ORANGE COUNTY SANITATION DISTRICT

Marine Monitoring Annual Report

Year 2018-2019

Orange County, California

ORANGE COUNTY SANITATION DISTRICT
LABORATORY, MONITORING, AND COMPLIANCE DIVISION
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March 13, 2020

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, 2018-19 Marine Monitoring Annual Report

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Dear Ms. Smythe,

Enclosed is the Orange County Sanitation District's (OCSD) 2018-19 Marine Monitoring Annual Report. This report focuses on the findings and conclusions for the monitoring period July 1, 2018 to June 30, 2019. 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, neither affected the receiving environment nor posed a risk to human health.

The results of the 2018-19 monitoring effort showed only minor changes in the coastal receiving water. Plume-related changes in dissolved oxygen, pH, and light 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 at least 95% of the time. This demonstrated that the receiving water outside the ZID was not degraded by OCSD's final effluent discharge. Furthermore, 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 (<25) and Fish Response Index (<45) values. In addition, contaminants in all sediment samples were comparable to background levels and no measurable toxicity was observed in whole sediment toxicity tests. The low levels of contaminants in fish tissue samples and the absence of disease symptoms in fish samples 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) 593-7450 or at lwiborg@ocsd.com.

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

Lan C. Wiborg, MPH
Director of Environmental Services

LCW:DT:bg
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Enclosure

cc: Tomas Torres, U.S. EPA, Region IX

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March 13, 2020

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 2020 – 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.

Lan C. Wiborg, MPH
Director of Environmental Services

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Acknowledgments

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EXECUTIVE SUMMARY

To evaluate potential environmental and human health impacts from its discharge of final effluent into the Pacific Ocean, 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 Newport Beach and Huntington Beach, California. The discharge, consisting of secondary-treated wastewater mixed with water reclamation flows, is released through a 120-in (305-cm) outfall extending 4.4 miles (7.1 km) offshore in 197 ft (60 m) of water. The data collected are used to determine compliance with receiving water conditions as specified in OCSD's National Pollution Discharge Elimination System permit (Order No. R8-2012-0035, Permit No. CA0110604), jointly issued in 2012 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 2018 through June 2019.

WATER QUALITY

The public health risks and measured environmental effects to the receiving water continue to be negligible. All state and federal offshore bacterial standards were met during the monitoring period. Minimal plume-related changes in dissolved oxygen, pH, and light transmissivity were detected less than 1.2 miles (2.0 km) beyond the initial mixing zone during some surveys. However, the limited, observable plume effects occurred primarily at depth, even during the winter when stratification was weakest. In addition, the changes were within the ranges of natural variability for the monitoring area and reflected seasonal and yearly changes of large-scale regional influences. In summary, the 2018-19 discharge of final effluent did not greatly affect the receiving water environment; therefore, beneficial uses were protected and maintained.

SEDIMENT QUALITY

Sediment parameters were comparable between benthic stations located within and beyond the zone of initial dilution[1] (ZID), and all measured values were below applicable 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

Infaunal communities were generally similar among within-ZID and non-ZID benthic stations based on comparable community measure values and the results of multivariate analyses. Moreover, the infaunal communities within the monitoring area can be classified as reference condition based on their low Benthic Response Index values (<25) and high Infaunal Trophic Index values (>60). These results indicate that the outfall discharge had an overall negligible effect on the benthic community structure within the monitoring area.

[1] The zone of initial dilution represents a 60 m area around the OCSD outfall diffuser.

Demersal Fishes and Epibenthic Macroinvertebrates

Community measure values of the epibenthic macroinvertebrates (EMIs) and demersal fishes collected at outfall and non-outfall trawl stations were comparable and were within regional and OCSD historical ranges. In addition, fish communities at all stations were classified as reference condition based on their low Fish Response Index values (<45). These results indicate that the monitoring area supports normal fish and EMI populations.

Contaminants in Fish Tissue

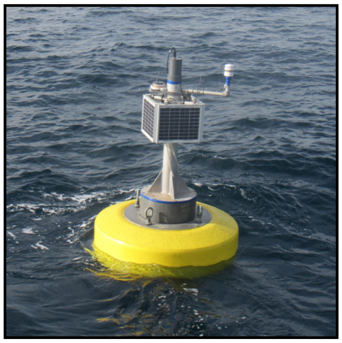
Concentrations of chlorinated pesticides and trace metals in muscle and/or liver tissues of flatfish and rockfish samples were similar between outfall and non-outfall locations. Moreover, mean concentrations of contaminants in muscle tissue of rockfish samples were below federal and state human consumption 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 monitoring area.

Fish Health

The color and odor of demersal fish samples appeared normal during the monitoring period. In addition, the low incidence (<1%) of external parasites and morphological abnormalities, combined with the absence of tumors, fin erosion, and skin lesions, in demersal fish samples showed that fishes in the monitoring area were healthy. These results indicate that the outfall is not an epicenter of disease.

CONCLUSION

Consistent with previous program years, California Ocean Plan water quality criteria, as well as state and federal bacterial standards, were met within the monitoring area in 2018-19. 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, the absence of symptoms of fish disease, and no exceedances in federal and state fish consumption guidelines in rockfish samples. In summary, OCSD's discharge of final effluent neither affected the receiving environment nor posed a risk to human health during the 2018-19 monitoring period.



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 Permit 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 (Figure 1-2). The monitoring area covers most of the San Pedro Shelf and extends southeast off the shelf (Figure 1-1). These nearshore coastal waters receive wastes from a variety of anthropogenic 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 et al. 2000, Schiff and Tiefenthaler 2001, Tiefenthaler et al. 2005).

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 262 ft (80 m), after which it increases rapidly down to the open basin. The outfall diffuser lies at about 197 ft (60 m) 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 ft² (102,193 m²) of seafloor was converted from a flat, sandy habitat into a raised, hard-bottom substrate.

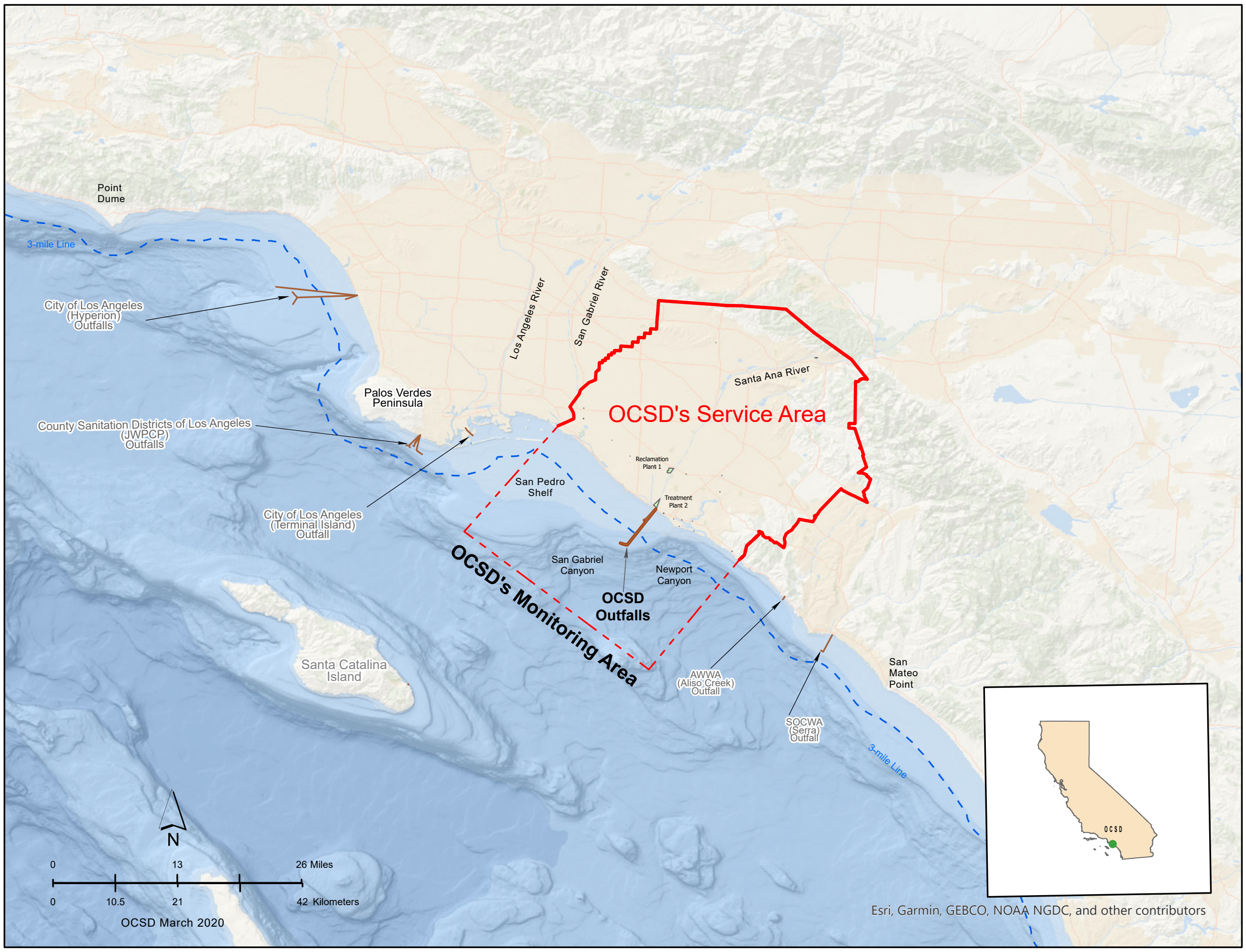


Figure 1–1 Regional setting and sampling area for OCSD's Ocean Monitoring Program.

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

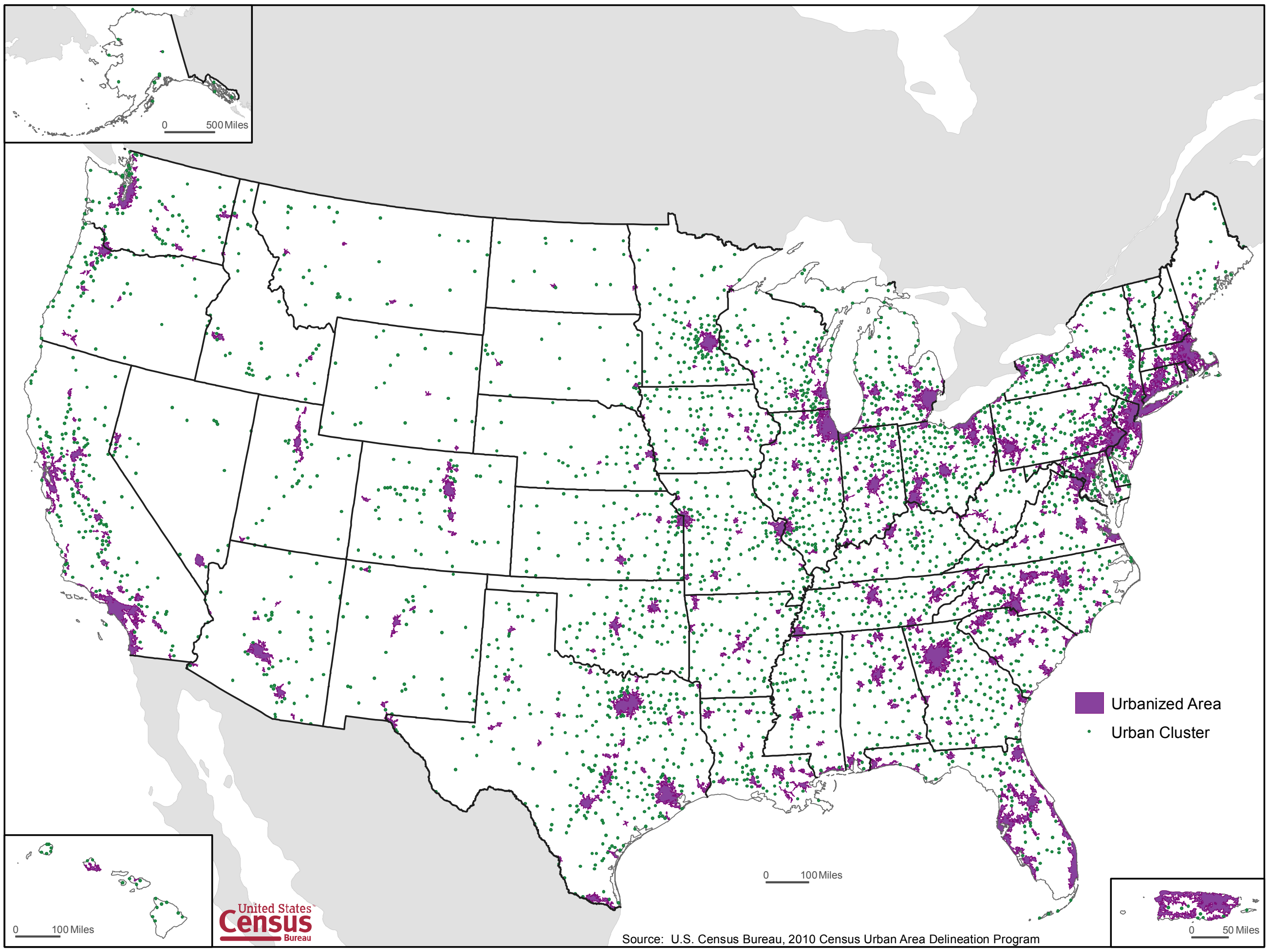


Figure 1–2 United States 2010 urbanized areas. (https://www.census.gov/library/visualizations/2010/geo/ua2010_uas_and_ucs_map.html).

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 fresh water, 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 and human health consequences. For 2018-19, both annual rainfall (NCEI 2019) and Santa Ana River flows (USGS 2019) were at or above historical averages (Figure 1-3). A previous year of well below average rainfall led to high quality beaches, with 95% of southern California beaches receiving "grades" of A or B by Heal the Bay (2019).

