshore	
	2223, 2303 2351, 2403	2205	2203	2103, 2104, 2183	
Oil and Grease	0	0	0	0	0
Trash/Debris	2	1	0	2	5
Biological Material (kelp)	0	0	0	0	0
Material of Sewage Origin	0	0	0	0	0
Totals	2	1	0	2	5

Table B–6 Summary of monthly Core COP water quality compliance parameters by season and depth strata for 2017-18.

Depth Strata (m)	Summer				Fall				Winter				Spring				Annual			
	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev	Min	Mean	Max	Std Dev
Dissolved Oxygen (mg/L)																				
1-15	7.17	7.85	8.52	0.22	6.84	7.55	8.00	0.18	6.28	7.83	8.76	0.36	5.02	7.97	9.66	0.75	5.02	7.80	9.66	0.47
16-30	6.00	7.69	8.69	0.56	5.80	7.28	8.03	0.38	4.61	6.89	8.49	0.81	3.66	6.61	9.85	1.45	3.66	7.11	9.85	0.99
31-45	4.19	6.10	7.99	0.74	4.92	6.34	7.77	0.56	4.10	5.92	7.34	0.88	3.30	4.87	8.05	0.80	3.30	5.81	8.05	0.94
45-60	3.89	5.15	6.64	0.62	4.74	5.59	7.00	0.43	3.90	5.22	6.45	0.71	3.09	4.00	5.07	0.39	3.09	4.99	7.00	0.81
61-75	3.74	4.59	5.83	0.48	4.39	5.12	6.69	0.41	3.60	4.75	6.00	0.60	2.96	3.53	4.44	0.35	2.96	4.50	6.69	0.76
All	3.74	6.73	8.69	1.35	4.39	6.69	8.03	0.97	3.60	6.50	8.76	1.29	2.96	5.96	9.85	1.90	2.96	6.47	9.85	1.45
pH																				
1-15	7.96	8.08	8.17	0.04	7.84	7.97	8.06	0.04	7.75	7.96	8.11	0.06	7.52	7.86	7.97	0.09	7.52	7.97	8.17	0.10
16-30	7.85	8.01	8.14	0.06	7.79	7.91	8.04	0.05	7.59	7.88	8.04	0.12	7.43	7.73	7.98	0.17	7.43	7.88	8.14	0.15
31-45	7.67	7.87	8.04	0.08	7.64	7.80	7.91	0.05	7.53	7.76	8.01	0.14	7.38	7.56	7.90	0.12	7.38	7.75	8.04	0.15
45-60	7.64	7.76	7.93	0.06	7.63	7.72	7.83	0.04	7.50	7.68	7.88	0.11	7.36	7.46	7.62	0.06	7.36	7.66	7.93	0.14
61-75	7.59	7.69	7.84	0.05	7.58	7.66	7.79	0.04	7.46	7.63	7.77	0.10	7.33	7.41	7.53	0.05	7.33	7.60	7.84	0.13
All	7.59	7.93	8.17	0.15	7.58	7.85	8.06	0.12	7.46	7.83	8.11	0.16	7.33	7.66	7.98	0.20	7.33	7.82	8.17	0.19
Light Transmissivity (%)																				
1-15	77.75	84.03	88.32	1.78	71.90	85.56	88.12	1.92	73.66	83.97	88.39	3.55	67.36	81.66	88.25	5.48	67.36	83.80	88.39	3.80
16-30	73.93	84.65	88.34	2.19	65.26	85.89	88.40	2.27	55.97	85.55	88.51	2.96	64.76	82.98	88.54	4.53	55.97	84.77	88.54	3.33
31-45	74.30	85.76	88.74	1.68	81.06	87.31	89.08	1.05	75.12	87.29	88.92	1.26	66.53	85.72	88.93	3.01	66.53	86.53	89.08	2.06
45-60	76.15	86.64	89.21	1.70	84.64	87.62	89.15	0.92	82.02	87.74	89.33	0.99	79.69	86.93	89.29	2.28	76.15	87.24	89.33	1.64
61-75	77.68	87.15	89.39	1.81	84.48	87.86	89.32	0.90	83.90	87.80	89.40	1.26	78.88	86.70	89.32	2.92	77.68	87.38	89.40	1.94
All	73.93	85.23	89.39	2.18	65.26	86.53	89.32	1.93	55.97	85.99	89.40	3.00	64.76	84.09	89.32	4.70	55.97	85.46	89.40	3.28
*Ammonium (mg/L) **																				
1-15	0.011	0.014	0.015	0.002	0.011	0.012	0.031	0.003	0.015	0.015	0.077	0.005	0.015	0.015	0.020	0.000	0.011	0.014	0.077	0.003
16-30	0.011	0.014	0.052	0.004	0.011	0.014	0.086	0.008	0.014	0.017	0.061	0.007	0.014	0.017	0.040	0.005	0.011	0.015	0.086	0.007
31-45	0.011	0.038	0.194	0.046	0.011	0.033	0.198	0.045	0.015	0.026	0.113	0.022	0.015	0.020	0.053	0.009	0.011	0.029	0.198	0.035
45-60	0.011	0.022	0.129	0.023	0.011	0.021	0.105	0.021	0.015	0.021	0.114	0.019	0.015	0.018	0.121	0.015	0.011	0.021	0.129	0.019
61-75	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
All	0.011	0.018	0.194	0.021	0.011	0.017	0.198	0.020	0.014	0.018	0.114	0.013	0.014	0.017	0.121	0.008	0.011	0.018	0.198	0.016

* Ammonium values below MDL (0.02 mg/L) were adjusted to 75% of MDL (0.015 mg/L)
ns = Not Sampled

Table B–7 Species richness and abundance values of the major taxonomic groups collected at each depth stratum and season for the 2017-18 infauna surveys. Values represent the mean and range (in parentheses).

Season	Parameter	Stratum	Annelida	Arthropoda	Mollusca	Echinodermata	Misc. Phyla
Summer	Number of Species	Middle Shelf Zone 1 (31-50 m)	56 (50-62)	20 (14-23)	13 (10-16)	5 (0-7)	9 (5-12)
		Middle Shelf Zone 2, Within-ZID (51-90 m)	59 (47-67)	20 (16-29)	12 (8-16)	6 (5-8)	8 (7-10)
		Middle Shelf Zone 2, Non-ZID (51-90 m)	54 (15-69)	15 (1-28)	14 (2-21)	5 (3-9)	7 (2-12)
		Middle Shelf Zone 3 (91-120 m)	46 (36-59)	7 (2-12)	13 (10-19)	4 (2-6)	5 (2-10)
		Outer Shelf (121-200 m)	20 (9-31)	4 (1-8)	10 (6-14)	2 (0-6)	2 (1-2)
		Upper Slope/Canyon (201-500 m)	13 (9-21)	4 (0-8)	7 (4-12)	2 (1-4)	0 (0-2)
	Abundance	Middle Shelf Zone 1 (31-50 m)	347 (297-446)	68 (38-101)	39 (18-69)	18 (0-30)	15 (9-23)
		Middle Shelf Zone 2, Within-ZID (51-90 m)	334 (260-459)	61 (37-82)	25 (23-26)	18 (13-24)	18 (10-23)
		Middle Shelf Zone 2, Non-ZID (51-90 m)	327 (109-515)	37 (1-64)	36 (2-57)	18 (8-62)	13 (3-22)
		Middle Shelf Zone 3 (91-120 m)	187 (103-261)	13 (2-20)	71 (26-99)	51 (28-96)	8 (2-14)
		Outer Shelf (121-200 m)	65 (16-167)	5 (1-13)	35 (18-58)	5 (0-11)	2 (1-2)
		Upper Slope/Canyon (201-500 m)	28 (16-44)	6 (0-15)	12 (8-21)	3 (1-7)	0 (0-2)
Winter	Number of Species	Middle Shelf Zone 2, Within-ZID (51-90 m)	50 (34-57)	16 (10-21)	6 (3-8)	3 (3-3)	5 (4-7)
		Middle Shelf Zone 2, Non-ZID (51-90 m)	54 (24-79)	16 (11-26)	6 (1-10)	3 (1-6)	6 (3-9)
	Abundance	Middle Shelf Zone 2, Within-ZID (51-90 m)	233 (102-383)	39 (20-49)	11 (4-17)	5 (4-7)	8 (4-10)
		Middle Shelf Zone 2, Non-ZID (51-90 m)	301 (85-535)	39 (24-62)	12 (3-19)	5 (1-13)	11 (4-28)

Table B–8 Abundance of epibenthic macroinvertebrates by station and species for the Summer 2017 and Winter 2018 trawl surveys.

Stratum	Middle Shelf Zone 1				Middle Shelf Zone 2												Outer Shelf					
Station	**T2**	**T24**	**T6**	**T18**	**T23**		**T22**		**T1**		**T12**		**T17**		**T11**		**T10**	**T25**	**T14**	**T19**		
Nominal Depth	**35**	**36**	**36**	**36**	**58**		**60**		**55**		**57**		**60**		**60**		**137**	**137**	**137**	**137**		
Season	**S**	**S**	**S**	**S**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**S**	**S**	**S**	**Total**	**%**
Ophiura luetkenii	427	483	450		34	11	55	21	1118	5	13	16	4	1	2333	10	1				4982	62.7
Sicyonia ingentis			3		10	3	12	7	36	31	33	21	67	3	11	29	9	23	145	248	691	8.7
Lytechinus pictus	1	3	25	40	40	157	25	134	13	91	6	13	27	32	1	4	6	10	5	1	634	8
Thesea sp B	18	55	26		9	11	5	9	23	37	10	37	9	7	42	30					328	4.1
Strongylocentrotus fragilis																	113	95	6	37	251	3.2
Ophiothrix spiculata	1	199	14	2	1	1	5	1	9	8		2				1					244	3.1
Hamatoscalpellum californicum	3	14	9		5		20	5	8	35	14	32	21	4	5	15					190	2.4
Astropecten californicus	1	7	14		9	3	24	8	10	37	7	15	5	23	4	12	1		1	2	183	2.3
Philine auriformis		57	62	11		1	1		28		3				2				1		166	2.1
Sicyonia penicillata						28		18		5		18		4		13					86	1.1
Luidia foliolata				2	8		4	3	3		5		6	2	2	11	1	1	4		52	0.7
Pleurobranchaea californica		6	8	1				1	2		1		1		3						23	0.3
Luidia asthenosoma						6		1		2	2	5	3	1		1		1			22	0.3
Heterogorgia tortuosa		3	1		1					2		2	1		3	2					15	0.2
Neocrangon zacae																			1	11	12	0.2
Octopus rubescens			1		1		1								1		1		1	3	9	0.1
Acanthoptilum sp	4	1				1															6	0.1
Ericerodes hemphillii			3	1	1																5	0.1
Loxorhynchus crispatus	1	3							1												5	0.1
Orthopagurus minimus		1	1		1			1													4	0.1
Acanthodoris brunnea	1		1	1																	3	<0.1
Astropecten ornatissimus																				3	3	<0.1
Flabellina iodinea	1	2																			3	<0.1
Simnia sp											1		1		1						3	<0.1
Amphichondrius granulatus													1			1					2	<0.1
Aphrodita japonica			2																		2	<0.1
Calinaticina oldroydii																				2	2	<0.1
Diaulula sandiegensis		2																			2	<0.1
Luidia armata			2																		2	<0.1
Neocrangon resima																			1	1	2	<0.1
Platydoris macfarlandi						1				1											2	<0.1
Stylatula elongata	1																			1	2	<0.1
Amphiura arcystata								1													1	<0.1
Apostichopus californicus																		1			1	<0.1
Astropecten sp				1																	1	<0.1
Cancellaria crawfordiana																			1		1	<0.1
Coryrhynchus lobifrons					1																1	<0.1
Doriopsilla albopunctata			1																		1	<0.1
Octopus californicus																1					1	<0.1
Paguristes turgidus												1									1	<0.1
Platymera gaudichaudii					1																1	<0.1
Rocinela angustata																				1	1	<0.1
Stylochus exiguus			1																		1	<0.1
Tochuina gigantea		1																			1	<0.1
Tritia insculpta											1										1	<0.1
Total Abundance	**459**	**837**	**624**	**59**	**122**	**223**	**152**	**210**	**1251**	**254**	**96**	**162**	**146**	**77**	**2408**	**130**	**132**	**131**	**166**	**310**	**7949**	**100**
Total No. of Species	**11**	**15**	**18**	**8**	**14**	**11**	**10**	**13**	**11**	**11**	**12**	**11**	**12**	**9**	**12**	**13**	**7**	**6**	**10**	**11**	**45**	

Table B–9 Total biomass (kg) of epibenthic macroinvertebrates by station and species for the Summer 2017 and Winter 2018 trawl surveys.