Beaches are a primary reason for people to visit coastal California (Kildow and Colgan 2005, NOAA 2015). Although highest visitations occur during the warmer, summer months, southern

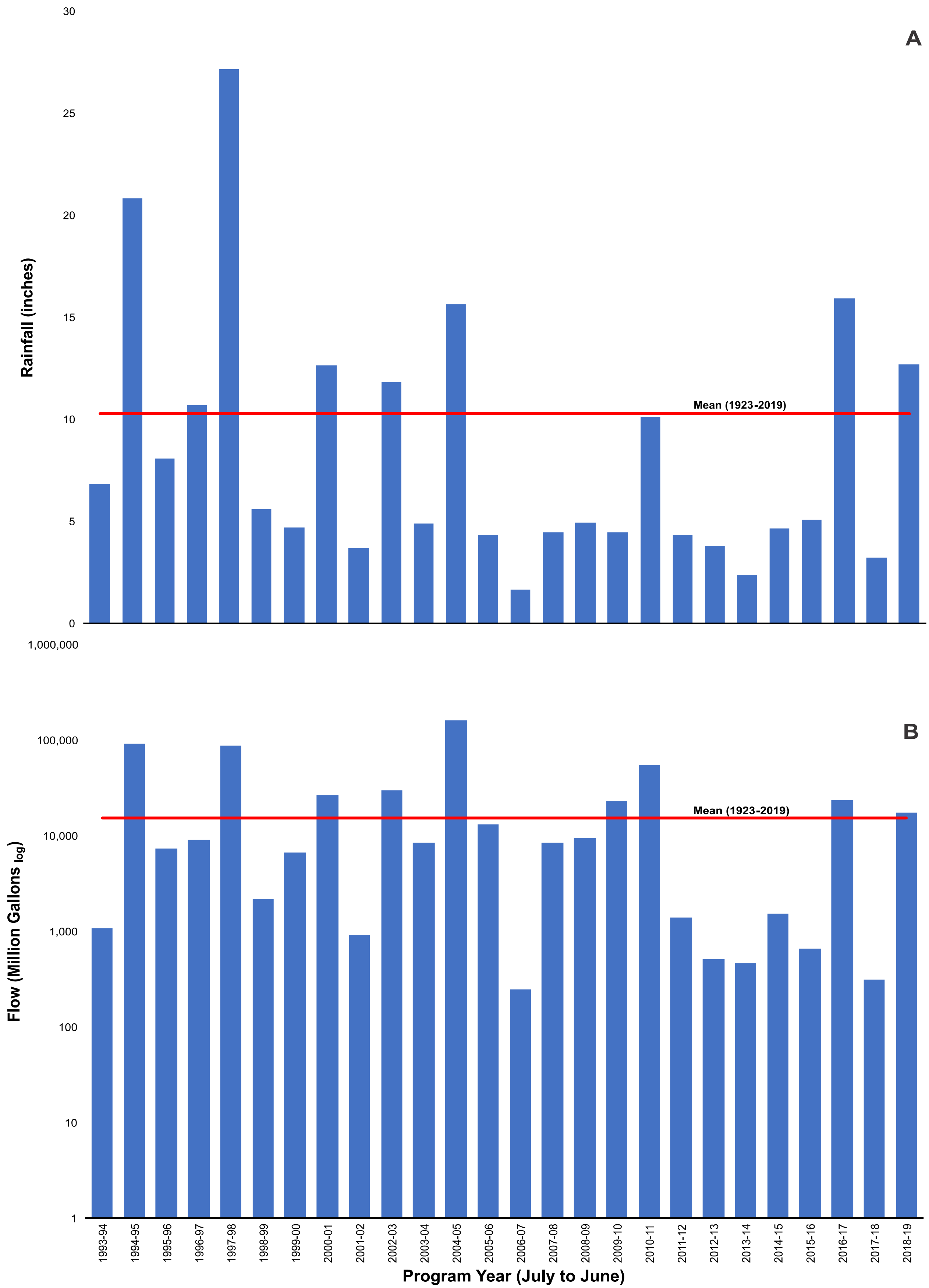


Figure 1–3 Annual Newport Harbor rainfall (A) and Santa Ana River flows (B).

California's Mediterranean climate and convenient beach access results in significant year-round use by the public (Figure 1-4). For 2018-19, beach attendance for the City of Newport Beach was just below 7.5 million. A large percentage of the local economies rely on beach use and its associated recreational activities, which are highly dependent upon local water quality conditions (Turbow and Jiang 2004, Leeworthy and Wiley 2007, Leggett et al. 2014). In 2012, Orange County's coastal economy accounted 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).

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 (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 treated effluent at an approximate depth of 60 m.

OCSD will accept up to 10 million gallons per day (MGD; 3.8×10^7 L/day) of dry-weather urban runoff that would otherwise have entered the ocean without treatment (OCSD 2019). 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 2018-19, OCSD treated 337 million gallons (MG; 1.3×10^9 L) of flow, nearly identical to the 2013-2018 average yearly flow of 378 MG (1.4×10^9 L). Monthly average daily diversion flows ranged from 0.3–1.6 MGD (1.1–6.1×10^6 L/day) with an average daily amount of 1 MGD (3.8×10^6 L/day).

OCSD has a long history of providing treated effluent 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 (1.1–3.8×10^7 L/day) of the final effluent have 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 (1.3×10^8 L/day). Over time, the average net GAP and GWRS diversions (diversions minus return flows to OCSD) increased to 44 MGD (1.7×10^8 L/day) in 2008-09, 61 MGD (2.3×10^8 L/day) in 2013-14, and 97 MGD (3.7×10^8 L/day) in 2018-19 (Figure 1-5).

During 2018-19, OCSD's 2 wastewater treatment plants received and processed influent volumes averaging 191 MGD (7.2×10^8 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 104 MGD (3.9×10^8 L/day) of treated wastewater to the ocean (Figure 1-5).

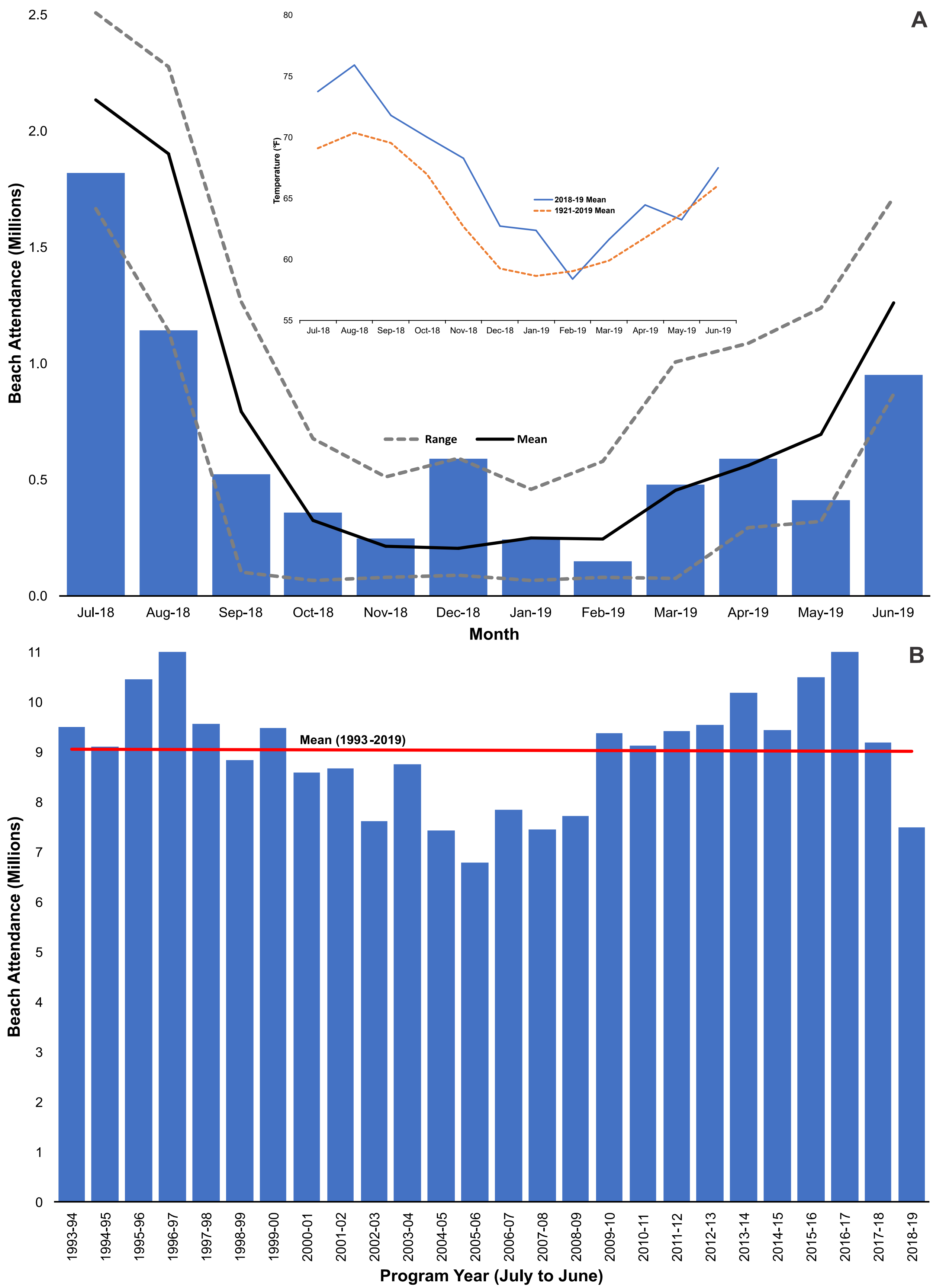


Figure 1–4 Monthly 2018-19 beach attendance and air temperature (A) and annual beach attendance (B) for the City of Newport Beach, California.

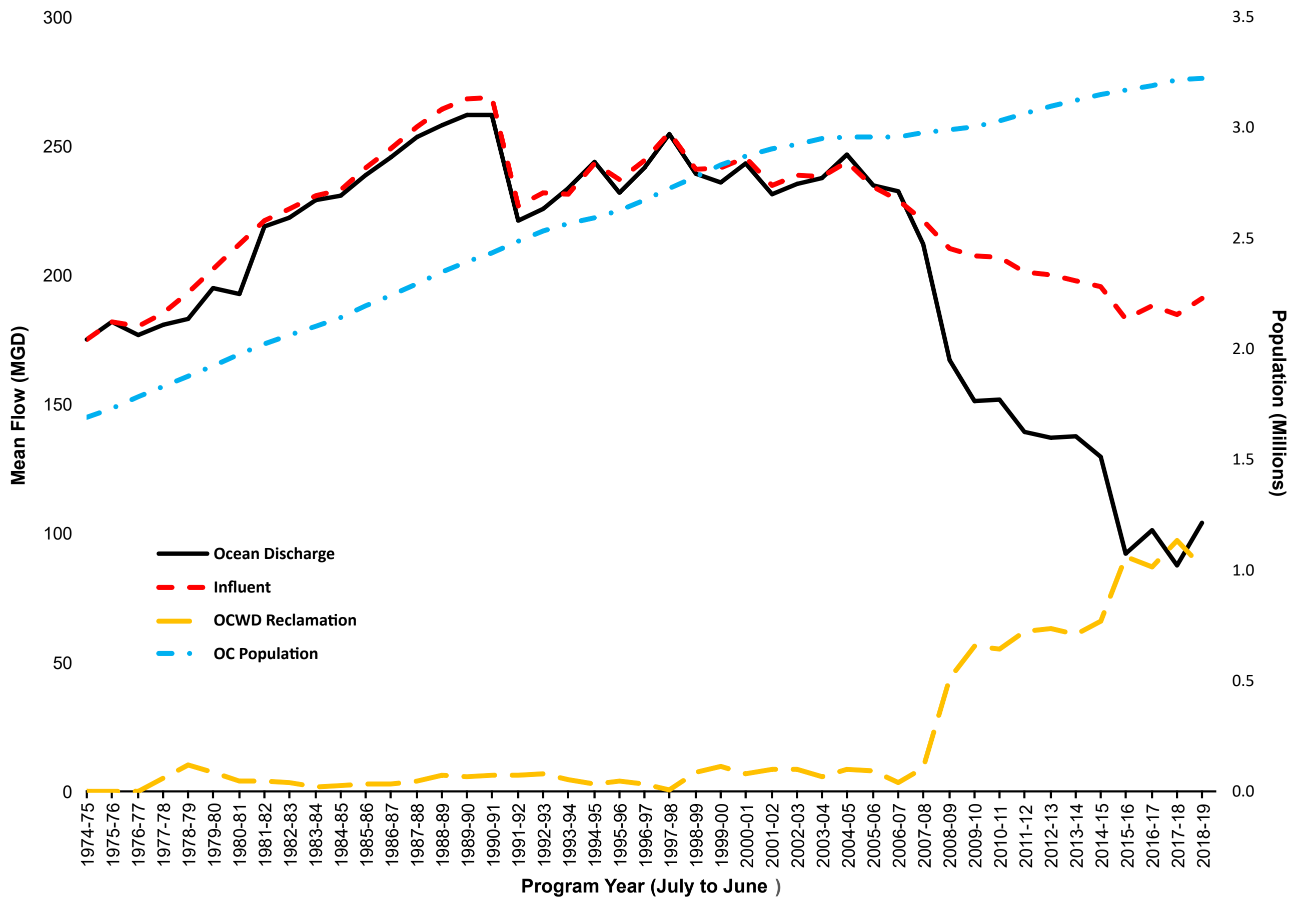


Figure 1–5 OCSD's average annual influent and ocean discharge, OCWD's reclamation, and annual population for Orange County, California, 1974-2019.

Prior to 1990, the annual wastewater discharge volumes increased faster than Orange County population growth (CDF 2019) (Figure 1-5). 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. Reductions in influent flows have been attributed to improved water efficiency and decreases in water use.

The combined effect of reduced influent and increased 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 health, which include fish tissue contaminant analyses.

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 website (http://sccwrp.org).

Other collaborative regional monitoring efforts include:

- Participation in the Southern California Bight Regional Water Quality Program (previously known as the Central Bight Water Quality Program), a water quality sampling effort with other Publicly Owned Treatment Works (POTWs) such as the City of Oxnard, the City of Los Angeles, the County Sanitation Districts of Los Angeles, and the City of San Diego.
- 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 information collected provides a broad understanding of both natural and anthropogenic processes that affect coastal oceanography and marine biology, the near-coastal ocean ecosystem, and its related beneficial uses.

This report presents OMP compliance determinations for data collected from July 2018 through June 2019. 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 2018-19 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 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 2018-19 Core OMP sampling locations included 28 offshore water quality stations, 29 benthic stations to assess sediment chemistry and bottom-dwelling communities, 6 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 (see Appendix A).

WATER QUALITY

Offshore bacteria

For all 3 fecal indicator bacteria (FIB), over 98% of the samples were below their 30-day geomean values (Table B-1). Overall, less than 1% of the samples exceeded single sample criteria with the highest density observed for any single sample at any single depth for total coliforms, fecal coliforms, and enterococci was 4,611, 583, and 1,467 MPN/100 mL, respectively. With most (61-89%) samples being below detection, the majority of the depth-averaged values used for water contact compliance were below detection (Tables B-2, B-3, and B-4). 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 oils and grease or floating particles of sewage origin at any inshore (Zone A) or offshore (Zone B) station groups in 2018-19 (Tables B-5 and B-6). Therefore, compliance was achieved.

Table 2–1 List of compliance criteria from OCSD's NPDES permit (Order No. R8-2012-0035, Permit No. CA0110604) and compliance status for each criterion in 2018-19. N/A = Not Applicable.

Criteria	Criteria Met
Bacterial Characteristics	
V.A.1.a. For the CA 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 CA 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 CA Ocean Plan Water-Contact Standards, enterococci 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, enterococci 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 CA 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 99.2% and 97.8% of the time for Zone A and B station groups, respectively, with an overall compliance rate of 98.5% (Table 2-2). This is above the 20-year average of 95% (Figure 2-4). All light transmissivity values (Table B-7) were within natural ranges of variability to which marine organisms are exposed (OCSD 1996a). Hence, there were no impacts from the wastewater discharge relative to ocean discoloration at any offshore station.

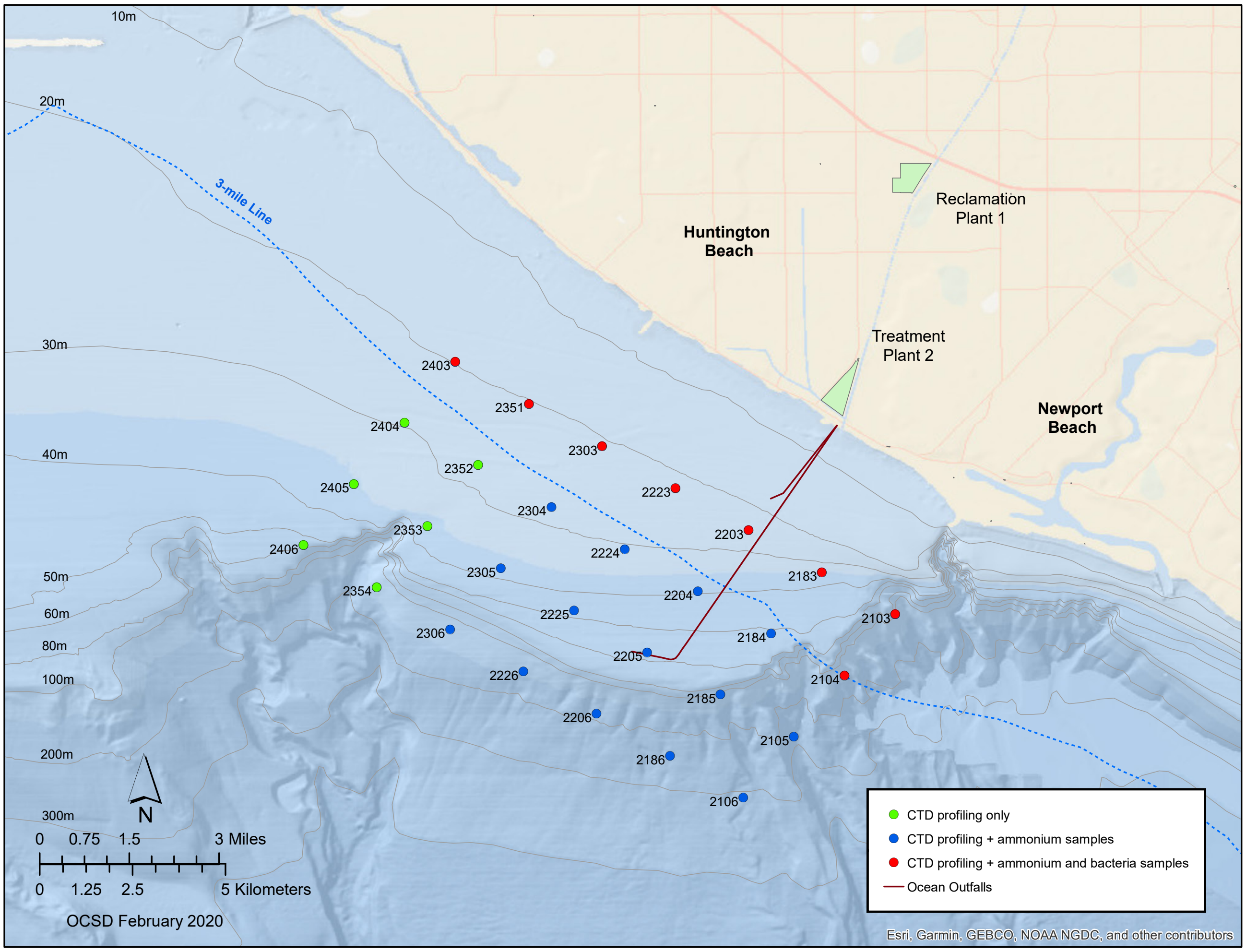

Figure 2–1 Offshore water quality monitoring stations for 2018-19.

Dissolved Oxygen (DO)

In 2018-19, compliance was met 97.3% for Zone A and 92.4% for Zone B with a combined compliance of 94.9% (Table 2-2), slightly below the 20-year average of 96% (Figure 2-4). The DO values (Table B-7) 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 wastewater discharge.

Acidity (pH)

Compliance was nearly 100% for Zone A and 97% for Zone B; the combined overall compliance was 98.3% which was above the 20-year average of 95% (Table 2-2; Figure 2-4). There were no environmentally significant effects to pH from the wastewater discharge as the measured values (Table B-7) were within the range to which marine organisms are naturally exposed.

Nutrients (Ammonium)

For the 2018-19 program year, nearly 80% of the samples were below the method detection limit (Table B-8). Detectable ammonium concentrations, including estimated values, ranged from 0.014 to 0.379 mg/L. Plume-related changes in ammonium were not considered environmentally significant as maximum values were 10 times less than the chronic (4 mg/L) and 15 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).

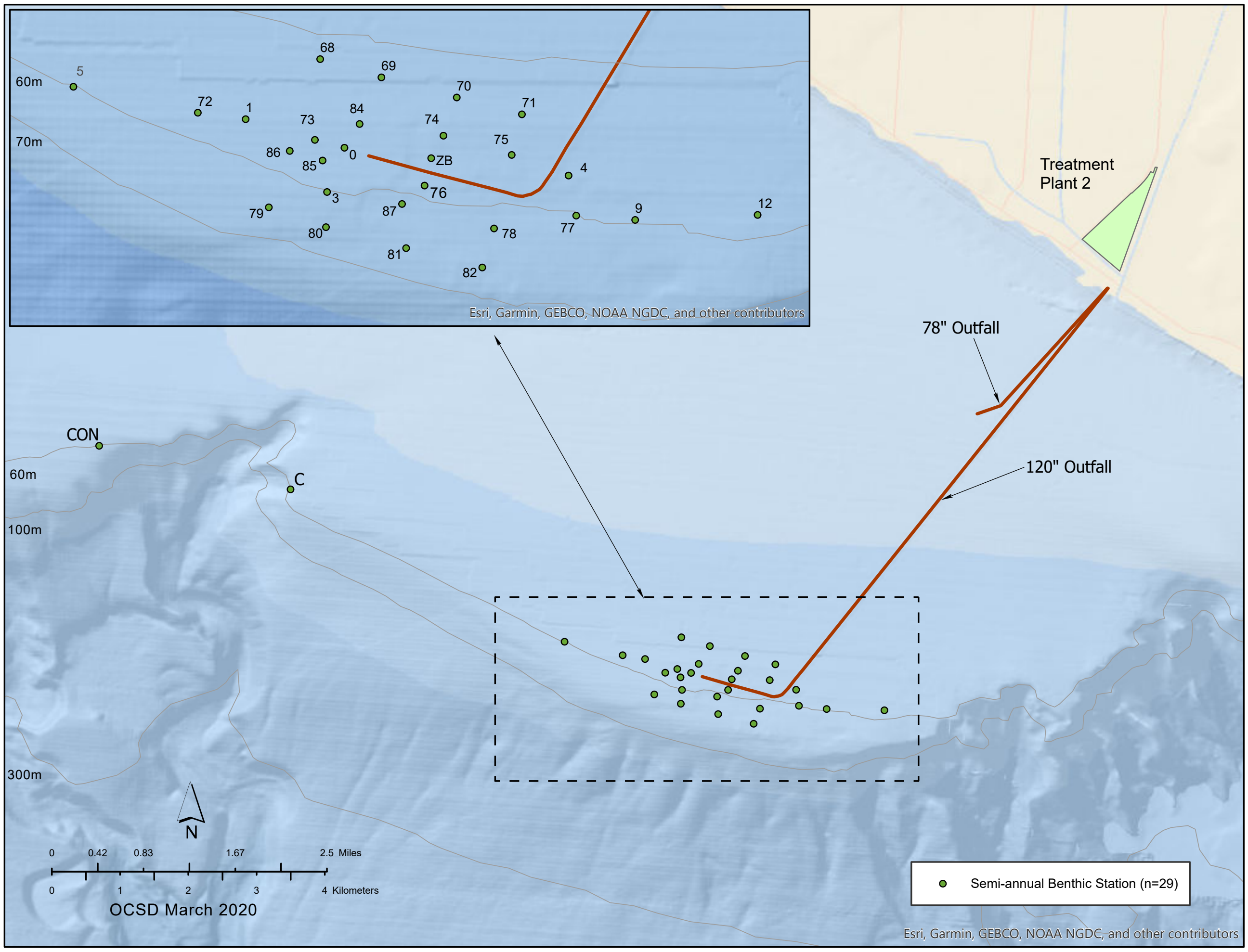

Figure 2–2 Benthic (sediment geochemistry and infauna) monitoring stations for 2018-19.

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 2018 through June 2019, 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 2018-19 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 2018-19 water quality monitoring program detected minor changes in measured water quality parameters related to the discharge of wastewater to the coastal ocean. This is consistent with previously reported results (e.g., OCSD 2017). Plume-related changes in DO, pH, and light transmissivity were measurable beyond the initial mixing zone during some surveys. This usually extended only into the nearfield stations, typically <2 km away from the

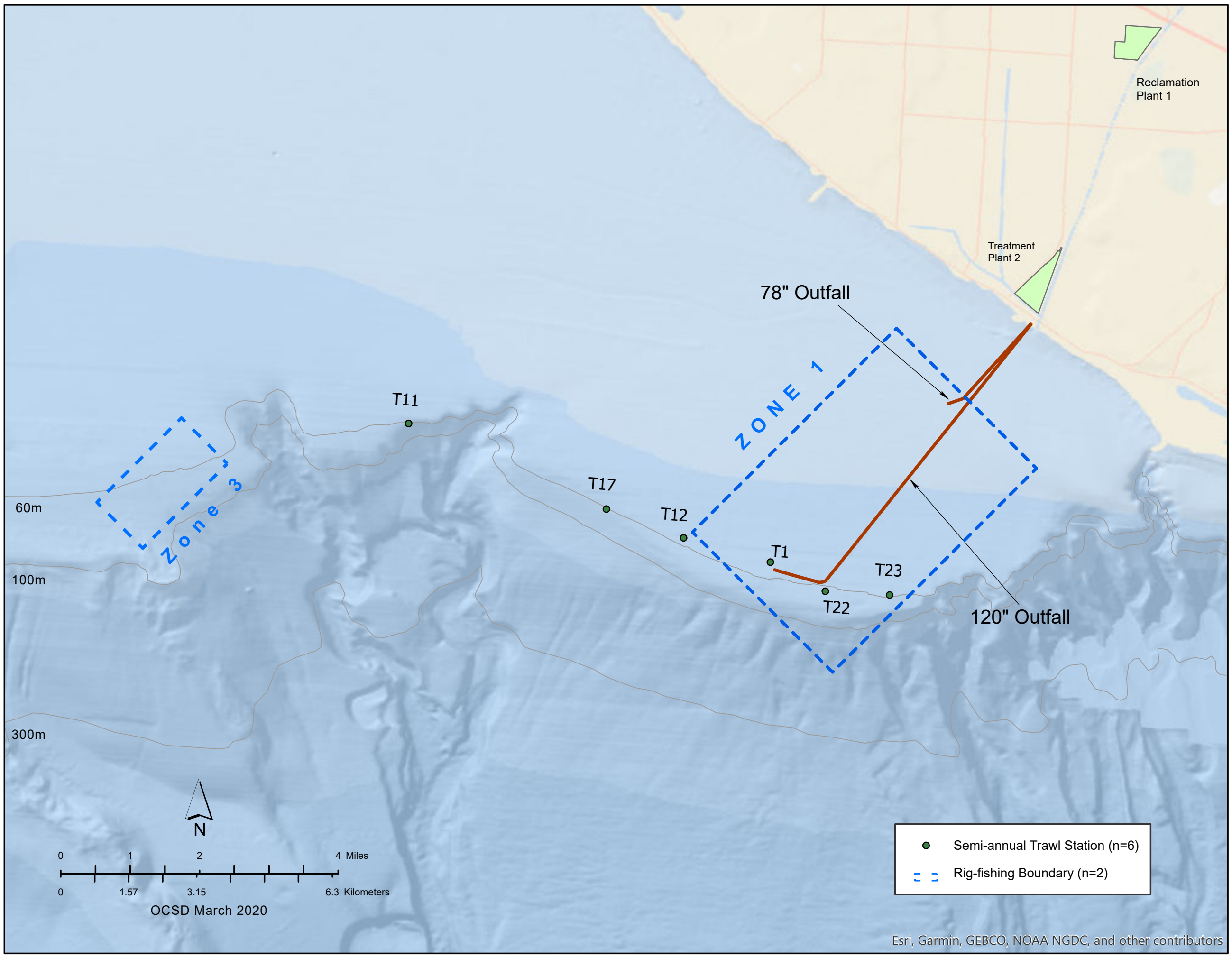

Figure 2–3 Trawl monitoring stations, as well as rig-fishing locations, for 2018-19.

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 monitoring 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 when stratification was weakest. In summary, OMP staff concluded that the discharge in 2018-19 did not demonstrably affect the receiving water environment and that beneficial uses were protected and maintained.

SEDIMENT GEOCHEMISTRY

The physical properties and chemical concentrations of sediment samples collected in the summer and winter surveys were similar between the within-ZID and non-ZID station groups (Tables 2-3, 2-4, 2-5, and 2-6). Chemical contaminant concentrations of the sediment samples were also well below applicable Effects Range-Median (ERM) guidelines of biological concern (Long et al. 1995) and were comparable to regional values. Furthermore, there was no measurable sediment toxicity at any of the 9 stations monitored in the winter survey (Table 2-7). These results indicate that compliance was met.

Table 2–2 Summary of offshore water quality compliance testing results for dissolved oxygen, pH, and light transmissivity for 2018-19.