Stratum	Middle Shelf Zone 1				Middle Shelf Zone 2												Outer Shelf					
Station	T2	T24	T6	T18	T23		T22		T1		T12		T17		T11		T10	T25	T14	T19		
Nominal Depth	35	36	36	36	58		60		55		57		60		60		137	137	137	137		
Season	S	S	S	S	S	W	S	W	S	W	S	W	S	W	S	W	S	S	S	S	Total	%
Strongylocentrotus fragilis																	5.510	4.810	0.300	1.748	12.368	40.7
Ophiura luetkenii	0.470	0.700	0.630		0.013	0.004	0.019	0.016	1.900	0.001	0.003	0.011	0.001	0.001	2.800	0.007	0.001				6.577	21.7
Sicyonia ingentis			0.010		0.040	0.001	0.040	0.014	0.110	0.031	0.160	0.025	0.510	0.003	0.031	0.028	0.047	0.230	1.948	3.348	6.576	21.7
Sicyonia penicillata						0.330		0.210		0.049		0.154		0.063		0.126					0.932	3.1
Lytechinus pictus	0.001	0.002	0.021	0.040	0.035	0.220	0.007	0.070	0.010	0.095	0.010	0.015	0.035	0.130	0.003	0.001	0.043	0.059	0.032	0.007	0.836	2.8
Apostichopus californicus																		0.475			0.475	1.6
Astropecten californicus	0.018	0.009	0.011		0.010	0.030	0.039	0.008	0.020	0.072	0.020	0.050	0.006	0.067	0.022	0.054	0.010		0.025	0.002	0.473	1.6
Calinaticina oldroydii																				0.448	0.448	1.5
Ophiothrix spiculata	0.001	0.298	0.020	0.001	0.001	0.001	0.004	0.001	0.009	0.007		0.001				0.001					0.345	1.1
Luidia foliolata				0.001	0.001		0.001	0.008	0.001		0.001		0.001	0.004	0.001	0.011	0.120	0.085	0.045		0.280	0.9
Platymera gaudichaudii					0.250																0.250	0.8
Thesea sp B	0.010	0.026	0.015		0.002	0.002	0.002	0.001	0.019	0.017	0.004	0.025	0.004	0.002	0.023	0.012					0.164	0.5
Octopus californicus																0.143					0.143	0.5
Pleurobranchaea californica		0.005	0.007	0.001				0.004	0.001		0.038		0.060		0.005						0.121	0.4
Philine auriformis		0.034	0.044	0.005		0.001	0.001		0.020		0.001				0.001				0.001		0.108	0.4
Octopus rubescens			0.004		0.005		0.010								0.010		0.010		0.008	0.021	0.068	0.2
Luidia asthenosoma						0.006		0.023		0.009	0.001	0.015	0.001	0.001		0.001		0.001			0.058	0.2
Loxorhynchus crispatus	0.010	0.015							0.007												0.032	0.1
Hamatoscalpellum californicum	0.001	0.003	0.001		0.001		0.003	0.001	0.001	0.006	0.001	0.001	0.003	0.001	0.001	0.001					0.025	0.1
Neocrangon zacae																			0.001	0.011	0.012	<0.1
Heterogorgia tortuosa		0.001	0.001		0.001					0.001		0.001	0.001		0.001	0.001					0.008	<0.1
Stylatula elongata	0.004																			0.001	0.005	<0.1
Aphrodita japonica			0.004																		0.004	<0.1
Ericerodes hemphillii			0.002	0.001	0.001																0.004	<0.1
Orthopagurus minimus		0.001	0.001		0.001			0.001													0.004	<0.1
Acanthodoris brunnea	0.001		0.001	0.001																	0.003	<0.1
Acanthoptilum sp	0.001	0.001				0.001															0.003	<0.1
Cancellaria crawfordiana																			0.003		0.003	<0.1
Flabellina iodinea	0.001	0.002																			0.003	<0.1
Platydoris macfarlandi						0.002				0.001											0.003	<0.1
Simnia sp											0.001		0.001		0.001						0.003	<0.1
Amphichondrius granulatus													0.001			0.001					0.002	<0.1
Diaulula sandiegensis		0.002																			0.002	<0.1
Luidia armata			0.002																		0.002	<0.1
Neocrangon resima																			0.001	0.001	0.002	<0.1
Amphiura arcystata								0.001													0.001	<0.1
Astropecten ornatissimus																				0.001	0.001	<0.1
Astropecten sp				0.001																	0.001	<0.1
Coryrhynchus lobifrons					0.001																0.001	<0.1
Doriopsilla albopunctata			0.001																		0.001	<0.1
Paguristes turgidus												0.001									0.001	<0.1
Rocinela angustata																				0.001	0.001	<0.1
Stylochus exiguus			0.001																		0.001	<0.1
Tochuina gigantea		0.001																			0.001	<0.1
Tritia insculpta											0.001										0.001	<0.1
Total Biomass	**0.518**	**1.100**	**0.776**	**0.051**	**0.362**	**0.598**	**0.126**	**0.358**	**2.098**	**0.289**	**0.241**	**0.299**	**0.624**	**0.272**	**2.899**	**0.387**	**5.741**	**5.660**	**2.364**	**5.589**	**30.352**	**100**

Table B–10 Abundance of demersal fishes by station and species for the Summer 2017 and Winter 2018 trawl surveys.

Stratum	Middle Shelf Zone 1				Middle Shelf Zone 2												Outer Shelf					
Station	**T2**	**T24**	**T6**	**T18**	**T23**		**T22**		**T1**		**T12**		**T17**		**T11**		**T10**	**T25**	**T14**	**T19**		
Nominal Depth	**35**	**36**	**36**	**36**	**58**		**60**		**55**		**57**		**60**		**60**		**137**	**137**	**137**	**137**		
Season	**S**	**S**	**S**	**S**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**S**	**S**	**S**	**Total**	**%**
Citharichthys sordidus		39	47	46	2	40	8	35	41	69	3	23	9	21	15	105	348	245	229	229	1554	30.6
Sebastes saxicola																	187	132	120	193	632	12.4
Icelinus quadriseriatus	13	40	41	24		5	18	33	23	32	2	25	21	2	55	81					415	8.2
Citharichthys xanthostigma	27	28	26	1		6		36	14	51	26	78	43	16	6	6					364	7.2
Synodus lucioceps	27	4	2	2	23	4	33	45	22	7	45	27	39	20	4	5	11	2			322	6.3
Microstomus pacificus							1		1								47	77	39	103	268	5.3
Symphurus atricaudus	7	2	4	2	10	19	10	28	17	30	10	19	14	11	5	67	2	3	1	4	265	5.2
Sebastes semicinctus																221	18				239	4.7
Zaniolepis latipinnis	1				4	30	28	1		5	42	5	14	6		61	2				199	3.9
Lyopsetta exilis																	28	52	23	60	163	3.2
Lycodes pacificus																	28	13	7	72	120	2.4
Hippoglossina stomata	8	8	4			3		26	1	8		3			4	8	4		1	1	79	1.6
Sebastes sp																			15	49	64	1.3
Zalembius rosaceus					2	1	2		4		1					53					63	1.2
Pleuronichthys verticalis	1	2	1	1	1	7	2	10	1	4		5	2	9		15	1				62	1.2
Citharichthys stigmaeus		9	13	37																	59	1.2
Zaniolepis frenata																	22	12	11	1	46	0.9
Parophrys vetulus	1					1		1			1			4		15	3	2			28	0.6
Xystreurys liolepis	2							1	1	14		2			1	4					25	0.5
Chitonotus pugetensis									2	2	1	3	9	2	3	2					24	0.5
Porichthys notatus					2		8								2		5	1	3	3	24	0.5
Sebastes elongatus																	5	3	11	1	20	0.4
Glyptocephalus zachirus																	1	2	1	12	16	0.3
Odontopyxis trispinosa									2				1		5	1					9	0.2
Scorpaena guttata															1	3					4	0.1
Chilara taylori																	2	1			3	0.1
Pleuronichthys decurrens		1			1																2	<0.1
Raja inornata		1		1																	2	<0.1
Sebastes chlorostictus																	2				2	<0.1
Sebastes hopkinsi												1								1	2	<0.1
Agonopsis sterletus																				1	1	<0.1
Argentina sialis																	1				1	<0.1
Hydrolagus colliei																				1	1	<0.1
Kathetostoma averruncus																				1	1	<0.1
Merluccius productus																		1			1	<0.1
Sebastes rubrivinctus												1									1	<0.1
Total Abundance	**87**	**134**	**138**	**114**	**45**	**116**	**110**	**216**	**129**	**222**	**131**	**192**	**152**	**91**	**101**	**647**	**717**	**546**	**461**	**732**	**5081**	**100**
Total No. of Species	**9**	**10**	**8**	**8**	**8**	**10**	**9**	**10**	**12**	**10**	**9**	**12**	**9**	**9**	**11**	**15**	**19**	**14**	**12**	**16**	**36**	

Table B–11 Total biomass (kg) of demersal fishes by station and species for the Summer 2017 and Winter 2018 trawl surveys.

Stratum	Middle Shelf Zone 1				Middle Shelf Zone 2												Outer Shelf					
Station	**T2**	**T24**	**T6**	**T18**	**T23**		**T22**		**T1**		**T12**		**T17**		**T11**		**T10**	**T25**	**T14**	**T19**		
Nominal Depth	**35**	**36**	**36**	**36**	**58**		**60**		**55**		**57**		**60**		**60**		**137**	**137**	**137**	**137**		
Season	**S**	**S**	**S**	**S**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**S**	**S**	**S**	**Total**	**%**
Citharichthys sordidus		0.189	0.189	0.214	0.004	1.396	0.033	1.045	0.088	0.560	0.027	0.297	0.022	1.230	0.200	3.669	5.678	3.753	2.726	1.395	22.715	20.8
Citharichthys xanthostigma	1.191	0.627	0.338	0.039		0.451		1.856	0.693	2.465	1.461	1.799	2.108	1.263	0.217	0.615					15.123	13.9
Sebastes saxicola																	3.919	2.787	2.755	3.173	12.634	11.6
Synodus lucioceps	1.201	0.026	0.010	0.015	0.959	0.180	1.281	1.652	0.802	0.513	2.022	0.693	1.329	0.653	0.058	0.148	0.676	0.346			12.564	11.5
Microstomus pacificus							0.024		0.005								1.863	2.693	2.283	1.588	8.456	7.8
Hippoglossina stomata	0.933	0.350	0.072			0.225		1.690	0.012	0.689		0.247			0.162	0.561	0.412		0.085	0.300	5.738	5.3
Symphurus atricaudus	0.098	0.060	0.041	0.038	0.137	0.286	0.141	0.409	0.218	0.555	0.132	0.269	0.189	0.183	0.063	1.181	0.036	0.051	0.022	0.065	4.174	3.8
Lyopsetta exilis																	1.005	1.445	0.541	1.134	4.125	3.8
Pleuronichthys verticalis	0.125	0.088	0.080	0.170	0.068	0.508	0.093	0.517	0.032	0.348		0.424	0.046	0.428		0.911	0.100				3.938	3.6
Zaniolepis latipinnis	0.022				0.093	0.755	0.557	0.024		0.169	0.762	0.112	0.065	0.159		1.069	0.037				3.824	3.5
Parophrys vetulus	0.290					0.130		0.086			0.110			0.460		1.506	0.270	0.401			3.253	3
Lycodes pacificus																	0.743	0.284	0.169	1.617	2.813	2.6
Xystreurys liolepis	0.927							0.052	0.475	0.621		0.103			0.066	0.129					2.373	2.2
Icelinus quadriseriatus	0.034	0.075	0.077	0.073		0.019	0.073	0.060	0.091	0.119	0.008	0.079	0.087	0.005	0.221	0.195					1.216	1.1
Porichthys notatus					0.056		0.203								0.056		0.182	0.052	0.350	0.275	1.174	1.1
Zalembius rosaceus					0.058	0.002	0.065		0.158		0.028					0.535					0.846	0.8
Raja inornata		0.700		0.021																	0.721	0.7
Zaniolepis frenata																	0.370	0.195	0.106	0.007	0.678	0.6
Scorpaena guttata															0.175	0.260					0.435	0.4
Sebastes semicinctus																0.088	0.294				0.382	0.4
Glyptocephalus zachirus																	0.004	0.030	0.015	0.246	0.295	0.3
Citharichthys stigmaeus		0.028	0.046	0.193																	0.267	0.2
Sebastes elongatus																	0.005	0.004	0.026	0.230	0.265	0.2
Chitonotus pugetensis									0.030	0.012	0.008	0.014	0.115	0.015	0.025	0.008					0.227	0.2
Merluccius productus																		0.152			0.152	0.1
Sebastes chlorostictus																	0.145				0.145	0.1
Sebastes sp																			0.025	0.090	0.115	0.1
Hydrolagus colliei																				0.100	0.100	0.1
Pleuronichthys decurrens		0.019			0.057																0.076	0.1
Kathetostoma averruncus																				0.055	0.055	0.1
Sebastes hopkinsi												0.015								0.018	0.033	<0.1
Chilara taylori																	0.018	0.012			0.030	<0.1
Sebastes rubrivinctus												0.030									0.030	<0.1
Odontopyxis trispinosa									0.006				0.002		0.011	0.002					0.021	<0.1
Agonopsis sterletus																				0.010	0.010	<0.1
Argentina sialis																	0.001				0.001	<0.1
Total Biomass	**4.821**	**2.162**	**0.853**	**0.763**	**1.432**	**3.952**	**2.470**	**7.391**	**2.610**	**6.051**	**4.558**	**4.082**	**3.963**	**4.396**	**1.254**	**10.877**	**15.758**	**12.205**	**9.103**	**10.303**	**109.004**	**100**