Parameter	Number of Observations	Out-of-Range Occurrences		Out-of-Compliance	
		Number	Percent	Number	Percent
Zone A Stations (Inshore Station Group)					
Dissolved Oxygen	523	56	10.7%	14	2.7%
pH	523	39	7.5%	1	0.2%
Light Transmissivity	523	258	49.3%	4	0.8%
Zone B Stations (Offshore Station Group)					
Dissolved Oxygen	503	52	10.3%	38	7.6%
pH	503	16	3.2%	16	3.2%
Light Transmissivity	503	94	18.7%	11	2.2%
Zone A and Zone B Stations Combined					
Dissolved Oxygen	1026	108	10.5%	52	5.1%
pH	1026	55	5.4%	17	1.7%
Light Transmissivity	1026	352	34.3%	15	1.5%

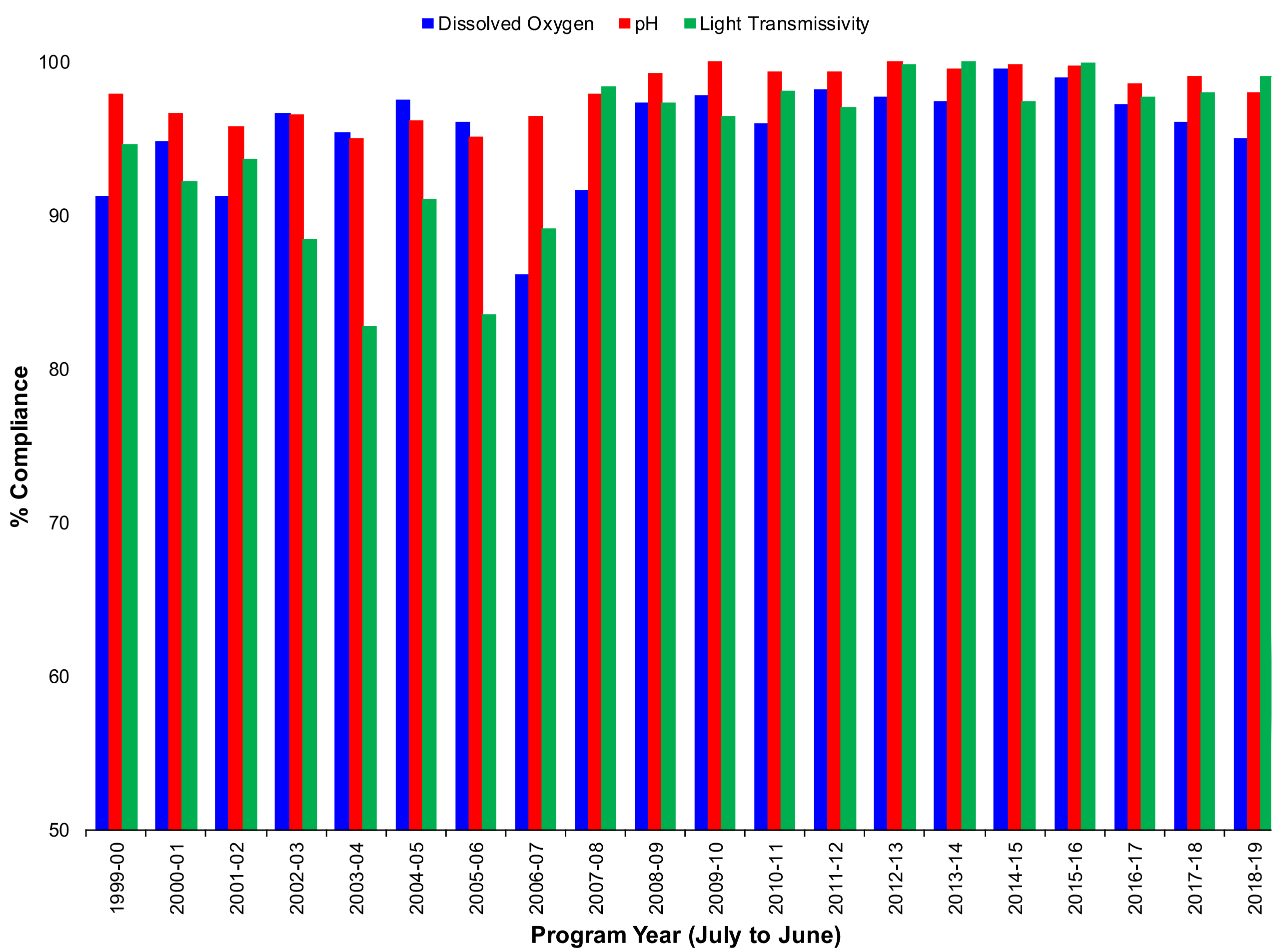

Figure 2–4 Summary of mean percent compliance for dissolved oxygen (DO), pH, and light transmissivity for all compliance stations compared to reference stations, 1999-2019.

Table 2–3 Physical properties, as well as biogeochemical and contaminant concentrations, of sediment samples collected at each semi-annual station in Summer 2018 compared to Effects Range-Median (ERM) and regional values. ND = Not Detected, N/A = Not Applicable.

Station	Nominal 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, Non-ZID (51-90 m)											
1	56	3.15	7.1	0.38	ND	1000	70	59.9	1.42	ND	0.51
3	60	3.06	9.8	0.42	1.91	1000	130	43.9	1.53	ND	1.56
5	59	3.34	10.0	0.42	1.61	1000	100	40.5	1.55	ND	ND
9	59	2.90	7.2	0.36	2.54	860	390	89.2	1.24	ND	ND
12	58	2.75	6.4	0.37	2.33	750	420	45.2	1.18	ND	ND
68	52	3.31	11.0	0.42	ND	950	420	82.1	2.94	ND	ND
69	52	3.20	9.1	0.38	1.71	1000	410	69.0	1.41	ND	4.31
70	52	3.22	15.4	0.41	ND	940	460	47.3	1.54	ND	ND
71	52	3.06	9.1	0.34	1.28	860	430	47.2	1.23	ND	ND
72	55	3.21	8.6	0.39	1.61	980	420	87.1	1.52	ND	29.89
73	55	3.13	10.1	0.50	2.43	1100	390	89.6	1.87	ND	12.49
74	57	3.06	10.4	0.39	2.72	980	480	49.7	1.18	ND	15.50
75	60	3.00	6.4	0.34	1.75	950	410	72.9	1.23	ND	11.99
77	60	3.01	7.5	0.38	2.38	1000	440	110.5	1.29	ND	ND
78	63	3.03	8.0	0.37	2.41	950	380	61.3	1.23	ND	ND
79	65	3.16	10.8	0.38	3.53	960	370	62.8	1.13	1.00	0.24
80	65	3.29	14.1	0.39	2.02	940	350	22.6	1.19	ND	ND
81	65	3.14	11.3	0.37	4.77	910	340	ND	ND	ND	ND
82	65	2.76	6.3	0.34	1.45	820	70	29.6	ND	ND	ND
84	54	3.14	10.8	0.51	2.18	1100	430	137.1	0.86	ND	7.29
85	57	2.98	7.3	0.49	3.23	1300	130	200.5	1.69	ND	28.60
86	57	3.00	7.1	0.45	2.79	1400	69	527.2	0.88	ND	15.21
87	60	3.09	8.2	0.37	1.47	1100	380	63.8	ND	ND	ND
C	56	3.04	8.3	0.37	2.56	990	330	37.3	ND	ND	ND
CON	59	3.20	9.7	0.39	1.78	1000	370	28.2	1.10	ND	ND
	Mean	**3.09**	**9.2**	**0.40**	**2.29**	**994**	**328**	**87.7**	**1.17**	**0.04**	**5.10**
Middle Shelf Zone 2, Within-ZID (51-90 m)											
0	56	2.99	7.0	0.49	2.01	1400	110	249.5	1.59	ND	5.59
4	56	3.03	6.4	0.34	ND	950	90	21.5	1.13	ND	ND
76	58	2.99	8.1	0.37	2.24	1100	360	38.4	1.13	ND	0.68
ZB	56	3.01	7.4	0.41	2.03	970	360	116.7	ND	ND	2.08
	Mean	**3.00**	**7.2**	**0.40**	**2.09**	**1105**	**230**	**106.5**	**0.96**	**ND**	**2.09**
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	690	55.0	18.00	N/A	2.70

Table 2–4 Metal concentrations (mg/kg) in sediment samples collected at each semi-annual station in Summer 2018 compared to Effects Range-Median (ERM) and regional values. N/A = Not Applicable.

Station	Nominal Depth (m)	Sb	As	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Zn
Middle Shelf Zone 2, Non-ZID (51-90 m)														
1	56	0.1	3.91	36.8	0.26	0.14	18.20	8.54	6.31	0.02	8.1	1.38	0.12	38.9
3	60	0.1	3.50	32.2	0.27	0.15	18.60	8.65	5.93	0.04	8.4	1.21	0.11	43.4
5	59	0.1	4.15	42.9	0.31	0.21	18.80	8.86	6.69	0.02	8.8	1.50	0.15	39.5
9	59	0.1	3.55	47.4	0.26	0.11	17.10	6.43	5.34	0.01	7.5	1.30	0.08	36.8
12	58	0.0	3.21	34.7	0.24	0.11	15.90	5.60	5.30	0.02	7.3	1.26	0.07	35.0
68	52	0.1	4.19	45.7	0.27	0.15	18.10	7.88	6.64	0.02	8.4	1.34	0.13	40.5
69	52	0.1	3.19	40.5	0.25	0.20	18.10	8.20	6.00	0.07	8.5	1.31	0.20	40.6
70	52	0.1	3.06	39.8	0.26	0.20	17.80	7.84	6.25	0.02	8.1	1.32	0.13	41.6
71	52	0.1	3.32	37.2	0.25	0.22	16.50	6.55	5.33	0.02	7.8	1.39	0.11	38.7
72	55	0.1	3.05	38.2	0.26	0.16	17.90	8.39	6.24	0.02	8.4	1.52	0.14	38.6
73	55	0.1	3.88	37.8	0.25	0.31	19.90	10.60	7.44	0.04	8.2	1.38	0.17	42.6
74	57	0.1	3.57	39.8	0.26	0.19	17.60	7.36	5.71	0.01	8.0	1.41	0.10	40.1
75	60	0.0	3.97	42.0	0.26	0.21	16.90	6.80	5.26	0.01	7.9	1.39	0.10	39.5
77	60	0.0	3.72	35.3	0.27	0.11	17.50	7.11	5.44	0.01	8.2	1.30	0.09	38.4
78	63	0.0	2.74	34.1	0.28	0.10	17.10	6.81	5.25	0.01	7.8	1.49	0.09	36.8
79	65	0.0	3.13	37.1	0.26	0.12	17.40	7.81	5.66	0.02	8.9	1.69	0.13	39.9
80	65	0.0	3.95	40.5	0.30	0.08	16.90	7.69	5.82	0.01	8.2	1.38	0.08	39.9
81	65	0.0	3.02	35.2	0.28	0.09	16.70	6.47	5.30	0.01	8.0	1.32	0.08	38.5
82	65	0.1	3.22	37.9	0.30	0.09	17.70	6.84	5.23	0.01	8.6	1.21	0.08	41.9
84	54	0.1	3.54	39.8	0.26	0.38	19.20	10.10	6.23	0.03	8.4	1.46	0.19	44.2
85	57	0.1	3.24	32.4	0.27	0.59	20.60	11.80	6.39	0.03	8.3	1.37	0.20	42.6
86	57	0.1	3.94	36.0	0.27	0.28	19.10	11.40	7.13	0.03	7.8	1.45	0.19	42.1
87	60	0.1	4.31	39.1	0.29	0.10	17.80	7.12	5.66	0.02	8.1	1.35	0.09	39.7
C	56	0.1	2.86	45.1	0.25	0.11	17.20	6.58	5.83	0.01	8.3	1.27	0.08	39.7
CON	59	0.1	3.07	49.3	0.25	0.10	17.90	6.61	6.20	0.02	8.5	1.39	0.08	39.0
	Mean	**0.1**	**3.49**	**39.1**	**0.27**	**0.18**	**17.86**	**7.92**	**5.94**	**0.02**	**8.2**	**1.38**	**0.12**	**39.9**
Middle Shelf Zone 2, Within-ZID (51-90 m)														
0	56	0.1	4.44	35.2	0.26	0.30	19.30	10.50	7.07	0.31	8.2	1.52	0.20	40.8
4	56	0.1	3.21	35.7	0.27	0.18	17.80	6.84	5.42	0.02	7.6	1.40	0.10	39.0
76	58	0.1	3.15	35.0	0.26	0.14	16.60	7.20	5.05	0.05	7.7	1.24	0.11	39.0
ZB	56	0.1	3.39	38.7	0.27	0.26	17.40	7.92	5.46	0.02	8.1	1.51	0.11	42.6
	Mean	**0.1**	**3.55**	**36.2**	**0.26**	**0.22**	**17.78**	**8.12**	**5.75**	**0.10**	**7.9**	**1.42**	**0.13**	**40.4**
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	0.9	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 2–5 Physical properties, as well as biogeochemical and contaminant concentrations, of sediment samples collected at each semi-annual station in Winter 2019 compared to Effects Range-Median (ERM) and regional values. ND = Not Detected, N/A = Not Applicable.

Station	Nominal 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, Non-ZID (51-90 m)											
1	56	3.36	15.5	0.41	1.16	1000	480	27.0	1.44	ND	0.73
3	60	3.15	10.9	0.44	2.68	1000	430	26.3	1.56	ND	0.67
5	59	3.50	12.9	0.41	2.36	840	450	2.7	1.81	ND	ND
9	59	3.12	11.8	0.42	2.80	820	370	21.8	1.10	ND	ND
12	58	2.98	10.2	0.35	2.36	790	420	55.0	1.25	ND	ND
68	52	3.38	14.0	0.48	2.41	920	470	40.5	1.90	ND	ND
69	52	3.34	13.0	0.39	ND	920	510	40.3	1.64	ND	ND
70	52	3.32	16.6	0.48	1.60	940	500	29.5	1.87	ND	ND
71	52	3.18	12.3	0.48	2.66	860	480	26.5	1.59	ND	ND
72	55	3.33	13.6	0.44	1.59	890	440	100.7	1.79	ND	ND
73	55	3.30	16.9	0.46	5.45	1400	450	260.2	1.81	ND	7.33
74	57	3.28	16.1	0.45	2.21	820	460	12.1	1.42	ND	0.64
75	60	3.03	7.9	0.37	2.41	850	410	60.0	0.98	ND	ND
77	60	3.11	9.9	0.46	3.42	850	410	18.6	1.06	ND	ND
78	63	3.02	5.6	0.39	3.49	830	340	16.0	0.98	ND	ND
79	65	3.25	8.5	0.42	1.83	900	440	174.4	1.21	ND	ND
80	65	3.41	15.0	0.43	2.73	880	440	17.9	1.16	ND	ND
81	65	3.14	10.4	0.37	1.56	850	440	14.6	1.03	ND	ND
82	65	3.04	9.6	0.39	2.80	870	360	13.1	0.91	ND	ND
84	54	3.26	15.0	0.46	2.85	1000	660	51.3	1.41	ND	0.59
85	57	3.06	9.0	0.48	3.45	1100	460	74.7	1.55	ND	0.64
86	57	3.20	12.7	0.42	4.20	980	470	36.5	1.26	ND	ND
87	60	3.15	12.4	0.49	2.96	890	390	407.1	1.31	ND	ND
C	56	3.34	13.9	0.43	3.89	900	510	40.0	1.62	ND	ND
CON	59	3.22	11.4	0.39	2.53	980	460	20.5	1.55	ND	ND
	Mean	**3.22**	**12.2**	**0.43**	**2.72**	**923**	**450**	**63.5**	**1.41**	**ND**	**0.42**
Middle Shelf Zone 2, Within-ZID (51-90 m)											
0	56	3.17	13.4	0.48	3.11	1200	510	62.2	1.79	1.42	7.05
4	56	3.19	11.8	0.37	2.76	830	470	6.5	1.14	ND	ND
76	58	3.17	10.4	0.35	3.21	960	400	65.6	1.14	ND	ND
ZB	56	3.12	11.0	0.45	3.58	910	580	58.1	0.77	ND	ND
	Mean	**3.16**	**11.6**	**0.41**	**3.16**	**975**	**490**	**48.1**	**1.21**	**0.36**	**1.76**
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	690	55.0	18.00	N/A	2.70

Table 2–6 Metal concentrations (mg/kg) in sediment samples collected at each semi-annual station in Winter 2019 compared to Effects Range-Median (ERM) and regional values. ND =Not Detected, N/A = Not Applicable.

Station	Nominal Depth (m)	Sb	As	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	Se	Ag	Zn
Middle Shelf Zone 2, Non-ZID (51-90 m)														
1	56	0.1	3.23	36.2	0.26	0.15	18.10	8.71	6.68	0.02	8.3	2.34	0.14	40.3
3	60	0.1	4.16	39.3	0.28	0.15	18.90	9.40	6.12	0.01	8.6	2.35	0.16	43.2
5	59	0.1	3.40	46.2	0.28	0.16	19.80	9.06	6.78	0.02	9.5	2.40	0.15	44.5
9	59	0.1	2.89	32.5	0.27	0.09	17.60	6.51	5.35	0.01	8.1	2.51	0.07	37.4
12	58	0.1	3.94	34.2	0.24	0.09	16.80	6.14	7.41	0.01	7.9	2.35	0.06	35.5
68	52	0.1	4.09	42.7	0.27	0.14	19.00	8.76	7.02	0.03	9.1	2.82	0.12	42.1
69	52	0.1	3.90	41.0	0.26	0.15	19.00	8.55	6.67	0.01	9.3	2.83	0.12	40.3
70	52	0.1	3.40	38.4	0.26	0.15	18.30	8.06	6.32	0.02	8.7	2.81	0.10	40.1
71	52	0.1	4.47	38.0	0.27	0.15	18.70	8.34	6.89	0.01	8.7	2.21	0.13	41.2
72	55	0.1	3.11	39.7	0.26	0.14	19.10	8.75	6.46	0.02	8.8	2.74	0.13	41.1
73	55	0.1	3.46	36.6	0.26	0.40	20.40	13.20	7.87	0.03	8.1	2.68	0.40	43.5
74	57	0.1	3.90	38.3	0.27	0.16	18.30	8.27	5.94	0.01	8.9	2.78	0.10	41.8
75	60	0.1	3.48	35.1	0.25	0.19	16.50	6.83	4.98	0.01	8.0	2.65	0.08	39.8
77	60	0.1	3.36	36.6	0.28	0.11	18.20	7.59	6.59	0.02	8.5	2.36	0.07	41.4
78	63	0.1	3.27	33.5	0.26	0.09	17.50	7.64	5.37	0.01	8.3	2.59	0.08	37.4
79	65	0.1	2.79	36.4	0.26	0.11	18.10	8.10	5.72	0.01	8.4	2.35	0.12	42.0
80	65	0.1	3.58	42.1	0.33	0.08	19.20	8.41	5.78	0.01	10.0	2.82	0.07	46.1
81	65	0.1	3.38	35.2	0.28	0.08	17.20	6.83	5.48	0.01	8.5	2.96	0.06	39.1
82	65	0.1	3.21	35.9	0.29	0.08	17.70	7.55	5.19	0.01	8.6	2.58	0.07	39.6
84	54	0.1	3.37	37.2	0.25	0.32	18.80	12.90	6.70	0.02	8.6	2.99	0.13	42.1
85	57	0.1	3.07	34.6	0.25	0.38	19.80	11.00	6.50	0.02	8.2	2.43	0.26	42.5
86	57	0.1	3.11	36.4	0.26	0.28	19.00	12.00	6.25	0.02	8.5	2.57	0.22	40.6
87	60	0.1	4.42	35.2	0.28	0.12	18.90	8.62	6.01	0.01	8.8	2.60	0.09	42.4
C	56	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CON	59	0.1	2.97	52.6	0.25	0.09	19.10	7.02	6.22	0.01	9.3	2.72	0.06	39.5
	Mean	**0.1**	**3.50**	**38.1**	**0.27**	**0.16**	**18.50**	**8.68**	**6.26**	**0.02**	**8.7**	**2.60**	**0.12**	**41.0**
Middle Shelf Zone 2, Within-ZID (51-90 m)														
0	56	0.1	4.90	35.9	0.26	0.29	20.60	12.20	7.90	0.03	9.2	2.16	0.16	44.8
4	56	0.1	3.90	33.4	0.27	0.10	18.50	6.92	5.89	0.01	8.4	2.36	0.08	39.2
76	58	0.1	2.88	35.1	0.26	0.10	17.30	7.17	5.10	0.01	8.1	2.12	0.08	40.1
ZB	56	0.1	3.80	35.7	0.25	0.19	17.60	7.71	5.65	0.02	8.4	2.45	0.10	40.2
	Mean	**0.1**	**3.87**	**35.0**	**0.26**	**0.17**	**18.50**	**8.50**	**6.14**	**0.02**	**8.5**	**2.27**	**0.10**	**41.1**
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	0.9	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 2018-19. The home sediment represents the control; N/A = Not Applicable.

Station	% Survival	% of home	p-value	Assessment
home	96	N/A	N/A	N/A
0	99	103	1.00	Nontoxic
1	95	99	0.89	Nontoxic
4	89	93	0.17	Nontoxic
72	98	102	0.99	Nontoxic
73	97	101	0.97	Nontoxic
76	96	100	0.91	Nontoxic
77	97	101	0.96	Nontoxic
CON	98	102	0.99	Nontoxic
ZB	92	96	0.96	Nontoxic
ZB Dup	91	95	0.32	Nontoxic

BIOLOGICAL COMMUNITIES

Infaunal Communities

A total of 566 invertebrate taxa comprising 22,056 individuals were collected in the 2018-19 monitoring year. The Annelida (segmented worms) was the dominant taxonomic group (Table B-9). Mean community measure values were comparable between within- and non-ZID stations, and all station values were within regional and OCSD historical ranges in both surveys (Tables 2-8 and 2-9). The infaunal community at all 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 most within-ZID stations was similar to that of 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 35 epibenthic macroinvertebrate (EMI) species, comprising 13,614 individuals and a total weight of 35.5 kg, was collected from 12 trawls conducted along the Middle Shelf Zone 2 stratum during the 2018-19 monitoring period (Tables B-10 and B-11). As with the previous monitoring period, *Ophiura luetkenii* (brittle star) was the most dominant species in terms of abundance (n=8,045; 59% of total), while *Sicyonia penicillata* (shrimp) was the dominant species in respect to biomass (12.0 kg; 34% of total). The EMI community composition was similar at the outfall and 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. 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 37 fish taxa, comprising 8,050 individuals and a total weight of 185.2 kg, were collected from the monitoring area during the 2018-19 trawling effort (Tables B-12 and B-13). 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 (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.

FISH BIOACCUMULATION AND HEALTH

Demersal and Sport Fish Tissue Chemistry

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 (Tables 2-12 and 2-13). Furthermore, mean 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 monitoring areas.

Table 2–8 Community measure values for each semi-annual station sampled during the Summer 2018 infauna survey, including regional and historical values. NC = Not Calculated.

Station	Nominal Depth (m)	Total No. of Species	Total Abundance	H'	SDI	ITI	BRI
Middle Shelf Zone 2, Non-ZID (51-90 m)							
1	56	80	295	3.90	30	75	16
3	60	103	450	4.00	35	75	12
5	59	77	276	3.70	27	76	16
9	59	87	387	3.87	27	77	14
12	58	98	377	3.86	30	75	14
68	52	103	514	3.89	28	72	15
69	52	104	433	3.92	28	76	15
70	52	101	511	3.70	24	74	12
71	52	97	506	3.77	24	74	17
72	55	90	307	3.98	31	80	13
73	55	98	411	3.98	31	74	15
74	57	80	330	3.79	25	74	15
75	60	70	281	3.71	23	74	22
77	60	93	411	3.80	26	73	14
78	63	91	378	3.91	30	81	14
79	65	85	349	3.80	25	71	16
80	65	83	264	4.00	33	78	9
81	65	92	375	3.95	30	80	13
82	65	62	264	3.56	21	75	8
84	54	104	464	4.01	30	77	12
85	57	85	272	3.91	29	82	12
86	57	106	377	4.10	37	71	15
87	60	76	256	3.84	31	77	12
C	56	78	248	3.79	27	70	16
CON	59	102	391	3.80	30	71	13
	Mean	**90**	**365**	**3.86**	**28**	**75**	**14**
Middle Shelf Zone 2, Within-ZID (51-90 m)							
0	56	106	446	4.02	33	74	19
4	56	77	271	3.82	27	75	13
76	58	101	326	4.02	35	71	15
ZB	56	66	212	3.81	26	81	16
	Mean	**88**	**314**	**3.92**	**30**	**75**	**16**
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 summer values (2008-2018 Fiscal Years) [mean (range)]							
Middle Shelf Zone 2, Non-ZID		94 (20-142)	408 (90-785)	3.68 (2.27-4.43)	27 (5-52)	77 (40-94)	18 (10-49)
Middle Shelf Zone 2, Within-ZID		88 (33-138)	482 (212-1491)	3.39 (0.36-4.10)	23 (1-38)	60 (1-91)	25 (13-52)

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.

Liver Histopathology

No histopathology analysis was conducted for the 2018-19 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 based on the low concentration of chemical contaminants in the monitoring area and the absence of sediment toxicity in controlled laboratory tests. In addition, the animal communities were comparable between outfall and non-outfall areas, there was negligible disease symptoms in fish samples, and contaminant concentrations in fish tissue samples did not exceed federal and state fish consumption guidelines. These results suggest that the receiving environment was not degraded by OCSD's discharge of treated wastewater, and as such, all permit compliance criteria were met in 2018-19 and environmental and human health were protected.

Table 2–9 Community measure values for each semi-annual station sampled during the Winter 2019 infauna survey, including regional and historical values. NC = Not Calculated.

Station	Nominal Depth (m)	Total No. of Species	Total Abundance	H'	SDI	ITI	BRI
Middle Shelf Zone 2, Non-ZID (51-90 m)							
1	56	82	501	3.40	20	69	21
3	60	102	454	3.91	31	74	16
5	59	67	271	3.30	19	72	16
9	59	97	527	3.49	23	74	14
12	58	89	361	3.65	25	74	16
68	52	82	495	3.53	20	65	19
69	52	88	430	3.67	24	70	15
70	52	105	574	3.67	24	76	13
71	52	98	507	3.55	20	73	14
72	55	81	486	3.29	18	71	20
73	55	118	750	3.81	26	72	15
74	57	122	498	4.09	34	74	15
75	60	107	610	3.82	28	74	15
77	60	88	508	3.47	20	74	13
78	63	100	597	3.67	24	74	14
79	65	80	404	3.39	20	71	18
80	65	84	500	3.48	19	75	15
81	65	84	324	3.70	25	79	16
82	65	85	403	3.68	23	76	15
84	54	112	734	3.61	24	69	16
85	57	80	283	3.77	26	82	13
86	57	114	539	3.85	29	75	15
87	60	79	330	3.74	25	74	13
C	56	82	279	3.71	29	74	17
CON	59	47	208	3.26	16	75	17
	Mean	**91**	**463**	**3.62**	**24**	**73**	**16**
Middle Shelf Zone 2, Within-ZID (51-90 m)							
0	56	82	255	3.90	31	73	21
4	56	95	495	3.69	24	72	16
76	58	86	387	3.60	21	75	18
ZB	56	98	406	3.89	29	74	16
	Mean	**90**	**386**	**3.77**	**26**	**74**	**18**
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 (2008-2018 Fiscal Years) [mean (range)]							
Middle Shelf Zone 2, Non-ZID		85 (45-142)	327 (96-634)	3.74 (2.87-4.32)	28 (9-48)	78 (47-95)	17 (9-46)
Middle Shelf Zone 2, Within-ZID		79 (35-135)	364 (88-1230)	3.46 (0.89-4.68)	24 (1-76)	62 (3-89)	23 (9-45)