Table B–12 Summary statistics of legacy OCSD Core nearshore stations for total coliforms, fecal coliforms, and enterococci bacteria (CFU/100 mL) by station and season for 2017-18.

Station	Summer				Fall				Winter				Spring				Annual			
	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev
Total Coliforms																				
39N	<17	16	83	1.67	<17	16	50	1.54	<17	26	1100	3.76	<17	16	50	1.55	<17	18	1100	2.18
33N	<17	24	1200	3.86	<17	17	50	1.53	<17	21	100	2.07	<17	15	33	1.31	<17	19	1200	2.24
27N	<17	13	17	1.11	<17	14	33	1.31	<17	37	300	3.39	<17	15	33	1.31	<17	18	300	2.12
21N	<17	15	50	1.46	<17	15	67	1.58	<17	31	>2400	4.36	<17	13	17	1.11	<17	18	>2400	2.32
15N	<17	16	67	1.65	<17	31	180	2.54	<17	34	>2400	4.76	<17	15	33	1.34	<17	22	>2400	2.71
12N	<17	17	50	1.51	<17	21	180	2.24	<17	35	>20000	8.12	<17	16	33	1.44	<17	21	>20000	3.2
9N	<17	19	200	2.05	<17	17	67	1.52	<17	28	>20000	5.79	<17	17	>67	1.69	<17	20	>20000	2.76
6N	<17	44	1000	3.93	<17	27	130	2.18	<17	38	>20000	6.06	<17	16	100	1.71	<17	29	>20000	3.56
3N	<17	31	800	3.92	<17	51	580	3.1	<17	45	>20000	6.71	<17	18	67	1.57	<17	34	>20000	3.91
0	<17	19	>280	2.25	<17	26	1500	3.56	<17	53	>20000	8.11	<17	33	4200	4.81	<17	31	>20000	4.65
3S	<17	14	17	1.15	<17	14	33	1.31	<17	39	>20000	10.44	<17	14	33	1.33	<17	18	>20000	3.46
6S	<17	13	<17	1	<17	16	67	1.66	<17	25	>5400	5.64	<17	14	>17	1.17	<17	16	>5400	2.5
9S	<17	13	<17	1	<17	19	220	2.27	<17	21	1100	3.4	<17	14	>17	1.17	<17	16	1100	2.11
15S	<17	13	17	1.08	<17	19	170	2.2	<17	14	33	1.31	<17	15	50	1.48	<17	15	170	1.6
21S	<17	15	33	1.42	<17	15	33	1.31	<17	18	130	1.93	<17	15	33	1.34	<17	16	130	1.52
27S	<17	23	220	2.59	<17	14	33	1.3	<17	15	83	1.68	<17	14	>17	1.19	<17	16	220	1.79
29S	<17	26	120	2.24	<17	16	33	1.51	<17	19	130	2.25	<17	26	280	2.77	<17	21	280	2.22
39S	<17	14	33	1.31	<17	13	17	1.11	<17	16	33	1.42	<17	16	33	1.42	<17	15	33	1.34
All	<17	19	1200	1.01	<17	20	1500	0.68	<17	29	>20000	2.66	<17	17	4200	0.87	<17	20	>20000	0.89
Fecal Coliforms																				
39N	<17	16	50	1.55	<17	17	100	1.91	<17	15	67	1.58	<17	13	17	1.08	<17	15	100	1.58
33N	<17	21	1000	3.39	<17	17	50	1.73	<17	16	67	1.65	<17	14	17	1.15	<17	17	1000	2.07
27N	<17	15	130	1.9	<17	15	33	1.31	<17	22	120	2.14	<17	14	17	1.13	<17	16	130	1.71
21N	<17	13	<17	1	<17	15	50	1.46	<17	20	560	2.9	<17	15	17	1.16	<17	15	560	1.79
15N	<17	15	33	1.31	<17	16	100	1.75	<17	28	270	2.73	<17	14	17	1.13	<17	17	270	1.9
12N	<17	15	33	1.31	<17	21	83	1.94	<17	22	2200	4.15	<17	14	33	1.31	<17	18	2200	2.24
9N	<17	19	150	2.02	<17	15	50	1.38	<17	21	5600	3.74	<17	16	170	1.79	<17	18	5600	2.27
6N	<17	33	880	3.75	<17	20	67	1.75	<17	21	7800	3.82	<17	15	100	1.59	<17	22	7800	2.83
3N	<17	30	520	3.77	<17	36	440	2.92	<17	25	12000	4.59	<17	16	50	1.53	<17	26	12000	3.27
0	<17	16	67	1.63	<17	26	900	3.18	<17	23	15000	4.16	<17	27	3100	4.66	<17	23	15000	3.4
3S	<17	13	17	1.08	<17	16	67	1.65	<17	25	3700	4.99	<17	14	17	1.16	<17	16	3700	2.36
6S	<17	13	<17	1	<17	14	17	1.13	<17	18	640	2.93	<17	14	33	1.3	<17	14	640	1.75
9S	<17	13	<17	1	<17	17	50	1.61	<17	17	200	2.13	<17	14	17	1.15	<17	15	200	1.58
15S	<17	13	17	1.08	<17	15	67	1.58	<17	15	50	1.46	<17	13	17	1.08	<17	14	67	1.36
21S	<17	13	17	1.08	<17	14	17	1.13	<17	18	150	2.01	<17	14	17	1.13	<17	14	150	1.45
27S	<17	20	180	2.31	<17	13	<17	1	<17	16	120	1.85	<17	13	17	1.08	<17	15	180	1.71
29S	<17	15	33	1.31	<17	15	33	1.42	<17	17	50	1.62	<17	19	230	2.37	<17	17	230	1.71
39S	<17	13	<17	1	<17	13	17	1.08	<17	13	<17	1	<17	13	17	1.08	<17	13	17	1.06
All	<17	17	1000	0.95	<17	18	900	0.58	<17	20	15000	1.22	<17	15	3100	0.86	<17	17	15000	0.63

Table B–12 Continues.

Table B–12 continued.

Station	Summer				Fall				Winter				Spring				Annual			
	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev
									Enterococci											
39N	<2	2	10	1.76	2	8	168	3.44	<2	5	250	4.51	<2	3	16	2.39	<2	4	250	3.23
33N	<2	4	46	3.43	<2	8	106	4.33	<2	5	44	3.44	<2	4	26	2.49	<2	5	106	3.44
27N	<2	2	12	1.77	<2	8	320	6.88	<2	15	228	6.43	<2	3	70	3.01	<2	5	320	5.39
21N	<2	3	12	1.88	<2	3	104	3.4	<2	10	>400	7.06	<2	4	32	2.89	<2	5	>400	3.97
15N	<2	3	24	2.3	<2	7	106	4.06	<2	10	254	5.18	<2	3	12	2.09	<2	5	254	3.73
12N	<2	3	32	2.45	<2	4	24	2.71	<2	7	>400	6.82	<2	2	14	1.99	<2	4	>400	3.61
9N	<2	4	202	3.54	<2	4	60	2.68	<2	4	>400	5.1	<2	3	134	2.84	<2	4	>400	3.48
6N	<2	8	222	4.61	<2	6	44	2.94	<2	6	>400	4.76	<2	3	26	2.35	<2	6	>400	3.78
3N	<2	7	>400	5.3	<2	16	>400	4.14	<2	7	>400	4.9	<2	3	14	2.12	<2	7	>400	4.45
0	<2	2	32	2.21	<2	5	50	2.81	<2	9	>400	3.95	<2	6	>400	4.92	<2	5	>400	3.72
3S	<2	2	6	1.68	<2	2	24	2.31	<2	5	>400	5.66	<2	4	90	3.62	<2	3	>400	3.41
6S	<2	2	4	1.43	<2	3	60	2.73	<2	5	336	4.46	<2	3	26	2.58	<2	3	336	2.9
9S	<2	2	4	1.32	<2	5	>400	5.74	<2	5	174	3.57	<2	2	18	2.08	<2	3	>400	3.4
15S	<2	2	4	1.39	<2	3	64	2.9	<2	2	18	2.1	<2	3	10	1.86	<2	3	64	2.1
21S	<2	2	8	1.6	<2	2	6	1.7	<2	3	62	2.9	<2	3	12	1.97	<2	2	62	2.05
27S	<2	4	56	3.6	<2	2	10	1.68	<2	3	70	3.22	<2	4	18	2.55	<2	3	70	2.81
29S	<2	9	38	2.88	<2	3	20	2.48	<2	4	42	3.47	<2	6	24	2.79	<2	5	42	3.01
39S	<2	2	14	2.24	<2	2	10	1.87	<2	2	10	2	<2	2	8	1.91	<2	2	14	1.97
All	<2	4	>400	1.15	<2	5	>400	1.36	<2	6	>400	1.49	<2	3	>400	0.75	<2	4	>400	0.84

Table B–13 Summary statistics of Orange County Health Care Agency nearshore stations for total coliforms, fecal coliforms, and enterococci bacteria (CFU/100 mL) by station and season for 2017-18.