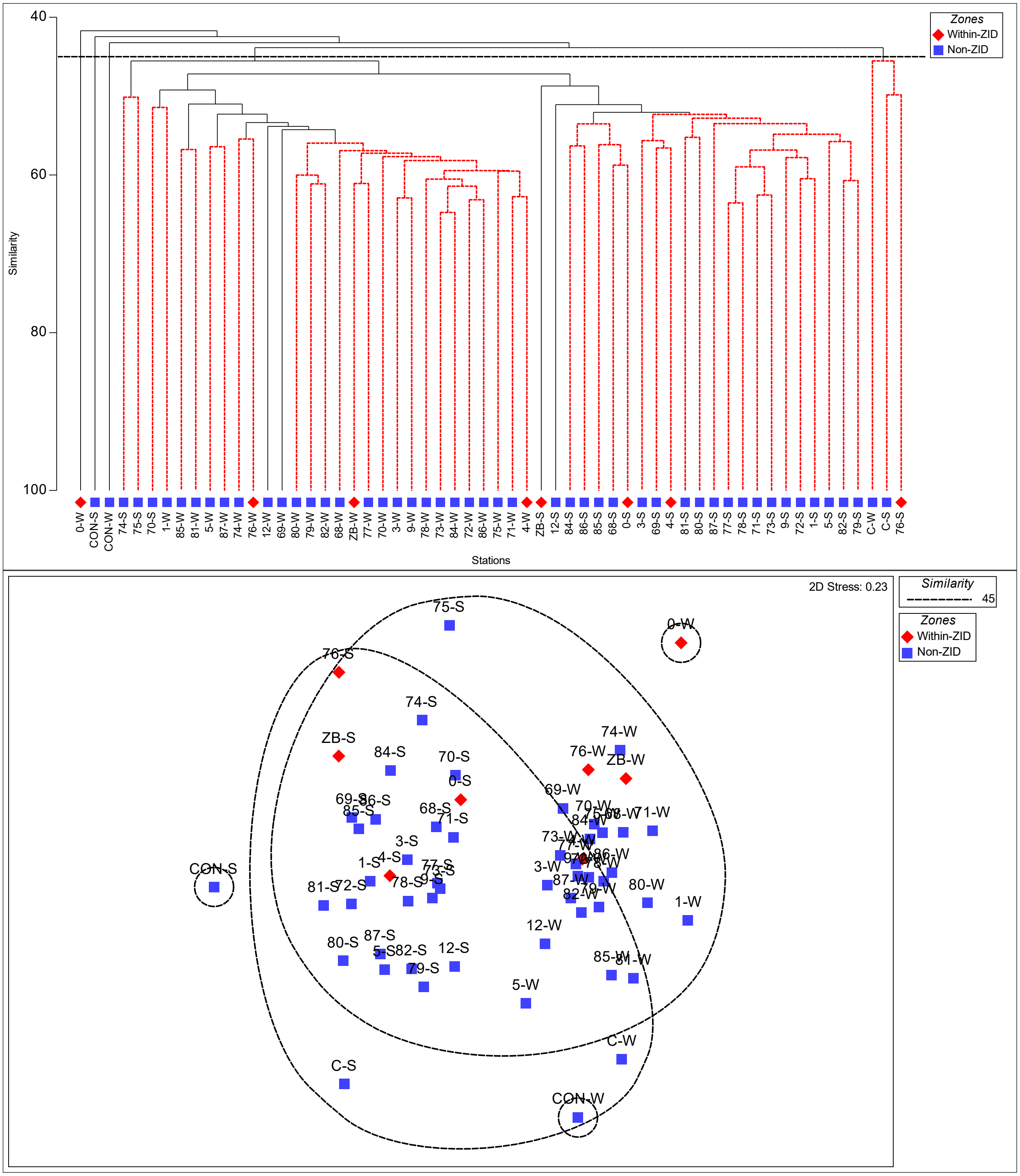

Figure 2–5 Dendrogram (top panel) and non-metric multidimensional scaling (nMDS) plot (bottom panel) of the infauna collected at within- and non-ZID stations along the Middle Shelf Zone 2 stratum for the Summer 2018 (S) and Winter 2019 (W) benthic surveys. Stations connected by red dashed lines in the 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.

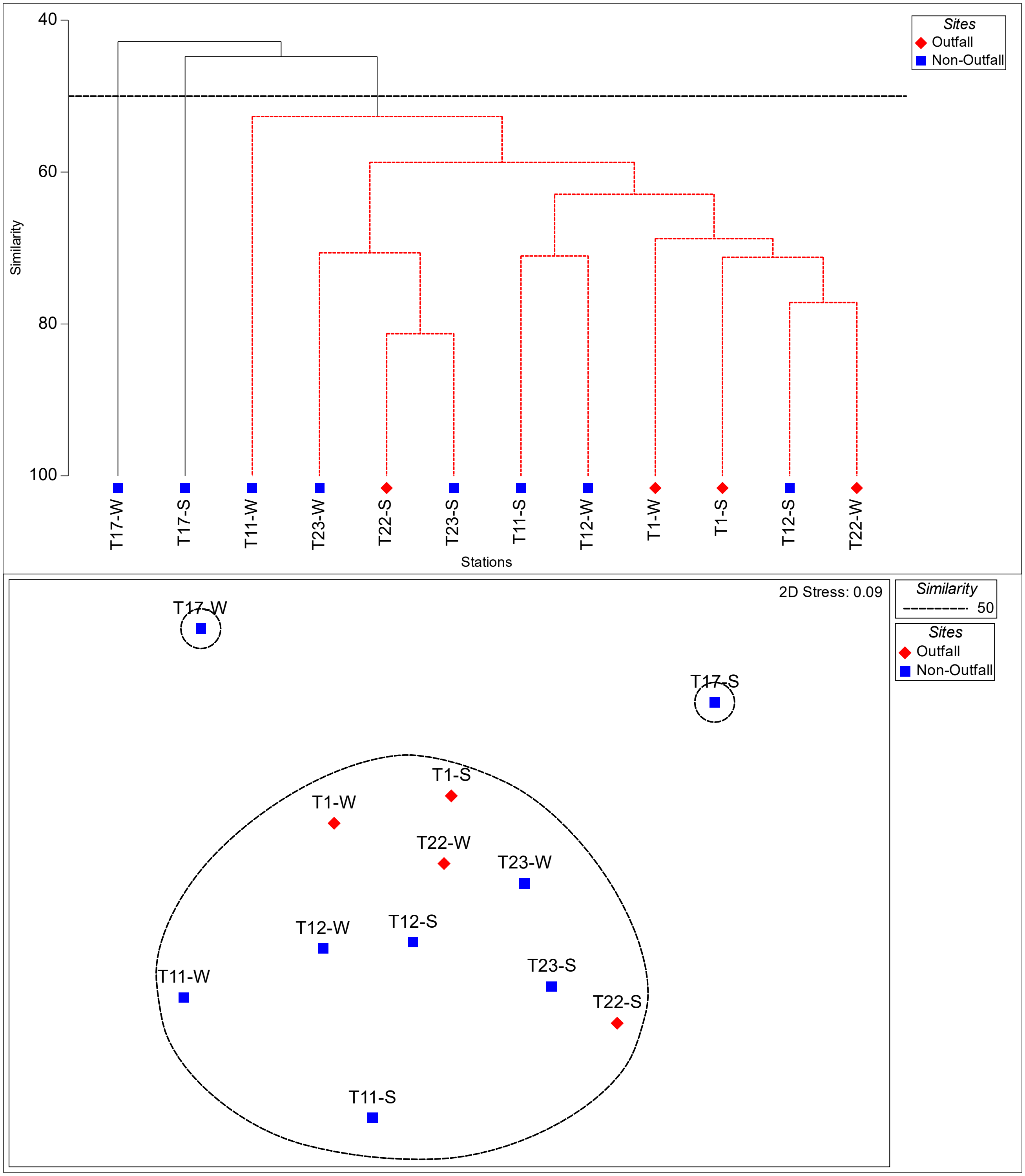

Figure 2–6 Dendrogram (top panel) and non-metric multidimensional scaling (nMDS) plot (bottom panel) of the epibenthic macroinvertebrates collected at outfall and non-outfall stations along the Middle Shelf Zone 2 stratum for the Summer 2018 (S) and Winter 2019 (W) trawl surveys. Stations connected by red dashed lines in the dendrogram are not significantly differentiated based on the SIMPROF test. The three main clusters formed at a 50% similarity on the dendrogram are superimposed on the nMDS plot.

Table 2–10 Summary of epibenthic macroinvertebrate community measures for each semi-annual station sampled during the Summer 2018 and Winter 2019 trawl surveys, including regional and historical values. NC = Not Calculated.

Quarter	Station	Nominal Depth (m)	Total No. of Species	Total Abundance	Biomass (kg)	H'	SDI
			Middle Shelf Zone 2, Non-outfall (51-90 m)				
Summer	T23	58	9	708	1.37	0.45	1
	T12	57	10	1155	1.98	0.66	1
	T17	60	6	188	0.60	0.90	2
	T11	60	17	1620	3.15	0.44	1
		Mean	**11**	**918**	**1.77**	**0.61**	**1**
			Middle Shelf Zone 2, Outfall (51-90 m)				
	T22	60	13	456	0.94	0.58	1
	T1	55	12	208	0.99	1.56	3
		Mean	**13**	**332**	**0.97**	**1.07**	**2**
			Middle Shelf Zone 2, Non-outfall (51-90 m)				
Winter	T23	58	14	1392	1.20	0.67	1
	T12	57	9	4284	2.83	0.36	1
	T17	60	7	898	5.34	0.43	1
	T11	60	17	1163	1.77	0.72	1
		Mean	**12**	**1934**	**2.79**	**0.55**	**1**
			Middle Shelf Zone 2, Outfall (51-90 m)				
	T22	60	13	372	0.47	1.62	3
	T1	55	12	1170	2.49	1.58	3
		Mean	**13**	**771**	**1.48**	**1.60**	**3**
			Regional summer values [area-weighted mean (range)]				
		Bight'13 Middle Shelf	12 (3-23)	1093 (19-17973)	5.00 (0.31-36)	1.11 (0.09-2.49)	NC
			OCSD historical values (2008-2018 FY) [mean (range)]				
		Middle Shelf Zone 2, Non-outfall	11 (5-19)	365 (12-2498)	1.57 (0.04-11.16)	1.33 (0.06-2.43)	3 (1-9)
		Middle Shelf Zone 2, Outfall	12 (7-18)	287 (49-1436)	1.42 (0.08-5.67)	1.44 (0.22-2.15)	3 (1-5)

Table 2–11 Summary of demersal fish community measures for each semi-annual station sampled during the Summer 2018 and Winter 2019 trawl surveys, including regional and District historical values. NC = Not Calculated.

Quarter	Station	Nominal Depth (m)	Total No. of Species	Total Abundance	Biomass (kg)	H'	SDI	FRI
				Middle Shelf Zone 2, Non-outfall (51-90 m)				
Summer	T23	58	15	395	23.89	1.55	2	20
	T12	57	17	428	5.21	1.83	3	21
	T17	60	14	262	4.09	2.20	5	22
	T11	60	13	341	5.45	1.58	2	23
		Mean	**15**	**357**	**9.66**	**1.79**	**3**	**22**
				Middle Shelf Zone 2, Outfall (51-90 m)				
	T22	60	17	411	11.58	1.57	3	23
	T1	55	13	506	6.10	1.58	3	16
		Mean	**15**	**459**	**8.84**	**1.58**	**3**	**19**
				Middle Shelf Zone 2, Non-outfall (51-90 m)				
Winter	T23	58	17	540	19.51	2.00	5	23
	T12	57	19	485	20.92	2.06	4	27
	T17	60	17	835	10.00	1.66	3	25
	T11	60	20	2736	55.85	0.89	1	32
		Mean	**18**	**1149**	**26.57**	**1.65**	**3**	**27**
				Middle Shelf Zone 2, Outfall (51-90 m)				
	T22	60	16	561	7.99	1.81	4	22
	T1	55	18	550	14.59	2.18	5	25
		Mean	**17**	**556**	**11.29**	**2.00**	**5**	**23**
				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)
				OCSD historical values (2008-2018 Fiscal Years) [mean (range)]				
		Middle Shelf Zone 2, Non-outfall	14 (3-25)	580 (45-12274)	12.90 (1.25-135.64)	1.72 (0.14-2.18)	3 (1-6)	23 (12-34)
		Middle Shelf Zone 2, Outfall	13 (2-18)	415 (110-3227)	16.97 (2.47-78.72)	1.69 (0.67-2.14)	3 (1-6)	22 (13-32)

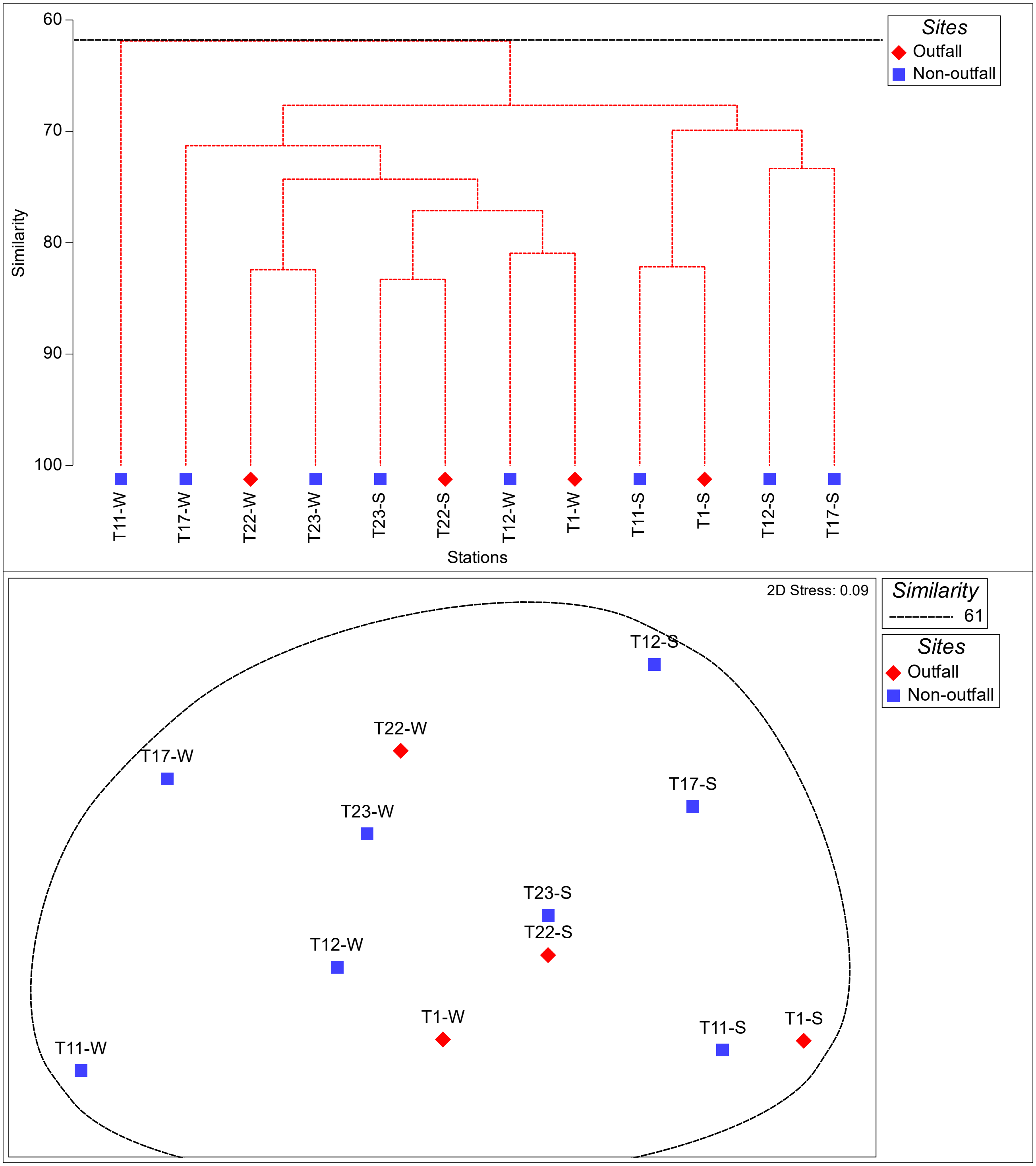

Figure 2–7 Dendrogram (top panel) and non-metric multidimensional scaling (nMDS) plot (bottom panel) of the demersal fishes collected at outfall and non-outfall stations along the Middle Shelf Zone 2 stratum for the Summer 2018 (S) and Winter 2019 (W) trawl surveys. Stations connected by red dashed lines in the dendrogram are not significantly differentiated based on the SIMPROF test. The single cluster formed at a 61% similarity on the dendrogram is superimposed on the nMDS plot.