Station	Summer				Fall				Winter				Spring				Annual			
	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev	Min.	Mean	Max.	Std Dev
Total Coliforms																				
OSB02	<17	111	>20000	6.73	<17	57	460	2.34	17	332	>20000	7.03	<17	105	>1300	4.33	<17	122	>20000	5.51
OSB03	17	180	>20000	5.67	<17	107	400	3.24	17	178	>20000	6.07	<17	93	2200	5.17	<17	133	>20000	4.9
OSB05	<17	146	>20000	7.07	17	122	>1100	3.28	<17	152	>20000	6.43	<17	60	600	3.3	<17	113	>20000	4.9
OSB04	<17	50	>20000	7.07	<17	35	420	2.72	<17	137	>20000	6.64	<17	19	83	1.85	<17	46	>20000	5.01
OSB01	<17	14	>17	1.17	<17	13	17	1.08	<17	27	520	3.4	<17	16	67	1.65	<17	17	520	2.04
OSUB1	<17	14	33	1.31	<17	15	67	1.58	<17	33	500	3.55	<17	13	17	1.08	<17	18	500	2.16
BCO-1	<17	15	33	1.42	<17	14	17	1.16	<17	24	270	2.5	<17	17	67	1.62	<17	17	270	1.77
HB1U		0				0			>1100		>1100			0			>1100		>1100	
HB1		0				0			>40000		>40000			0			>40000		>40000	
HB1D	<17	14	33	1.31	<17	16	130	1.89	<17	25	>1200	3.72	<17	14	17	1.16	<17	17	>1200	2.14
HB2U		0				0			17	284	>3800	53.67		0			17	284	>3800	53.67
HB2		0				0			>40000	50000	>40000	1		0			>40000	50000	>40000	1
HB2D	<17	14	17	1.13	<17	18	83	1.78	<17	51	>20000	10.15	<17	15	33	1.42	<17	21	>20000	3.62
HB3U		0				0			>7400		>7400			0			>7400		>7400	
HB3		0				0			>40000		>40000			0			>40000		>40000	
HB3D	<17	15	33	1.31	<17	17	150	1.96	<17	47	5400	8.12	<17	15	33	1.34	<17	20	5400	3.28
HB4U		0				0			33	908	>20000	108.66		0			33	908	>20000	108.66
HB4		0				0			>40000	50000	>40000	1		0			>40000	50000	>40000	1
HB4D	<17	14	33	1.31	<17	17	300	2.38	<17	26	>3600	5.01	<17	15	33	1.31	<17	17	>3600	2.55
HB5U		0				0			17	184	2000	29.12		0			17	184	2000	29.12
HB5		0				0			>40000	50000	>40000	1		0			>40000	50000	>40000	1
HB5D	<17	14	33	1.3	<17	32	230	3.04	<17	24	100	2.2	<17	14	>17	1.19	<17	20	230	2.15
SAR-N	<17	16	33	1.42	<17	24	350	2.73	<17	127	>20000	9.2	<17	24	270	2.69	<17	33	>20000	4.57
TM	<17	26	100	2.12	<17	41	320	2.93	<17	45	1200	4.53	<17	28	150	2.68	<17	34	1200	3.03
BGCU	<17	25	>150	2.41	<17	42	660	3.56	<17	26	220	2.92	<17	74	520	3.29	<17	38	660	3.21
BGC	>67	1938	>21000	4.09	>800	3310	>20000	2.71	400	2775	>40000	3.64	>2300	5586	>12000	1.72	>67	3158	>40000	3.15
BGCD	<17	51	>1000	4.4	<17	62	1000	4.24	<17	31	960	4.09	<17	99	1600	7.55	<17	56	1600	5.03
PPCU	<17	25	>130	2.56	<17	29	800	5.14	<17	33	83	3.76	<17	15	>17	1.23	<17	23	800	2.79
PPC	>2200	31687	>40000	2.73	>1800	17437	>40000	3.58	1100	3595	>9400	5.34	>1500	7434	>40000	3.88	1100	15371	>40000	3.89
PPCD	<17	23	>100	2.49	<17	22	>100	2.13	<17	16	50	1.55	<17	20	330	2.45	<17	20	330	2.15
WFCU	<17	17	50	1.59	<17	15	>50	1.58	<17	20	180	2.41	<17	20	50	1.52	<17	18	180	1.76
WFC	>200	1022	>2100	2.52	>67	526	1400	2.19	130	1003	>40000	5.92	>180	1533	12000	2.97	>67	963	>40000	3.35
WFCD	<15	16	83	1.69	<17	15	>17	1.19	<17	16	33	1.51	<17	20	100	2.12	<15	17	100	1.66
ONB39	<17	13	17	1.08	<17	15	50	1.48	<17	30	220	2.73	<17	15	67	1.6	<17	17	220	1.93
MDCU	<17		<17			0			<17	19	67	1.91	<17	13	<17	1	<17	16	67	1.7
MDC	>40000		>40000			0			400	3778	>40000	5.59	>870	3557	>40000	4.85	400	4399	>40000	5.42
MDCD	<17	14	>17	1.17	<17	16	67	1.66	<17	37	>70000	10.8	<17	14	>17	1.18	<17	18	>70000	3.52
ELMOROU		0				0			<17	15	17	1.23	<17		<17		<17	14	17	1.18
ELMORO		0				0			600	1510	3800	3.69	>40000		>40000		600	4849	>40000	9.22
ELMOROD	<17	13	<17	1	<17	14	33	1.31	<17	16	100	1.83	<17	15	33	1.31	<17	14	100	1.43
All	<15	3053	>40000	1.94	<17	847	>40000	1.01	<17	6904	>70000	18.64	<17	2296	>40000	1.55	<15	7290	>70000	18.77

Table B–13 continues.

Table B–13 continued.

Station	Summer Min.	Summer Mean	Summer Max.	Summer Std Dev	Fall Min.	Fall Mean	Fall Max.	Fall Std Dev	Winter Min.	Winter Mean	Winter Max.	Winter Std Dev	Spring Min.	Spring Mean	Spring Max.	Spring Std Dev	Annual Min.	Annual Mean	Annual Max.	Annual Std Dev
Fecal Coliforms																				
OSB02	<17	49	>20000	6.25	<17	43	250	2.43	<17	77	>20000	7.9	<17	55	920	3.36	<17	55	>20000	4.78
OSB03	<17	163	>20000	5.7	17	102	500	2.57	17	83	4800	4.02	<17	72	920	3.52	<17	100	>20000	3.89
OSB05	<17	116	8600	6.34	17	108	1100	3.54	17	93	8900	5.14	<17	78	680	3.19	<17	98	8900	4.33
OSB04	<17	42	>20000	7.42	<17	29	520	2.9	<17	46	6000	5.28	<17	17	67	1.74	<17	31	>20000	4.24
OSB01	<17	14	17	1.13	<17	13	17	1.08	<17	19	200	2.22	<17	14	33	1.3	<17	15	200	1.55
OSUB1	<17	13	<17	1	<17	14	17	1.13	<17	16	170	2.04	<17	13	<17	1	<17	14	170	1.44
BCO-1	<17	14	33	1.31	<17	16	83	1.76	<17	17	150	1.96	<17	20	83	1.89	<17	16	150	1.74
HB1U		0				0			280		280			0			280		280	
HB1		0				0			19000		19000			0			19000		19000	
HB1D	<17	13	<17	1	<17	16	100	1.76	<17	20	420	2.66	<17	13	17	1.11	<17	15	420	1.79
HB2U		0				0			17	137	1100	19.08		0			17	137	1100	19.08
HB2		0				0			4000	5329	7100	1.5		0			4000	5329	7100	1.5
HB2D	<17	13	17	1.08	<17	16	100	1.76	<17	34	9400	9.79	<17	13	17	1.08	<17	17	9400	3.35
HB3U		0				0			2000		2000			0			2000		2000	
HB3		0				0			14000		14000			0			14000		14000	
HB3D	<17	13	17	1.11	<17	15	33	1.31	<17	30	820	3.79	<17	13	17	1.11	<17	17	820	2.11
HB4U		0				0			50	552	6100	29.87		0			50	552	6100	29.87
HB4		0				0			11000	12410	14000	1.19		0			11000	12410	14000	1.19
HB4D	<17	13	17	1.08	<17	15	120	1.86	<17	19	980	3.31	<17	14	17	1.13	<17	15	980	1.96
HB5U		0				0			17	74	320	7.97		0			17	74	320	7.97
HB5		0				0			8000	20000	>40000	3.65		0			8000	20000	>40000	3.65
HB5D	<17	14	33	1.31	<17	24	180	2.76	<17	15	33	1.31	<17	15	50	1.46	<17	17	180	1.81
SAR-N	<17	14	33	1.31	<17	20	180	2.37	<17	44	>20000	7.73	<17	18	200	2.12	<17	22	>20000	3.4
TM	<17	27	83	2.11	<17	34	170	2.95	<17	22	180	2.31	<17	29	270	2.97	<17	28	270	2.55
BGCU	<17	19	230	2.41	<17	28	420	2.87	<17	13	17	1.11	<17	39	420	3.64	<17	23	420	2.73
BGC	15	111	2100	3.1	46	188	2000	3.55	31	263	4500	4.77	77	378	11000	4.36	15	213	11000	4.07
BGCD	<17	25	1000	4.03	<17	39	600	3.36	<17	26	700	3.53	<17	32	270	3.18	<17	30	1000	3.44
PPCU	<17	13	17	1.1	<17	35	5800	12.16	17	34	67	2.64	<17	13	<17	1	<17	18	5800	3.5
PPC	1100	4387	>40000	3.64	480	1877	>40000	5.61	320	820	2100	3.78	120	684	2800	3.01	120	1860	>40000	4.52
PPCD	<17	13	<17	1	<17	25	2800	4.44	<17	13	17	1.11	<17	17	330	2.45	<17	16	2800	2.43
WFCU	<17	14	50	1.46	<17	14	33	1.33	<17	16	33	1.46	<17	15	67	1.58	<17	15	67	1.45
WFC	15	164	1300	3.45	<15	65	200	2.77	15	79	5800	5.15	31	320	9600	4.92	<15	133	9600	4.44
WFCD	<15	13	17	1.12	<17	14	33	1.31	<17	16	33	1.41	<17	16	50	1.66	<15	15	50	1.41
ONB39	<17	14	33	1.31	<17	13	17	1.08	<17	15	33	1.42	<17	16	67	1.66	<17	15	67	1.4
MDCU	<17		<17			0			<17	13	<17	1	<17	13	<17	1	<17	13	<17	1
MDC	200		200			0			62	428	7200	4.56	150	453	1400	2.22	62	414	7200	3.46
MDCD	<17	13	<17	1	<17	13	17	1.11	<17	17	280	2.35	<17	14	33	1.3	<17	14	280	1.57
ELMOROU		0				0			<17	13	<17	1	<17		<17		<17	13	<17	1
ELMORO		0				0			15	117	920	18.37	31		31		15	75	920	9
ELMOROD	<17	13	17	1.11	<17	13	17	1.08	<17	16	130	1.9	<17	13	17	1.08	<17	14	130	1.39
All	<15	197	>40000	1.94	<15	107	>40000	2.24	<15	1905	>40000	5.80	<17	82	11000	1.12	<15	1928	>40000	5.27

Table B–13 continues.

Table B–13 continued.

Station	Summer Min.	Summer Mean	Summer Max.	Summer Std Dev	Fall Min.	Fall Mean	Fall Max.	Fall Std Dev	Winter Min.	Winter Mean	Winter Max.	Winter Std Dev	Spring Min.	Spring Mean	Spring Max.	Spring Std Dev	Annual Min.	Annual Mean	Annual Max.	Annual Std Dev
										Enterococci										
OSB02	2	31	>400	3.9	<2	16	202	3.43	20	72	>400	2.53	6	39	>400	3.1	<2	34	>400	3.6
OSB03	4	32	>400	4.18	4	15	70	2.29	4	22	>400	3.47	4	20	90	2.57	4	21	>400	3.11
OSB05	<2	16	324	4.21	2	15	>400	3.84	4	36	>400	3.95	<2	17	140	2.68	<2	19	>400	3.72
OSB04	2	6	>400	4.42	<2	6	180	3.8	2	20	>400	5.27	<2	7	38	2.84	<2	8	>400	4.28
OSB01	<2	2	10	1.85	<2	3	28	2.72	<2	6	218	6.37	<2	2	24	2.2	<2	3	218	3.34
OSUB1	<2	2	10	1.87	<2	3	14	1.91	<2	6	278	4.66	<2	2	20	2.17	<2	3	278	2.76
BCO-1	<2	3	16	2.21	<2	2	10	2	<2	5	174	4.66	<2	8	118	5	<2	4	174	3.66
HB1U		0				0			>400		>400			0			>400		>400	
HB1		0				0			>400		>400			0			>400		>400	
HB1D	<2	2	6	1.54	<2	5	90	4.48	<2	11	>400	5.7	<2	4	22	2.83	<2	5	>400	3.99
HB2U		0				0			192	310	>400	1.97		0			192	310	>400	1.97
HB2		0				0			>400	500	>400	1		0			>400	500	>400	1
HB2D	<2	3	10	1.99	<2	4	188	3.97	<2	17	>400	7.68	<2	4	26	2.33	<2	6	>400	4.34
HB3U		0				0			>400		>400			0			>400		>400	
HB3		0				0			>400		>400			0			>400		>400	
HB3D	<2	3	20	2.24	<2	6	80	3.81	<2	14	>400	6.64	<2	4	40	3.21	<2	6	>400	4.26
HB4U		0				0			78	197	>400	3.72		0			78	197	>400	3.72
HB4		0				0			>400	500	>400	1		0			>400	500	>400	1
HB4D	<2	2	6	1.53	<2	5	138	3.96	<2	8	>400	4.82	<2	3	30	2.48	<2	4	>400	3.49
HB5U		0				0			94	162	278	2.15		0			94	162	278	2.15
HB5		0				0			>400	500	>400	1		0			>400	500	>400	1
HB5D	<2	2	10	1.69	<2	5	122	4	<2	7	80	4.37	<2	2	12	1.83	<2	4	122	3.25
SAR-N	<2	2	6	1.62	<2	4	42	3.46	<2	16	>400	4.01	<2	6	80	3.68	<2	5	>400	3.92
TM	<2	7	38	3.19	<2	11	58	3.54	<2	5	118	3.42	<2	11	330	5.1	<2	8	330	3.82
BGCU	<2	4	32	3.11	<2	7	88	3.68	<2	4	56	3.48	2	11	284	6.2	<2	6	284	4.16
BGC	116	238	>400	1.41	50	162	>400	1.88	64	191	>400	2.05	134	237	>400	1.54	50	204	>400	1.75
BGCD	<2	5	134	5.29	<2	10	120	3.91	<2	5	106	4.46	<2	11	218	4.85	<2	7	218	4.64
PPCU	<2	6	32	3.01	<2	3	8	2.07	4	5	6	1.33	<2	3	8	1.98	<2	4	32	2.46
PPC	>400	500	>400	1	>400	500	>400	1	>400	500	>400	1	>200	408	>400	1.42	>200	472	>400	1.22
PPCD	<2	4	38	2.74	<2	3	248	4.07	<2	2	8	1.88	<2	4	48	3.72	<2	3	248	3.04
WFCU	<2	4	18	2.26	<2	2	18	2.12	<2	4	84	3.89	<2	3	8	1.91	<2	3	84	2.47
WFC	116	277	>400	1.6	60	115	294	1.54	98	259	>400	1.96	88	413	>400	1.62	60	244	>400	1.99
WFCD	<2	4	14	2.1	<2	3	32	2.65	<2	3	20	2.56	<2	4	80	3.56	<2	3	80	2.67
ONB39	<2	2	10	1.85	<2	2	16	2.07	<2	5	70	3.64	<2	2	4	1.32	<2	3	70	2.48
MDCU	10		10			0			<2	3	14	2.26	<2	3	30	3.67	<2	3	30	2.7
MDC	>400		>400			0			40	219	>400	2.87	90	217	>400	2.02	40	230	>400	2.48
MDCD	<2	2	6	1.46	<2	3	20	2.71	<2	3	>400	5.18	<2	2	14	2.04	<2	3	>400	2.81
ELMOROU		0				0			2	3	4	1.63	<2		<2		<2	2	4	1.66
ELMORO		0				0			112	237	>400	2.88	>400		>400		112	304	>400	2.37
ELMOROD	<2	2	4	1.32	<2	2	8	1.67	<2	3	80	3.32	<2	2	18	2.1	<2	2	80	2.14
All	<2	60	>400	1.16	<2	35	>400	0.99	<2	147	>400	1.77	<2	65	>400	1.28	<2	145	>400	1.13

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APPENDIX C
Quality Assurance/Quality Control

INTRODUCTION

The Orange County Sanitation District's (OCSD) Core Ocean Monitoring Program (OMP) is designed to measure compliance with permit conditions and for temporal and spatial trend analysis. The program includes measurements of:

- Water quality;
- Sediment quality;
- Benthic infaunal community health;
- Fish and epibenthic macroinvertebrate community health;
- Fish bioaccumulation (chemical body burden); and
- Fish health (including external parasites and diseases).

The Core OMP complies with OCSD's Quality Assurance Project Plan (QAPP) (OCSD 2016a) requirements and applicable federal, state, local, and contract requirements. The objectives of the quality assurance program are as follows:

- Scientific data generated will be of sufficient quality to stand up to scientific and legal scrutiny.
- Data will be gathered or developed in accordance with procedures appropriate for the intended use of the data.
- Data will be of known and acceptable precision, accuracy, representativeness, completeness, and comparability as required by the program.

The various aspects of the program are conducted on a schedule that varies weekly, monthly, quarterly, semi-annually, and annually. Sampling and data analyses are designated by quarters 1 through 4, which are representative of the summer (July-September), fall (October-December), winter (January-March), and spring (April-June) seasons, respectively.

This appendix details quality assurance/quality control (QA/QC) information for the collection and analysis of water quality, sediment geochemistry, fish tissue chemistry, and benthic infauna for OCSD's 2017-18 Core OMP.

WATER QUALITY NARRATIVE

OCSD's Laboratory, Monitoring, and Compliance (LMC) staff collected 633, 654, 654, and 631 discrete ammonium samples during the quarterly collections between July 1, 2017 and June 30, 2018. All samples were iced upon collection, preserved with 1:1 sulfuric acid upon receipt by the LMC laboratory staff, and stored at <6.0 °C until analysis according to the LMC's Standard Operating Procedures (SOPs) (OCSD 2016b).

LMC staff also collected 175 bacteria samples in each quarter during the 2017-18 monitoring period. All samples were iced upon collection and stored at <10 °C until analysis in accordance with LMC SOPs.

Ammonium

The samples were analyzed for ammonium on a segmented flow analyzer using Standard Methods 4500-NH_3-G-Ocean Water. Sodium phenolate, sodium salicylate and sodium hypochlorite, or dichloroiscyanuric acid were added to the samples to react with ammonium to form indophenol blue in a concentration proportional to the ammonium concentration in the sample. The blue color was intensified with sodium nitroprusside and was measured at 660 nm.

A typical sample batch included a blank and a spike in seawater collected from a control site at a maximum of every 20 samples; an external reference sample was also run once each month. One spike and spike replicate were added to the batch every 10 samples. The method detection limit (MDL) for low-level ammonium samples using the segmented flow instrument is shown in Table C-1. All samples were analyzed within the required holding time. All analyses conducted met the QA/QC criteria for accuracy and precision, with one noted exception in the Summer quarter (Table C-2). This exception was found to be caused by analyst error; a repeat analysis met the QA/QC criteria.

Table C–1 Method Detection Limits (MDLs) and Reporting Limits (RLs) for 2017-18.

Receiving waters					
Parameter	**MDL (MPN/100mL)**	**RL (MPN/100mL)**	**Parameter**	**MDL (mg/L)**	**RL (mg/L)**
Total coliform	10	10	Ammonium (effective through 9/18/2017)	0.013 *	0.020
E. coli	10	10	Ammonium (effective 9/19/2017)	0.014 *	0.040
Enterococci	10	10			
Sediments					
Parameter	**MDL (ng/g dry)**	**RL (ng/g dry)**	**Parameter**	**MDL (ng/g dry)**	**RL (ng/g dry)**
Organochlorine Pesticides					
2,4'-DDD	2.18	2.2	Endosulfan-alpha	1.54	2.0
2,4'-DDE	1.51	2.0	Endosulfan-beta	1.03	2.0
2,4'-DDT	1.56	2.0	Endosulfan-sulfate	0.94	2.0
4,4'-DDD	1.47	2.0	Endrin	3.52	5.0
4,4'-DDE	1.75	2.0	*gamma*-BHC	2.64	2.7
4,4'-DDT	0.56	0.6	Heptachlor	2.01	2.1
4,4'-DDMU	2.16	2.2	Heptachlor epoxide	1.02	1.1
Aldrin	0.42	0.5	Hexachlorobenzene	0.98	1.0
cis-Chlordane	1.29	2.0	Mirex	0.70	0.7
trans-Chlordane	1.58	2.0	*trans*-Nonachlor	1.48	2.0
Dieldrin	1.84	2.0			
PCB Congeners					
PCB 18	0.20	0.2	PCB 126	0.21	0.2
PCB 28	0.14	0.2	PCB 128	0.31	0.4
PCB 37	0.40	0.4	PCB 138	0.19	0.2
PCB 44	0.17	0.2	PCB 149	0.17	0.2
PCB 49	0.39	0.4	PCB 151	0.16	0.2
PCB 52	0.20	0.2	PCB 153/168	0.79	0.8
PCB 66	0.31	0.4	PCB 156	0.20	0.2
PCB 70	0.30	0.3	PCB 157	0.15	0.2
PCB 74	0.24	0.3	PCB 167	0.19	0.2
PCB 77	0.15	0.2	PCB 169	0.11	0.2
PCB 81	0.17	0.2	PCB 170	0.11	0.2
PCB 87	0.26	0.3	PCB 177	0.15	0.2
PCB 99	0.18	0.2	PCB 180	0.17	0.2
PCB 101	0.19	0.2	PCB 183	0.18	0.2
PCB 105	0.17	0.2	PCB 187	0.14	0.2
PCB 110	0.18	0.2	PCB 189	0.13	0.2
PCB 114	0.17	0.2	PCB 194	0.13	0.2
PCB 118	0.16	0.2	PCB 201	0.19	0.2
PCB 119	0.20	0.2	PCB 206	0.17	0.2
PCB 123	0.14	0.2			

Table C–1 continues.

Table C–1 continued.

Parameter	MDL	RL	Parameter	MDL	RL
Sediments					
Parameter	**MDL (ng/g dry)**	**RL (ng/g dry)**	**Parameter**	**MDL (ng/g dry)**	**RL (ng/g dry)**
PAH Compounds					
1,6,7-Trimethylnaphthalene	0.6	1	Benzo[g,h,i]perylene	0.5	1
1-Methylnaphthalene	0.6	1	Benzo[k]fluoranthene	0.3	1
1-Methylphenanthrene	0.6	1	Biphenyl	0.5	1
2,3,6-Trimethylnaphthalene	0.5	1	Chrysene	0.5	1
2,6-Dimethylnaphthalene	0.4	1	Dibenz[a,h]anthracene	0.6	1
2-Methylnaphthalene	0.7	1	Dibenzothiophene	0.5	1
Acenaphthene	0.4	1	Fluoranthene	0.4	1
Acenaphthylene	0.5	1	Fluorene	0.9	1
Anthracene	1.0	1	Indeno[1,2,3-c,d]pyrene	0.5	1
Benz[a]anthracene	0.9	1	Naphthalene	1.3	2
Benzo[a]pyrene	0.4	1	Perylene	1.2	2
Benzo[b]fluoranthene	0.5	1	Phenanthrene	0.7	1
Benzo[e]pyrene	1.0	1	Pyrene	0.5	1
Parameter	**MDL (µg/kg dry)**	**RL (µg/kg dry)**	**Parameter**	**MDL (µg/kg dry)**	**RL (µg/kg dry)**
Metals					
Antimony	0.116	0.20	Lead	0.040	0.10
Arsenic	0.054	0.10	Mercury	0.038	0.040
Barium	0.151	0.20	Nickel	0.114	0.20
Beryllium	0.030	0.10	Selenium	0.481	0.50
Cadmium	0.089	0.10	Silver	0.139	0.20
Chromium	0.058	0.10	Zinc	0.862	1.50
Copper	0.138	0.20			
Parameter	**MDL (mg/kg dry)**	**RL (mg/kg dry)**	**Parameter**	**MDL (%)**	**RL (%)**
Miscellaneous Parameters					
Dissolved Sulfides	1.03	1.03	Grain Size	0.01	0.01
Total Nitrogen	0.49	60	Total Organic Carbon	0.02	0.1
Total Phosphorus	0.17	3.8			
Fish Tissue					
Parameter	**MDL (ng/g wet)**	**RL (ng/g wet)**	**Parameter**	**MDL (ng/g wet)**	**RL (ng/g wet)**
Organochlorine Pesticides					
2,4'-DDD	1.42	2.00	*cis*-Chlordane	0.99	1.00
2,4'-DDE	1.05	2.00	*trans*-Chlordane	1.87	2.00
2,4'-DDT	0.91	1.00	Oxychlordane	1.86	2.00
4,4'-DDD	0.89	1.00	Heptachlor	0.96	1.00
4,4'-DDE	0.81	1.00	Heptachlor epoxide	0.94	1.00
4,4'-DDT	1.04	2.00	*cis*-Nonachlor	1.02	2.00
4,4'-DDMU	0.99	1.00	*trans*-Nonachlor	1.41	2.00
Dieldrin	0.97	5.00			
PCB Congeners					
PCB 18	1.12	2.00	PCB 126	1.18	2.00
PCB 28	0.94	1.00	PCB 128	1.63	2.00
PCB 37	1.31	2.00	PCB 138	0.71	1.00
PCB 44	1.43	2.00	PCB 149	0.65	1.00
PCB 49	1.57	2.00	PCB 151	0.87	1.00
PCB 52	1.42	2.00	PCB 153/168	1.43	2.00
PCB 66	1.12	2.00	PCB 156	1.45	2.00
PCB 70	0.76	1.00	PCB 157	1.66	2.00
PCB 74	0.78	1.00	PCB 167	1.02	2.00
PCB 77	0.78	1.00	PCB 169	1.69	2.00
PCB 81	0.81	1.00	PCB 170	0.94	1.00
PCB 87	0.98	1.00	PCB 177	1.36	2.00
PCB 99	1.12	2.00	PCB 180	0.71	1.00
PCB 101	0.71	1.00	PCB 183	1.31	2.00
PCB 105	0.74	1.00	PCB 187	0.71	1.00
PCB 110	0.96	1.00	PCB 189	1.00	1.00
PCB 114	0.82	1.00	PCB 194	1.24	2.00
PCB 118	0.76	1.00	PCB 201	1.41	2.00
PCB 119	0.92	1.00	PCB 206	0.96	2.00
PCB 123	0.69	1.00			
Parameter	**MDL (mg/kg dry)**	**RL (mg/kg dry)**	**Parameter**	**MDL (mg/kg dry)**	**RL (mg/kg wet)**
Metals					
Arsenic	0.054	0.100	Mercury	0.038	0.040
Selenium	0.481	0.500			