Table 2–12 Means and ranges of tissue contaminant concentrations in selected flatfishes collected by trawling in July 2018 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)
				2018-2019 values						
Pleuronichthys verticalis (Hornyhead Turbot)	Muscle	Non-outfall	10	121 (102-154)	0.31 (0-1.07)	0.02 (0.01-0.03)	9.21 (0-19.07)	0.14 (0-1.30)	ND (All ND)	ND (All ND)
		Outfall	5	130 (111-163)	ND (All ND)	0.03 (0.01-0.06)	1.72 (0-4.49)	1.62 (1.30-2.20)	ND (All ND)	ND (All ND)
	Liver	Non-outfall	10	121 (102-154)	1.46 (0-8.74)	0.08 (0.05-0.12)	392.20 (8.39-1754.90)	26.92 (0-72.80)	ND (All ND)	ND (All ND)
		Outfall	5	130 (111-163)	5.72 (1.08-14.70)	0.09 (0.01-0.16)	99.66 (61.90-148)	ND (All ND)	ND (All ND)	ND (All ND)
Parophrys vetulus (English Sole)	Muscle	Non-outfall	10	183 (156-218)	1.26 (0.65-2.93)	0.04 (0.02-0.07)	18.84 (6.18-84.16)	1.62 (0-10.50)	ND (All ND)	ND (All ND)
		Outfall	10	190 (152-268)	1.24 (0-2.76)	0.05 (0.02-0.10)	15.21 (3.75-34.60)	3.38 (1.10-8.11)	ND (All ND)	ND (All ND)
	Liver	Non-outfall	10	183 (156-218)	8.45 (3.17-13.40)	0.06 (0.03-0.12)	144.24 (42.60-292)	29.29 (0-78.96)	ND (All ND)	ND (All ND)
		Outfall	10	190 (152-268)	12.57 (4.03-25.30)	0.06 (0.02-0.14)	159.49 (70.70-449.60)	16.34 (0-48.60)	ND (All ND)	ND (All ND)
				OCSD historical values (2008-2018 Fiscal Years)						
Pleuronichthys verticalis (Hornyhead Turbot)	Muscle	Non-outfall	64	152 (98-217)	0.17 (0-0.68)	0.06 (0.01-0.30)	10.49 (0-38.75)	2.43 (0-18.36)	0.06 (0-1.45)	ND (All ND)
		Outfall	91	159 (110-204)	0.14 (0-0.77)	0.08 (0.01-0.42)	6.91 (0-54.50)	1.47 (0-12.57)	0.01 (0-0.71)	0.20 (0-12.70)
	Liver	Non-outfall	64	157 (98-217)	6.05 (0.42-30.40)	0.21 (0.05-0.79)	540.82 (0-2100)	44.79 (0-432.59)	ND (All ND)	ND (All ND)
		Outfall	91	158 (110-204)	8.13 (0-24.60)	0.18 (0.02-0.59)	484.28 (0-1822.70)	98.89 (0-457.80)	3.46 (0-81.70)	ND (All ND)
Parophrys vetulus (English Sole)	Muscle	Non-outfall	91	183 (124-268)	0.83 (0-6.22)	0.06 (0.02-0.12)	73.80 (0-524.30)	8.21 (0-61.20)	ND (All ND)	0.05 (0-4.45)
		Outfall	78	185 (136-290)	1.16 (0-8.23)	0.06 (0.01-0.11)	106.25 (3.97-633.46)	14.33 (0-130.90)	ND (All ND)	ND (All ND)
	Liver	Non-outfall	91	183 (124-268)	10.29 (1.93-26.80)	0.06 (0.02-0.19)	1316.70 (71.10-14300)	175.41 (0-1694.70)	0.08 (0-5.27)	ND (All ND)
		Outfall	78	184 (136-290)	11.66 (0-27.10)	0.06 (0.02-0.16)	1532.90 (95.70-20967)	203.93 (0-1627.29)	1.25 (0-30.80)	ND (All ND)

Table 2–13 Means and ranges of muscle tissue contaminant concentrations in selected scorpaenid and sand bass fishes collected by rig-fishing in April/May 2019 at Zones 1 (Outfall) and 3 (Non-outfall), including historical values and state and federal thresholds. ND = Not Detected; NC = Not Collected; 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)
2018-2019 values											
Non-outfall	*Scorpaena guttata* (California Scorpionfish)	3	190 (175-215)	1.76 (0.69-2.66)	0.08 (0.06-0.10)	8.17 (2.30-13.30)	0.65 (0.55-0.78)	28.29 (5.08-63.40)	3.21 (0-7.01)	ND (All ND)	ND (All ND)
Non-outfall	*Sebastes caurinus* (Copper Rockfish)	1	265	0.56	0.08	4.58	0.29	ND	ND	ND	ND
Non-outfall	*Sebastes miniatus* (Vermilion Rockfish)	6	241 (210-281)	1.10 (0-2.45)	0.04 (0.04-0.05)	2.74 (1.47-5.18)	0.42 (0.29-0.56)	11.71 (2.57-31.63)	1.92 (0-8.02)	ND (All ND)	ND (All ND)
Outfall	*Paralabrax nebulifer* (Barred Sand Bass)	8	304 (240-360)	1.80 (0.43-4.60)	0.07 (0.05-0.09)	1.42 (0.58-2.72)	0.47 (0.28-0.62)	101.51 (18.30-243.68)	69.99 (16.59-152.27)	0.96 (0-8)	ND (All ND)
Outfall	*Sebastes miniatus* (Vermilion Rockfish)	2	260 (both 260)	1.08 (0.33-1.84)	0.03 (0.02-0.04)	2.48 (2.13-2.82)	0.46 (0.39-0.53)	9.84 (3.10-16.58)	1.62 (0-3.25)	ND (All ND)	ND (All ND)
OCSD historical values (2012-2018 Fiscal Years)											
Non-outfall	*Scorpaena guttata* (California Scorpionfish)	NC	–	–	–	–	–	–	–	–	–
Non-outfall	*Sebastes caurinus* (Copper Rockfish)	10	310 (225-780)	0.66 (0-1.08)	0.12 (0.06-0.19)	1.64 (0.52-2.21)	0.69 (0.16-1.64)	16.88 (5.61-43)	1.60 (0-7.60)	ND (All ND)	ND (All ND)
Non-outfall	*Sebastes miniatus* (Vermilion Rockfish)	18	245 (215-295)	0.69 (0.34-1.28)	0.08 (0.05-0.20)	2.90 (1.07-10.30)	0.71 (0.07-1.54)	19.22 (4.00-99.20)	0.39 (0-2.46)	ND (All ND)	ND (All ND)
Outfall	*Paralabrax nebulifer* (Barred Sand Bass)	NC	–	–	–	–	–	–	–	–	–
Outfall	*Sebastes miniatus* (Vermilion Rockfish)	43	266 (149-317)	1.20 (0-3.82)	0.05 (0.02-0.08)	2.68 (0.68-5.89)	0.54 (0.17-0.88)	13.15 (0-58.30)	1.97 (0-17.24)	0.24 (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

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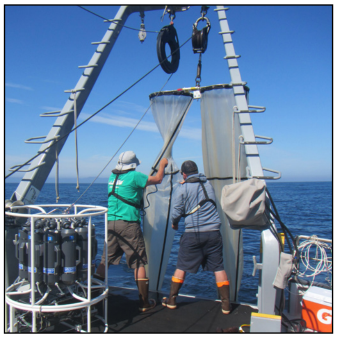

CHAPTER 3
Strategic Process Studies and Regional Monitoring

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 Permit 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/or focus on issues of interest to OCSD and/or its regulators, such as the effect of contaminants of emerging concern on local fish populations. SPS are proposed and must be approved by the RWQCB to ensure appropriate focus and level of effort. For the 2018-19 program year, 5 SPS were started.

Regional monitoring studies focus on the larger areas of the Southern California Bight. 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 2018-June 2019) 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.

STRATEGIC PROCESS STUDIES

For the 2018-19 program year, OCSD had 5 SPS that were designed to address potential changes in the quantity and quality of its discharged effluent when the Groundwater Replenishment System (GWRS) Final Expansion project is completed in 2023.

ROMS-BEC Ocean Outfall Modeling (2019-2022)

OCSD last modeled and characterized its discharge plume in the early 2000s. Since then, significant changes have occurred in both the quantity and quality of the effluent discharged due to water conservation and reclamation efforts. To evaluate the spatial extent and temporal variability of the discharged plume, OCSD will work with SCCWRP and their collaborators to model and assess the spatial and temporal extent of its discharged effluent before and after (compare and contrast) the implementation of the GWRS Final Expansion.

Microplastics Characterization (2019-2020)

Wastewater treatment plants are a known microplastics (1–5 mm) conduit to aquatic, marine, and terrestrial environments; however, data regarding microplastics from OCSD treatment processes are non-existent. This SPS will characterize the quantity and types of microplastics throughout OCSD's treatment system. Another goal of this study is to develop methods and analyses to help inform the transport, fate, and impacts of microplastics through OCSD's wastewater treatment process to the receiving environment.

Contaminants of Emerging Concern Monitoring (2019-2020)

Contaminants of Emerging Concern (CEC) are generally not lethal but can be detrimental to living organisms (including humans) over time. This study will provide a preliminary assessment of non-targeted CECs in OCSD's receiving environment using *in-vitro* cell bioassay techniques. Used as a screening tool, cell bioassays should help researchers evaluate potential impacts resulting from changes in the effluent and receiving environment water quality associated with the GWRS Final Expansion.

Sediment Linear Alkylbenzenes (2020-2021)

Linear Alkylbenzenes (LABs) are organic contaminants that can be used to track the presence and settling of wastewater particles in the offshore environment. From 1998-2014, OCSD used LABs to measure its discharge footprint and investigate whether other contaminants present in the sediment were associated with the effluent discharge. This study will provide updated data within OCSD's monitoring area for evaluating future changes due to GWRS Final Expansion. Included will be a literature review of potential alternative effluent tracers that may be used to complement or enhance the current LAB tracers for future applications.

Meiofauna Baseline (2020-2021)

The increase of reverse osmosis concentrate (brine) return flows from the GWRS Final Expansion may negatively affect marine biota in the receiving water. While meiofauna (animals ranging from 63–500 μm in size) are known to be more sensitive to anthropogenic impacts than macrofauna, information on meiofauna diversity and abundance in OCSD's monitoring area is non-existent. This study will characterize the meiofauna communities in the receiving environment and evaluate the suitability of using meiofauna for a Before-After Control-Impact study of the GWRS Final Expansion.

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 1–2 days/week 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 advisories, postings, or beach closures. Results are provided in OCHCA (2019).

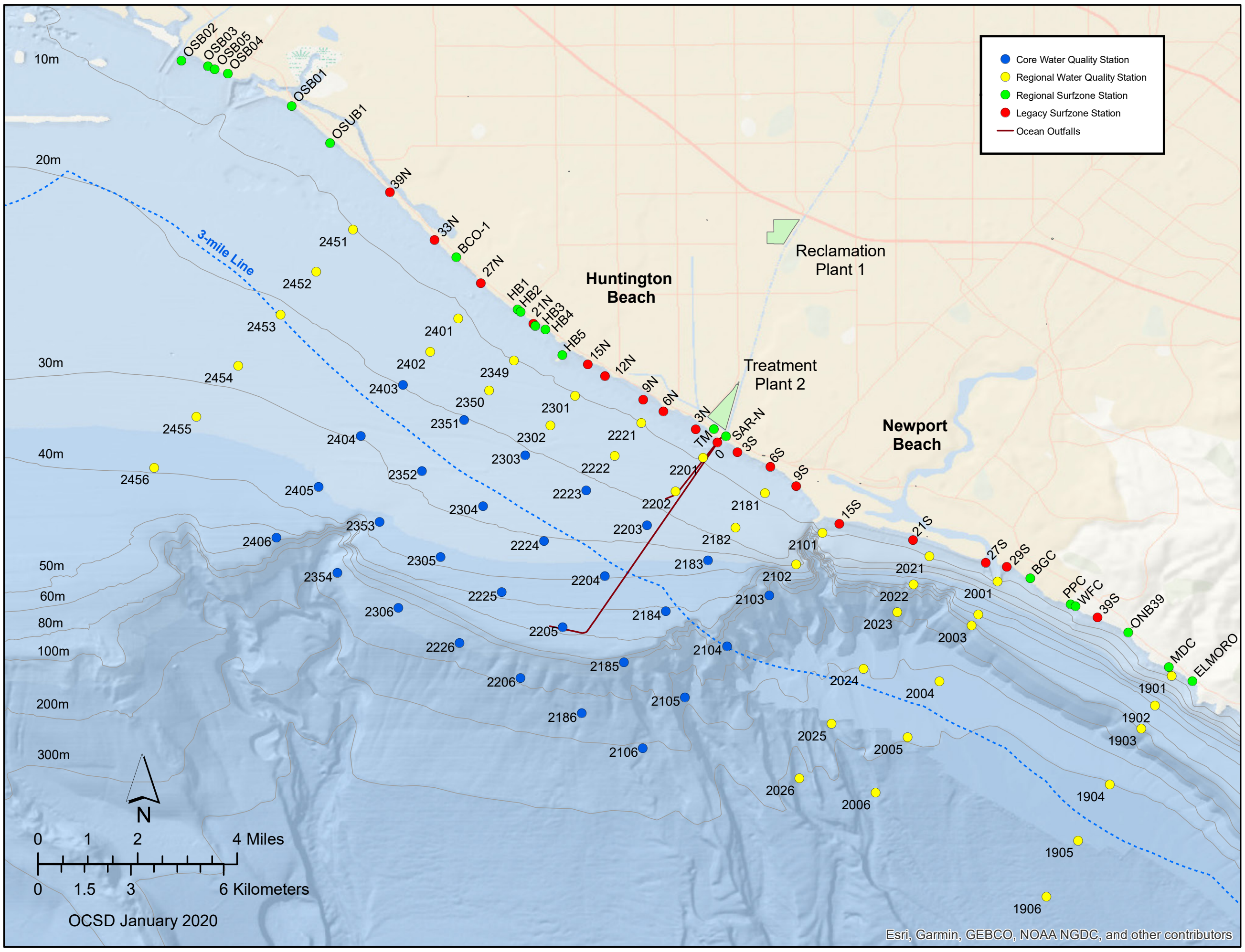

Figure 3–1 Offshore and nearshore (surfzone) water quality monitoring stations for 2018-19.