* Values reported between the MDL and the RL were estimated.

Table C–2 Water quality QA/QC summary for 2017-18.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	Ammonium	633 (9)	Blank	37	1	37	100
			Blank Spike	37	1	37	100
			Matrix Spike	68	1	68	100
			Matrix Spike Dup	68	1	67	99
			Matrix Spike Precision	68	1	67	99
Fall	Ammonium	654 (8)	Blank	36	1	36	100
			Blank Spike	36	1	36	100
			Matrix Spike	69	1	69	100
			Matrix Spike Dup	69	1	69	100
			Matrix Spike Precision	69	1	69	100
Winter	Ammonium	654 (9)	Blank	39	1	39	100
			Blank Spike	39	1	39	100
			Matrix Spike	69	1	69	100
			Matrix Spike Dup	69	1	69	100
			Matrix Spike Precision	69	1	69	100
Spring	Ammonium	631 (9)	Blank	37	1	37	100
			Blank Spike	37	1	37	100
			Matrix Spike	68	1	68	100
			Matrix Spike Dup	68	1	68	100
			Matrix Spike Precision	68	1	68	100

* An analysis passed if the following criteria were met:
For blank - Target accuracy % recovery <2X MDL.
For blank spike - Target accuracy % recovery 90-110.
For matrix spike and matrix spike duplicate - Target accuracy % recovery 80-120.
For matrix spike precision - Target precision % RPD <11%.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	Total Coliforms	35 (5)	Duplicate	32	1	29	91
	Fecal Coliforms	35 (5)	Duplicate	32	1	29	91
	Enterococci	35 (5)	Duplicate	32	1	29	91
Fall	Total Coliforms	35 (5)	Duplicate	32	1	32	100
	Fecal Coliforms	35 (5)	Duplicate	32	1	30	94
	Enterococci	35 (5)	Duplicate	32	1	30	94
Winter	Total Coliforms	35 (5)	Duplicate	32	1	29	91
	Fecal Coliforms	35 (5)	Duplicate	32	1	26	81
	Enterococci	35 (5)	Duplicate	32	1	28	88
Spring	Total Coliforms	35 (5)	Duplicate	32	1	29	91
	Fecal Coliforms	35 (5)	Duplicate	32	1	29	91
	Enterococci	35 (5)	Duplicate	32	1	29	91
Annual	Total Coliforms	700 (20)	Duplicate	134	1	125	93
	Fecal Coliforms	700 (20)	Duplicate	134	1	120	90
	Enterococci	700 (20)	Duplicate	134	1	121	90

* Analysis passed if the average range of logarithms is less than the precision criterion.

Bacteria

Samples collected offshore (i.e., Recreational (aka REC-1)) were analyzed for bacteria using Enterolert™ for enterococci and Colilert-18™ for total coliforms and *Escherichia coli*. Fecal coliforms were estimated by multiplying the *E. coli* result by a factor of 1.1. These methods utilize enzyme substrates that produce, upon hydrolyzation, a fluorescent signal when viewed under long-wavelength (365 nm) ultraviolet light. For samples collected along the surfzone, samples were analyzed by culture-based methods for direct count of bacteria. EPA Method 1600 was applied to enumerate enterococci bacteria. For enumeration of total and fecal coliforms, respectively, Standard Methods 9222B and 9222D were used. MDLs for bacteria are presented in Table C-1.

All samples were analyzed within the required holding time. REC-1 samples were processed and incubated within 8 hours of sample collection. Duplicate analyses were performed on a minimum of 10% of samples with at least 1 sample per sample batch. All equipment, reagents, and dilution waters used for sample analyses were sterilized before use. Sterility of sample bottles was tested for each new lot/batch before use. Each lot of medium, whether prepared or purchased, was tested for sterility and performance with known positive and negative controls prior to use. For surfzone samples, a positive and a negative control were run simultaneously with each batch of sample for each type of media used to ensure performance. New lots of Quanti-Tray and petri dish were checked for sterility before use. Each Quanti-Tray sealer was checked monthly by addition of Gram stain dye to 100 mL of water, and the tray was sealed and subsequently checked for leakage. Each lot of dilution blanks commercially purchased was checked for appropriate volume and sterility. New lots of ≤10 mL volume pipettes were checked for accuracy by weighing volume delivery on a calibrated top loading scale. Duplicate analyses were performed on a minimum of 10% of routine samples. Although the precision criterion is used to measure the precision of duplicate analyses for plate-based methods (APHA 2017), this criterion was used for most probable number methods due to a lack of criterion. Over 90% of duplicate analyses passed in 3 of the 4 quarters for all 3 fecal indicator bacteria (Table C-2). The analytical pass rate for fecal coliforms and enterococci was 81% and 88%, respectively, in the Winter quarter.

SEDIMENT CHEMISTRY NARRATIVE

OCSD's LMC laboratory received 68 sediment samples from LMC's OMP staff during July 2017, and 29 samples during January 2018. All samples were stored according to LMC SOPs. All samples were analyzed for organochlorine pesticides, polychlorinated biphenyl congeners (PCBs), polycyclic aromatic hydrocarbons (PAHs), trace metals, mercury, dissolved sulfides (DS), total organic carbon (TOC), total nitrogen (TN), total phosphorus (TP), and grain size. All samples were analyzed within the required holding times.

PAHs, PCBs, and Organochlorine Pesticides

The analytical methods used to detect PAHs, organochlorine pesticides, and PCBs in the samples are described in the LMC SOPs. All sediment samples were extracted using an accelerated solvent extractor (ASE). Approximately 10 g (dry weight) of sample was used for each analysis. A separatory funnel extraction was performed using 100 mL of sample when field and rinse blanks were included in the batch. All sediment extracts were analyzed by GC/MS.

A typical sample batch included 20 field samples with required QC samples. Sample batches that were analyzed for PAHs, organochlorine pesticides, and PCBs included the following QC samples: 1 sand blank, 1 blank spike, 1 standard reference material (SRM), 1 matrix spike set, and 1 sample duplicate. MDLs and SRM acceptance criteria for each PAH, PCB, and pesticide constituent are presented in Tables C-1 and C-3, respectively.

All analyses were performed with appropriate QC measures, as stated in OCSD's QAPP, with most of the compounds tested during the 2 quarters meeting QA/QC criteria (Table C-4). When constituent concentrations exceeded the calibration range of the instrument, dilutions were performed and the samples reanalyzed. Any deviations from standard protocol that occurred during sample preparation or analysis are noted in the raw data packages.

Trace Metals

Dried sediment samples were analyzed for trace metals in accordance with methods in the LMC SOPs. A typical sample batch for antimony, arsenic, barium, beryllium, cadmium, chromium, copper, nickel, lead, silver, selenium, and zinc analyses included 3 blanks, a blank spike, and 1 SRM. Additionally, sample duplicates, sample spikes, and sample spike duplicates were analyzed at least once for every 10 sediment samples. The analysis of the blank spike and SRM provided a measure of the accuracy of the analysis. The analysis of the sample, its duplicate, and the 2 sample spikes were evaluated for precision.

All samples were analyzed using inductively coupled mass spectroscopy. If any analyte exceeded both the appropriate calibration curve and linear dynamic range, the sample was diluted and reanalyzed. MDLs for metals are presented in Table C-1. Acceptance criteria for trace metal SRMs are presented in Table C-3. Most of the compounds tested for sediment trace metals during the 2 quarters met QA/QC criteria (Table C-4).

Table C–3 Acceptance criteria for standard reference materials for 2017-18.

Parameter	True Value (ng/g)	Acceptance Range (ng/g)	
		Minimum	Maximum
Sediments			
Organochlorine Pesticides, PCB Congeners, and Percent Dry Weight (SRM 1944; New York/New Jersey Waterway Sediment, National Institute of Standards and Technology)			
PCB 8	22.3	13.38	31.22
PCB 18	51.0	30.6	71.4
PCB 28	80.8	48.48	113.12
PCB 44	60.2	36.12	84.28
PCB 49	53.0	31.8	74.2
PCB 52	79.4	47.64	111.16
PCB 66	71.9	43.14	100.66
PCB 87	29.9	17.94	41.86
PCB 99	37.5	22.5	52.5
PCB 101	73.4	44.04	102.76
PCB 105	24.5	14.7	34.3
PCB 110	63.5	38.1	88.9
PCB 118	58.0	34.8	81.2
PCB 128	8.47	5.082	11.858
PCB 138	62.1	37.26	86.94
PCB 149	49.7	29.82	69.58
PCB 151	16.93	10.158	23.702
PCB 153/168	74.0	44.4	103.6
PCB 156	6.52	3.912	9.128
PCB 170	22.6	13.56	31.64
PCB 180	44.3	26.58	62.02
PCB 183	12.19	7.314	17.066
PCB 187	25.1	15.06	35.14
PCB 194	11.2	6.72	15.68
PCB 195	3.75	2.25	5.25
PCB 206	9.21	5.526	12.894
PCB 209	6.81	4.086	9.534
2,4’-DDD *	38.0	22.8	53.2
2,4’-DDE *	19.0	11.4	26.6
4,4’-DDD *	108.0	64.8	151.2
4,4’-DDE *	86.0	51.6	120.4
4,4’-DDT *	170.0	102	238
cis-Chlordane	16.51	9.906	23.114
trans-Chlordane *	19.0	11.4	26.6
gamma-BHC *	2.0	1.2	2.8
Hexachlorobenzene	6.03	3.618	8.442
cis-Nonachlor *	3.7	2.22	5.18
trans-Nonachlor	8.2	4.92	11.48
Percent Dry Weight	1.3	–	–
PAH Compounds and Percent Dry Weight (SRM 1944; New York/New Jersey Waterway Sediment, National Institute of Standards and Technology)			
1-Methylnaphthalene *	470	282	658
1-Methylphenanthrene *	1700	1020	2380
2-Methylnaphthalene *	740	444	1036
Acenaphthene *	390	234	546
Anthracene *	1130	678	1582
Benz[a]anthracene	4720	2832	6608
Benzo[a]pyrene	4300	2580	6020
Benzo[b]fluoranthene	3870	2322	5418
Benzo[e]pyrene	3280	1968	4592
Benzo[g,h,i]perylene	2840	1704	3976
Benzo[k]fluoranthene	2300	1380	3220
Biphenyl *	250	150	350
Chrysene	4860	2916	6804
Dibenz[a,h]anthracene	424	254.4	593.6
Dibenzothiophene *	500	300	700
Fluoranthene	8920	5352	12488
Fluorene *	480	288	672
Indeno[1,2,3-c,d]pyrene	2780	1668	3892
Naphthalene *	1280	768	1792
Perylene	1170	702	1638
Phenanthrene	5270	3162	7378
Pyrene	9700	5820	13580
Percent Dry Weight	1.3	–	–

Table C–3 continues.

Table C–3 continued.

Parameter	True Value (ng/g)	Acceptance Range (ng/g)	
		Minimum	Maximum
Sediments			
Metals			
(CRM-540 ERA Metals in Soil; Lot No. D099-540)			
Antimony	75.5	2.85	148
Arsenic	161	134	188
Barium	260	215	305
Beryllium	102	81.4	114
Cadmium	211	176	246
Chromium	136	112	160
Copper	166	139	192
Lead	111	92.1	130
Mercury	11.5	8.23	14.7
Nickel	91.9	76.2	108
Selenium	191	152	231
Silver	43.3	34.6	51.9
Zinc	199	162	237
Fish Tissue			
Organochlorine Pesticides, PCB Congeners, and Lipid			
(SRM1946, Lake Superior Fish Tissue; National Institute of Standards and Technology)			
PCB 18 *	0.84	0.504	1.176
PCB 28 *	2	1.2	2.8
PCB 44	4.66	2.796	6.524
PCB 49	3.8	2.28	5.32
PCB 52	8.1	4.86	11.34
PCB 66	10.8	6.48	15.12
PCB 70	14.9	8.94	20.86
PCB 74	4.83	2.898	6.762
PCB 77	0.327	0.196	0.458
PCB 87	9.4	5.64	13.16
PCB 99	25.6	15.36	35.84
PCB 101	34.6	20.76	48.44
PCB 105	19.9	11.94	27.86
PCB 110	22.8	13.68	31.92
PCB 118	52.1	31.26	72.94
PCB 126	0.38	0.228	0.532
PCB 128	22.8	13.68	31.92
PCB 138	115	69	161
PCB 149	26.3	15.78	36.82
PCB 153/168	170	102	238
PCB 156	9.52	5.712	13.328
PCB 170	25.2	15.12	35.28
PCB 180	74.4	44.64	104.16
PCB 183	21.9	13.14	30.66
PCB 187	55.2	33.12	77.28
PCB 194	13	7.8	18.2
PCB 201 *	2.83	1.698	3.962
PCB 206	5.4	3.24	7.56
2,4’-DDD	2.2	1.32	3.08
2,4’-DDE *	1.04	0.624	1.456
2,4’-DDT *	22.3	13.38	31.22
4,4’-DDD	17.7	10.62	24.78
4,4’-DDE	373	223.8	522.2
4,4’-DDT	37.2	22.32	52.08
cis-Chlordane	32.5	19.5	45.5
trans-Chlordane	8.36	5.016	11.704
Oxychlordane	18.9	11.34	26.46
Dieldrin	32.5	19.5	45.5
Heptachlor epoxide	5.5	3.3	7.7
cis-Nonachlor	59.1	35.46	82.74
trans-Nonachlor	99.6	59.76	139.44
Lipid *	10.17	–	–
Metals			
(SRM DORM-4; National Research Council Canada)			
Arsenic	6.87	4.81	8.93
Selenium	3.45	2.42	4.49
Mercury	0.412	0.288	0.536

* Parameter with non-certified value(s).

Table C–4 Sediment QA/QC summary for 2017-18. N/A = Not Applicable.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	PAHs	68 (5)	Blank	5	26	130	100
			Blank Spike	5	26	112	86
			Matrix Spike	5	26	123	95
			Matrix Spike Duplicate	5	26	128	98
			Matrix Spike Precision	5	26	130	100
			Duplicate	4	26	96	92
			CRM Analysis	5	21	86	82
Winter	PAHs	29 (2)	Blank	2	26	50	96
			Blank Spike	2	26	48	92
			Matrix Spike	2	26	52	100
			Matrix Spike Duplicate	2	26	47	90
			Matrix Spike Precision	2	26	51	98
			Duplicate	2	26	40	77
			CRM Analysis	2	21	35	83

* An analysis passed if the following criteria were met:
For blank - Target accuracy % recovery <3X MDL.
For blank spike - Target accuracy % recovery 60-120.
For matrix spike and matrix spike duplicate - Target accuracy % recovery 40-120.
For matrix spike precision - Target precision % RPD <25%.
For duplicate - Target precision % RPD <25% at 3X MDL of sample mean.
For SRM analysis - Target accuracy % recovery 60-140 or certified value, whichever is greater.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	PCBs and Pesticides	68 (5)	Blank	5	60	300	100
			Blank Spike	5	60	261	87
			Matrix Spike	5	60	252	84
			Matrix Spike Duplicate	5	60	242	81
			Matrix Spike Precision	5	60	288	96
			Duplicate	3	60	297	99
			CRM Analysis	5	33	139	84
Winter	PCBs and Pesticides	29 (2)	Blank	2	60	120	100
			Blank Spike	2	60	114	95
			Matrix Spike	2	60	100	83
			Matrix Spike Duplicate	2	60	80	67
			Matrix Spike Precision	2	60	115	96
			Duplicate	2	60	120	100
			CRM Analysis	2	33	60	91

* An analysis passed if the following criteria were met:
For blank - Target accuracy % recovery <3X MDL.
For blank spike - Target accuracy % recovery 60-120.
For matrix spike and matrix spike duplicate - Target accuracy % recovery 40-120.
For matrix spike precision - Target precision % RPD <25%.
For duplicate - Target precision % RPD <25% at 3X MDL of sample mean.
For SRM analysis - Target accuracy % recovery 60-140 or certified value, whichever is greater.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Lead, Nickel, Selenium, Silver, Zinc	68 (2)	Blank	8	12	96	100
			Blank Spike	4	12	48	100
			Matrix Spike	8	12	85	89
			Matrix Spike Dup	8	12	86	90
			Matrix Spike Precision	8	12	96	100
			Duplicate	8	12	89	93
			CRM Analysis	2	12	24	100
Summer	Mercury	68 (2)	Blank	4	1	8	100
			Blank Spike	4	1	8	100
			Matrix Spike	8	1	7	88
			Matrix Spike Dup	8	1	7	88
			Matrix Spike Precision	8	1	8	100
			Duplicate	8	1	8	100
			CRM Analysis	2	1	2	100
Winter	Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Lead, Nickel, Selenium, Silver, Zinc	29 (1)	Blank	4	12	48	100
			Blank Spike	2	12	24	100
			Matrix Spike	4	12	43	90
			Matrix Spike Dup	4	12	43	90
			Matrix Spike Precision	4	12	48	100
			Duplicate	4	12	44	92
			CRM Analysis	1	12	12	100
Winter	Mercury	29 (1)	Blank	2	1	2	100
			Blank Spike	2	1	2	100
			Matrix Spike	3	1	3	100
			Matrix Spike Dup	3	1	3	100
			Matrix Spike Precision	3	1	3	100
			Duplicate	3	1	3	100
			CRM Analysis	1	1	1	100

* An analysis passed if the following criteria were met.
For blank - Target accuracy % recovery <3X MDL, Sample results for analyte >10 x blank result.
For blank spike - Target accuracy % recovery 90-110.
For matrix spike and matrix spike duplicate – Target accuracy % recovery 70-130.
For matrix spike precision - Target precision % RPD <20.
For duplicate - Target precision % RPD 30.
For SRM analysis - Target accuracy % recovery 80-120% or certified value whichever is greater.

Table C–4 continues.

Table C–4 continued.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	Dissolved Sulfides	68 (7)	Blank	7	1	7	100
			Blank Spike	7	1	7	100
			Matrix Spike	7	1	7	100
			Matrix Spike Dup	7	1	7	100
			Matrix Spike Precision	7	1	7	100
			Duplicate	7	1	7	100
Winter	Dissolved Sulfides	29 (3)	Blank	3	1	3	100
			Blank Spike	3	1	3	100
			Matrix Spike	3	1	3	100
			Matrix Spike Dup	3	1	3	100
			Matrix Spike Precision	3	1	3	100
			Duplicate	3	1	3	100

* An analysis passed if the following criteria were met:
For blank - Target accuracy % recovery <2X MDL.
For blank spike - Target accuracy % recovery 80-120.
For matrix spike and matrix spike suplicate - Target accuracy % recovery 70-130.
For matrix spike precision - Target precision % RPD <30%.
For duplicate - Target precision % RPD <30% at 3X MDL of sample mean.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	TOC	68 (2)	Blank	4	1	4	100
			Blank Spike	N/A	N/A	N/A	N/A
			Matrix Spike	4	1	4	100
			Matrix Spike Dup	4	1	4	100
			Matrix Spike Precision	4	1	4	100
			Duplicate	8	1	7	88
Winter	TOC	29 (1)	Blank	2	1	2	100
			Blank Spike	N/A	N/A	N/A	N/A
			Matrix Spike	2	1	2	100
			Matrix Spike Dup	2	1	2	100
			Matrix Spike Precision	2	1	2	100
			Duplicate	4	1	4	100

* An analysis passed if the following criteria were met:
For blank - Target accuracy % recovery <10X MDL.
For matrix spike and matrix spike suplicate - Target accuracy % recovery 80-120.
For matrix spike precision - Target precision % RPD <10%.
For duplicate - Target precision % RPD <10% at 3X MDL of sample mean.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	Grain Size	68 (1)	Blank	N/A	N/A	N/A	N/A
			Blank Spike	N/A	N/A	N/A	N/A
			Matrix Spike	N/A	N/A	N/A	N/A
			Matrix Spike Dup	N/A	N/A	N/A	N/A
			Matrix Spike Precision	N/A	N/A	N/A	N/A
			Duplicate	7	1	7	100
Winter	Grain Size	29 (1)	Blank	N/A	N/A	N/A	N/A
			Blank Spike	N/A	N/A	N/A	N/A
			Matrix Spike	N/A	N/A	N/A	N/A
			Matrix Spike Dup	N/A	N/A	N/A	N/A
			Matrix Spike Precision	N/A	N/A	N/A	N/A
			Duplicate	3	1	3	100

* An analysis passed if the following criterion was met:
For duplicate - Target precision mean % RPD <10%.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	Total N	68 (2)	Blank	6	1	5	83
			Blank Spike	12	1	12	100
			Matrix Spike	7	1	3	43
			Matrix Spike Dup	7	1	3	43
			Matrix Spike Precision	7	1	7	100
			Duplicate	7	1	5	71
Winter	Total N	29 (1)	Blank	3	1	3	100
			Blank Spike	6	1	6	100
			Matrix Spike	5	1	3	60
			Matrix Spike Dup	5	1	3	60
			Matrix Spike Precision	5	1	5	100
			Duplicate	5	1	5	100

* An analysis passed if the following criteria were met:
For blank - Target accuracy % recovery <3X MDL.
For blank spike, matrix spike, and matrix spike duplicate - Target accuracy % recovery 80-120.
For matrix spike precision - Target precision % RPD <20%.
For duplicate - Target precision % RPD <20% at 3X MDL of sample mean.

Table C–4 continues.

Table C–4 continued.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	Total P	68 (1)	Blank	4	1	3	75
			Blank Spike	4	1	4	100
			Matrix Spike	7	1	6	86
			Matrix Spike Dup	7	1	5	71
			Matrix Spike Precision	7	1	7	100
			Duplicate	5	1	7	100
Winter	Total P	29 (1)	Blank	2	1	2	100
			Blank Spike	2	1	2	100
			Matrix Spike	3	1	3	100
			Matrix Spike Dup	3	1	3	100
			Matrix Spike Precision	3	1	3	100
			Duplicate	3	1	3	100

* An analysis passed if the following criteria were met:
For blank - Target accuracy % recovery <3X MDL.
For blank spike, matrix spike, and matrix spike duplicate - Target accuracy % recovery 80-120.
For matrix spike precision - Target precision % RPD <20%.
For duplicate - Target precision % RPD <20% at 3X MDL of sample mean.

Mercury

Dried sediment samples were analyzed for mercury in accordance with methods described in the LMC SOPs. QC for a typical batch included a blank, blank spike, and SRM. A set of sediment sample duplicates, sample spike, and spike duplicates were run once for every 10 sediment samples. When sample mercury concentration exceeded the appropriate calibration curve, the sample was diluted with the reagent blank and reanalyzed. The samples were analyzed for mercury on a Perkin Elmer FIMS 400 system.

The MDL for sediment mercury is presented in Table C-1. Acceptance criteria for mercury SRM is presented in Table C-3. All samples, with some noted exceptions, met the QA/QC criteria guidelines for accuracy and precision (Table C-4).

Dissolved Sulfides

DS samples were analyzed in accordance with methods described in the LMC SOPs. The MDL for DS is presented in Table C-1. All analyses in both quarters met the QA/QC criteria (Table C-4).

Total Organic Carbon

TOC samples were analyzed by ALS Environmental Services, Kelso, WA. The MDL for TOC is presented in Table C-1. The majority of analyzed TOC samples passed the QA/QC criteria (Table C-4).

Grain Size

Grain size samples were analyzed by Integral Consulting Inc., Santa Cruz, CA. The MDL for sediment grain size is presented in Table C-1. All analyzed grain size samples passed the QA/QC criteria of RPD ≤10% (Table C-4).

Total Nitrogen

TN samples were analyzed by Weck Laboratories, Inc., City of Industry, CA. The MDL for TN is presented in Table C-1. Most of the matrix spike precisions and their duplicate analyses had an RPD of less than 20% (Table C-4). Many of the laboratory control samples (LCS) met the acceptance criteria; only 50% of matrix spikes and matrix spike duplicates met the recovery criteria of 80-120% for the year due to matrix interferences in the analysis (Table C-4).

Total Phosphorus

TP samples were analyzed by Weck Laboratories. The MDL for TP is presented in Table C-1. The matrix spike precisions and their duplicate analyses had an RPD of less than 20% (Table C-4). Nearly all the associated LCS met the acceptance criteria; only 90% and 80% of matrix spikes and matrix spike duplicates, respectively, met the recovery criteria of 80-120% for the year due to matrix interferences in the analysis (Table C-4).

FISH TISSUE CHEMISTRY NARRATIVE

For the 2017-2018 program year, the LMC laboratory received 11 trawl fish samples and 20 rig fish samples in July 2017, and 16 trawl fish samples in January 2018. The individual samples were stored, dissected, and homogenized according to methods described in the LMC SOPs. A 1:1 muscle to water ratio was used for muscle samples. No water was used for liver samples. After the individual samples were homogenized, equal aliquots of muscle from each rig fish sample, and equal aliquots of muscle and liver from each trawl fish sample were frozen and distributed to the metals and organic chemistry sections of the analytical chemistry laboratory for analyses.

Organochlorine Pesticides and PCB Congeners

The analytical methods used for organochlorine pesticides and PCB congeners were according to methods described in the LMC SOPs. All fish tissue was extracted using an ASE 350 and analyzed by GC/MS.

All analyses were performed within the required holding time and with appropriate QC measures. A typical organic tissue or liver sample batch included up to 20 field samples with required QC samples. The QC samples included a laboratory blank, sample duplicates, matrix spike, matrix spike duplicate, SRM, and reporting level spike (matrix of choice was tilapia). The MDLs for pesticides and PCBs in fish tissue are presented in Table C-1. Acceptance criteria for PCB and pesticides SRM in fish tissue are presented in Table C-3.

Most compounds tested in each parameter group met the QA/QC criteria (Table C-5). In cases where constituent concentrations exceeded the calibration range of the instrument, the samples were diluted and reanalyzed. Any variances that occurred during sample preparation or analyses are noted in the Comments/Notes section of each batch summary.

Lipid Content

Percent lipid content was determined for each sample of fish using methods described in the LMC SOPs. Lipids were extracted by dichloromethane from approximately 1 to 2 g of sample and concentrated to 2 mL. A 100 µL aliquot of the extract was placed in a tared aluminum weighing boat and allowed to evaporate to dryness. The remaining residue was weighed, and the percent lipid content calculated. All analyses were performed within the required holding time and with appropriate QC measures. All analyzed samples passed except for 1 muscle tissue sample during the Winter quarter (Table C-5).

Mercury

Fish tissue samples were analyzed for mercury in accordance with LMC SOPs. Typical QC analyses for a tissue sample batch included a blank, a blank spike, and SRMs (liver and muscle). In the same batch, additional QC samples included duplicate analyses of the sample, spiked samples, and duplicate spiked samples, which were run approximately once every 10 samples.

The MDL for fish mercury is presented in Table C-1. Acceptance criteria for the mercury SRMs are presented in Table C-3. All samples were analyzed within their 6-month holding time and met the QA criteria guidelines (Table C-5).

Table C–5 Fish tissue QA/QC summary for 2017-18.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	PCBs and Pesticides	41 (4)	Blank	8	54	432	100
			Blank Spike	4	54	204	94
			Matrix Spike	4	54	212	99
			Matrix Spike Dup	4	54	213	99
			Matrix Spike Precision	4	54	214	99
			Duplicate	7	54	376	99
			SRM Analysis	4	41	132	80
Winter	PCBs and Pesticides	32 (2)	Blank	4	54	216	100
			Blank Spike	2	54	103	95
			Matrix Spike	2	54	107	99
			Matrix Spike Dup	2	54	106	98
			Matrix Spike Precision	2	54	101	94
			Duplicate	3	54	160	99
			SRM Analysis	2	41	68	83

* An analysis passed if the following criteria were met:
For blank - Target accuracy % recovery <3X MDL.
For blank spike - Target accuracy % recovery 60-120.
For matrix spike - Target accuracy % recovery 40-120.
For matrix spike duplicate - Target accuracy % recovery 40-120.
For matrix spike precision - Target precision % RPD <20%.
For duplicate - Target precision % RPD <20% at 3X MDL of sample mean.
For SRM analysis - Target accuracy % recovery 60-140 or certified value, whichever is greater.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	Percent Lipid - Liver	1	Duplicate Samples	1	1	1	100
	Percent Lipid - Muscle	3	Duplicate Samples	6	1	6	100
Winter	Percent Lipid - Liver	1	Duplicate Samples	1	1	1	100
	Percent Lipid - Muscle	1	Duplicate Samples	2	1	1	50

* An analysis passed if the following criteria were met:
For duplicate - Target precision % RPD <25%.

Quarter	Parameter	Total samples (Total batches)	QA/QC Sample Type	Number of QA/QC Samples Tested	Number of Compounds Tested	Number of Compounds Passed	% Compounds Passed *
Summer	Mercury	42 (2)	Blank	3	1	3	100
			Blank Spike	3	1	3	100
			Matrix Spike	5	1	5	100
			Matrix Spike Dup	5	1	5	100
			Matrix Spike Precision	5	1	5	100
			Duplicate	5	1	5	100
			SRM Analysis	2	1	2	100
Summer	Arsenic & Selenium	20 (1)	Blank	3	2	6	100
			Blank Spike	1	2	2	100
			Matrix Spike	2	2	4	100
			Matrix Spike Dup	2	2	4	100
			Matrix Spike Precision	2	2	4	100
			Duplicate	2	2	2	50
			SRM Analysis	1	2	2	100
Winter	Mercury	32 (2)	Blank	2	1	2	100
			Blank Spike	2	1	2	100
			Matrix Spike	4	1	4	100
			Matrix Spike Dup	4	1	4	100
			Matrix Spike Precision	4	1	4	100
			Duplicate	4	1	4	100
			SRM Analysis	4	1	4	100

* An analysis passed if the following criteria were met:
For blank - Target accuracy % recovery <2X MDL.
For blank spike - Target accuracy % recovery 90-110.
For matrix spike and matrix spike duplicate - Target accuracy % recovery 70-130.
For matrix spike precision - Target precision % RPD <25%.
For duplicate - Target precision % RPD <30% at 10X MDL of sample mean.
For SRM analysis - Target accuracy % recovery 80-120 or certified value, whichever is greater.

Arsenic and Selenium

Rig fish tissue samples were analyzed for arsenic and selenium in accordance with LMC SOPs. Typical QC analyses for a tissue sample batch included 3 blanks, a blank spike, and an SRM (muscle). Additional QC samples included duplicate analyses of a sample, and a pair of spiked and duplicate spiked samples, which were run at least once every 10 samples.

The MDLs for fish arsenic and selenium are presented in Table C-1. Acceptance criteria for the arsenic and selenium SRMs are presented in Table C-3. All samples were analyzed within a 6-month holding time and nearly all analyzed samples met the QA criteria guidelines (Table C-5).

BENTHIC INFAUNA NARRATIVE

The sorting and taxonomy QA/QC follow OCSD's QAPP. These QA/QC procedures were conducted on sediment samples collected for infaunal community analysis in July 2017 (summer) from 29 semi-annual stations (52–65 m) and 39 annual stations (40–300 m), and in January 2018 (winter) from the same 29 semi-annual stations (Table A-4).

Sorting

The sorting procedure involved removal, by Marine Taxonomic Services, Inc. (MTS) and Aquatic Bioassay and Consulting Laboratories, Inc. (ABC), of all organisms including their fragments from sediment samples into separate vials by major taxa (aliquots). The abundance of countable organisms (heads only) per station was recorded. After MTS' and ABC's in-house sorting efficiency criteria were met, the organisms and remaining particulates (grunge) were returned to OCSD. Ten percent of these samples (10 of 97) were randomly selected for re-sorting by OCSD staff. A tally was made of any countable organisms missed by MTS and ABC. A sample passed QC if the total number of countable animals found in the re-sort was ≤5% of the total number of individuals originally reported. Sorting results for all QA samples were well below the 5% QC limit.

Taxonomy

Selected benthic infauna samples underwent comparative taxonomic analysis by 2 independent taxonomists. Samples were randomly chosen for re-identification from each taxonomist's allotment of assigned samples. These were swapped between taxonomists with the same expertise in the major taxa. The resulting datasets were compared and a discrepancy report generated. The participating taxonomists reconciled the discrepancies. Necessary corrections to taxon names or abundances were made to the database. The results were scored and errors tallied by station. Percent errors were calculated using the equations below:

Equation 1. $\%Error_{\#\ Individuals} = (|\#\ Individuals_{Resolved} - \#\ Individuals_{Original}| \div \#\ Individuals_{Resolved}) \times 100$

Equation 2. $\%Error_{\#\ ID\ Taxa} = (\#\ Taxa_{Misidentification} \div \#\ Taxa_{Resolved}) \times 100$

Equation 3. $\%Error_{\#\ ID\ Individuals} = (\#\ Individuals_{Misidentification} \div \#\ Individuals_{Resolved}) \times 100$

Please refer to OCSD's QAPP for detailed explanation of the variables. The first 2 equations are considered gauges of errors in accounting (e.g., recording on wrong line, miscounting, etc.), which, by their random nature, are difficult to predict. Equation 3 is the preferred measure of identification accuracy. It is weighted by abundance and has a more rigorous set of corrective actions (e.g., additional taxonomic training) when errors exceed 10%.

In addition to the re-identifications, a Synoptic Data Review (SDR) was conducted upon completion of all data entry and QA. This consisted of a review of the infauna data for the survey year, aggregated by taxonomist (including both in-house and contractor). From this, any possible anomalous species reports, such as species reported outside its known depth range and possible data entry errors, were flagged for further investigation.

QC objectives for identification accuracy (Equation 3) were met in 2017-18 (Table C-6). The SDR revealed some anomalous taxa reported by one of the contracting taxonomists in the winter dataset.

Table C–6 Percent error rates calculated for the July 2017 infauna QA samples.

Error Type	Station				Mean
	0	1	21	64	
# Individuals	5.8	3.0	3.6	0.0	3.1
# ID Taxa	5.4	3.5	3.8	8.0	5.2
# ID Individuals	3.2	1.9	2.4	7.3	3.7

Further investigation by said taxonomist and OCSD staff revealed that data entry errors had occurred, which were corrected. No other significant changes to the 2017-18 infauna dataset were made following the SDR.

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OCSD. 2016b. Laboratory, Monitoring, and Compliance Standard Operating Procedures. Fountain Valley, CA.

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