Of the 38 OCSD-sampled regional surfzone stations, 18 are legacy (Core) stations sampled since the 1970s (Figure 3-1). Results for these stations were similar to those of previous years (OCSD 2017, 2018) with fecal indicator counts varying by quarter, location, and bacteria type (Table B-14). A general spatial pattern was associated with the mouth of the Santa Ana River. Quarterly geomeans peaked near the river mouth (Station 0) and tapered off upcoast and downcoast.

Southern California Bight Regional Water Quality Program

OCSD continued as 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 3-2). The participants use comparable 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

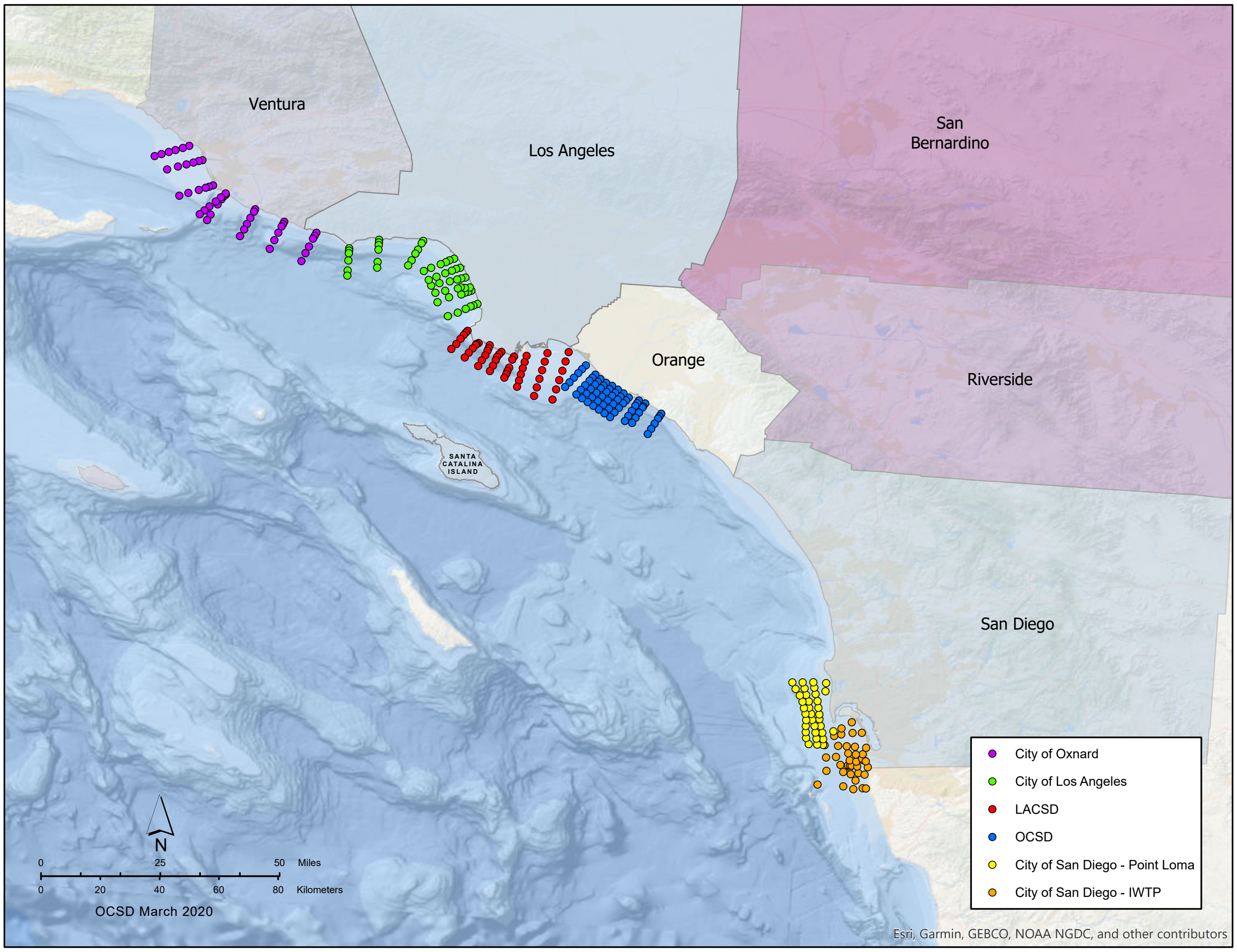

Figure 3–2 Southern California Bight Regional Water Quality Program monitoring stations for 2018-19.

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 (IOOS) guidelines.

Bight Regional Monitoring

Since 1994, OCSD has participated in 6 regional monitoring studies of environmental conditions within the Southern California Bight (SCB): 1994 Southern California Bight Pilot Project, Bight'98, Bight'03, Bight'08, Bight'13, and Bight'18. 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 2018, OCSD staff conducted field operations, ranging from Dana Point in southern Orange County to the Long Beach breakwater in southern Los Angeles County and southwest to the southern end of Santa Catalina Island, as part of the Bight'18 sampling effort (Figure 3-3). Summer 2018 benthic sampling included sediment geochemistry and infauna and trawling for epibenthic fish and macroinvertebrates. Ocean acidification sampling, including bongo net towing to collect pteropods, has taken place quarterly since January 2019.

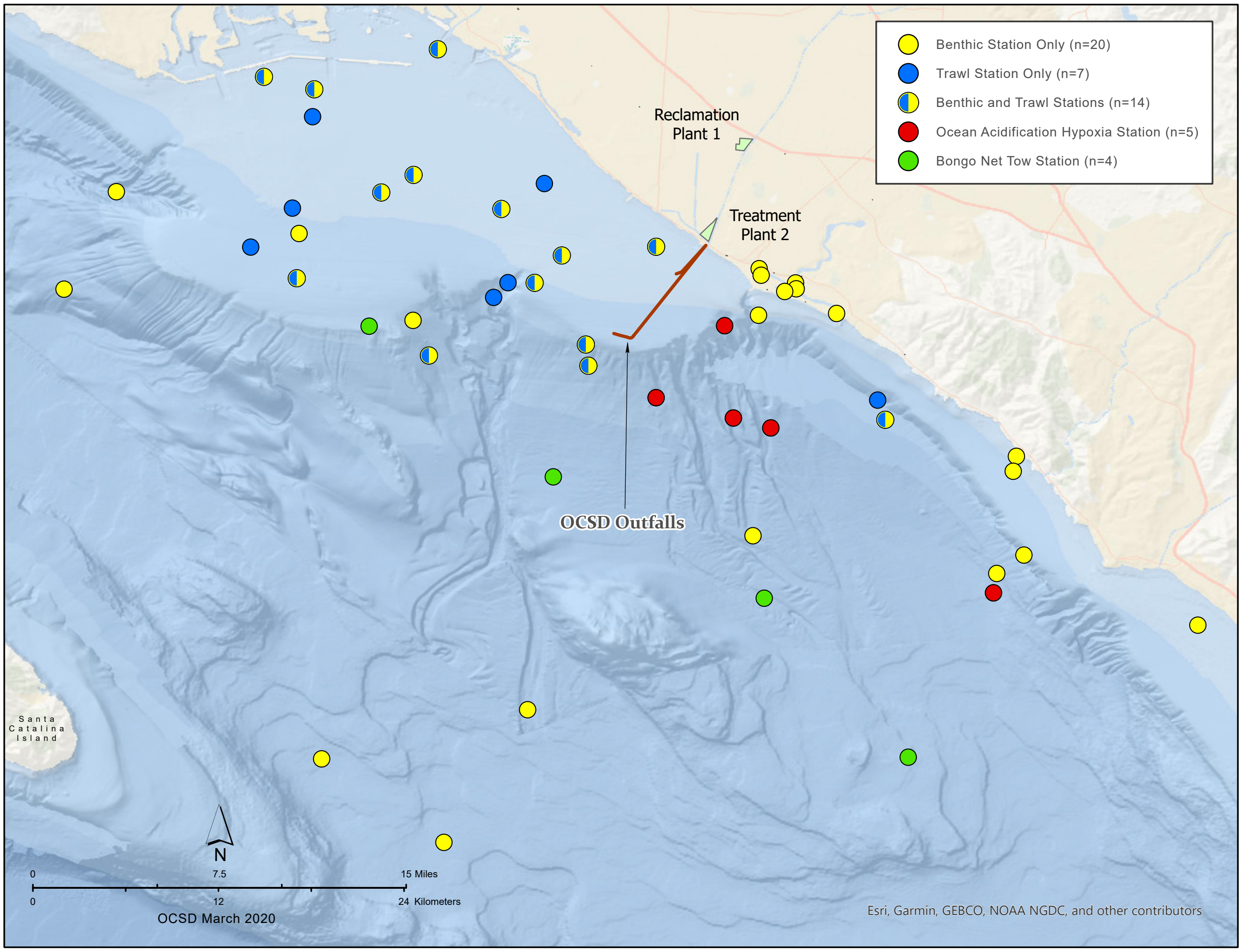

Figure 3–3 OCSD's Bight'18 sampling stations.

Detailed information is available on SCCWRP's website (http://www.sccwrp.org/about/research-areas/regional-monitoring/).

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 2019) to both consortium groups, regulators, and the public. Reports are available at https://www.mbcaquatic.com/reports/southern-california-bight-regional-aerial-kelp-surveys.

2018 CRKSC Results

Total combined kelp surface canopy in the Central Region increased by 61% in 2018 compared to 2017 (7.9 km2 versus 4.8 km2), the highest in 50 years. Of the 26 recognized beds, 24 showed a surface canopy, with 23 increasing in size and 1 decreasing in size. Eighteen beds exceeded

40% of their historical maximum size, with 12 at or above 80%, including 3 that reached maximum levels recorded. Six beds declined to less than 10% of their maximum size. Since 2007 total kelp coverage for the Central Region has been at or above the long-term average every year.

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 increase of 261% (0.033 km2 to 0.119 km2). However, this large increase represents only 28% 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 and Hypoxia Mooring

OCSD's Ocean Acidification and Hypoxia 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. Additionally, work was begun on establishing an automated data quality control system for telemetered data based on IOOS protocols (https://ioos.noaa.gov/project/qartod/).

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, pH, and light transmissivity. Appendix A contains the steps on how the comparison was compiled.

Results for 2018-19 were the same as previous comparisons. The SCCWRP methodology identified greater numbers of reference stations and fewer stations that did not meet COP criteria (Table 3-1, Figure 3-4). 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? Was it adjacent to other plume impacted station(s)?) 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 other sources. For example, in June 2019, the 3 stations identified with oxygen OROs and OOCs were located in the northwest portion of the OCSD station grid. Local currents showed a strong downcoast flow inshore at these stations with upcoast and offshore flows in the offshore portion of the grid where the outfall diffuser is located. The source of these impacts was more likely to be from the Long Beach area and not the outfall.

Table 3–1 Comparison of monthly California Ocean Plan compliance determinations using OCSD and SCCWRP methodologies for dissolved oxygen, pH, and light transmissivity for 2018-19.

Survey	Current Direction	Plume Impacted		Reference		Out-of-Range		Out-of-Compliance	
		OCSD	SCCWRP	OCSD	SCCWRP	OCSD	SCCWRP	OCSD	SCCWRP
Dissolved Oxygen									
Jul-18	UC	N/A	8	2	9	12	2	0	2
Aug-18	UC	N/A	3	2	14	1	0	0	0
Sep-18	DC	N/A	4	2	12	2	0	0	0
Oct-18	UC	N/A	3	2	15	0	0	0	0
Nov-18	UC	N/A	4	2	15	0	0	0	0
Dec-18	UC	N/A	2	2	7	0	0	0	0
Jan-19	DC	N/A	4	2	10	2	0	2	0
Feb-19	DC	N/A	4	2	13	8	0	3	0
Mar-19	UC	N/A	4	2	14	0	0	0	0
Apr-19	DC	N/A	5	2	14	12	0	12	0
Apr-19	UC	N/A	5	2	14	14	0	9	0
May-19	DC	N/A	4	2	12	13	0	5	0
Jun-19	UC	N/A	5	2	10	10	3	2	3
pH									
Jul-18	UC	N/A	8	2	9	1	0	0	0
Aug-18	UC	N/A	3	2	16	0	0	0	0
Sep-18	DC	N/A	4	2	14	0	0	0	0
Oct-18	UC	N/A	3	2	17	0	0	0	0
Nov-18	UC	N/A	4	2	16	0	0	0	0
Dec-18	UC	N/A	2	2	7	0	0	0	0
Jan-19	DC	N/A	4	2	11	0	0	0	0
Feb-19	DC	N/A	4	2	4	1	0	1	0
Mar-19	UC	N/A	4	2	15	10	0	0	0
Apr-19	DC	N/A	5	2	16	15	0	7	0
Apr-19	UC	N/A	5	2	16	9	0	7	0
May-19	DC	N/A	4	2	12	2	0	2	0
Jun-19	UC	N/A	5	2	10	0	0	0	0
Light Transmissivity									
Jul-18	UC	N/A	8	2	10	2	6	0	5
Aug-18	UC	N/A	3	2	16	11	3	0	3
Sep-18	DC	N/A	4	2	14	6	2	0	2
Oct-18	UC	N/A	3	2	17	15	2	0	2
Nov-18	UC	N/A	4	2	16	7	4	1	4
Dec-18	UC	N/A	2	2	7	23	1	2	1
Jan-19	DC	N/A	4	2	11	9	3	0	3
Feb-19	DC	N/A	4	2	14	8	3	1	3
Mar-19	UC	N/A	4	2	15	20	4	4	4
Apr-19	DC	N/A	5	2	16	13	4	1	2
Apr-19	UC	N/A	5	2	16	10	4	2	2
May-19	DC	N/A	4	2	12	5	3	0	3
Jun-19	UC	N/A	5	2	10	12	2	0	1

N/A = Not Applicable; DC = Downcoast; UC = Upcoast.

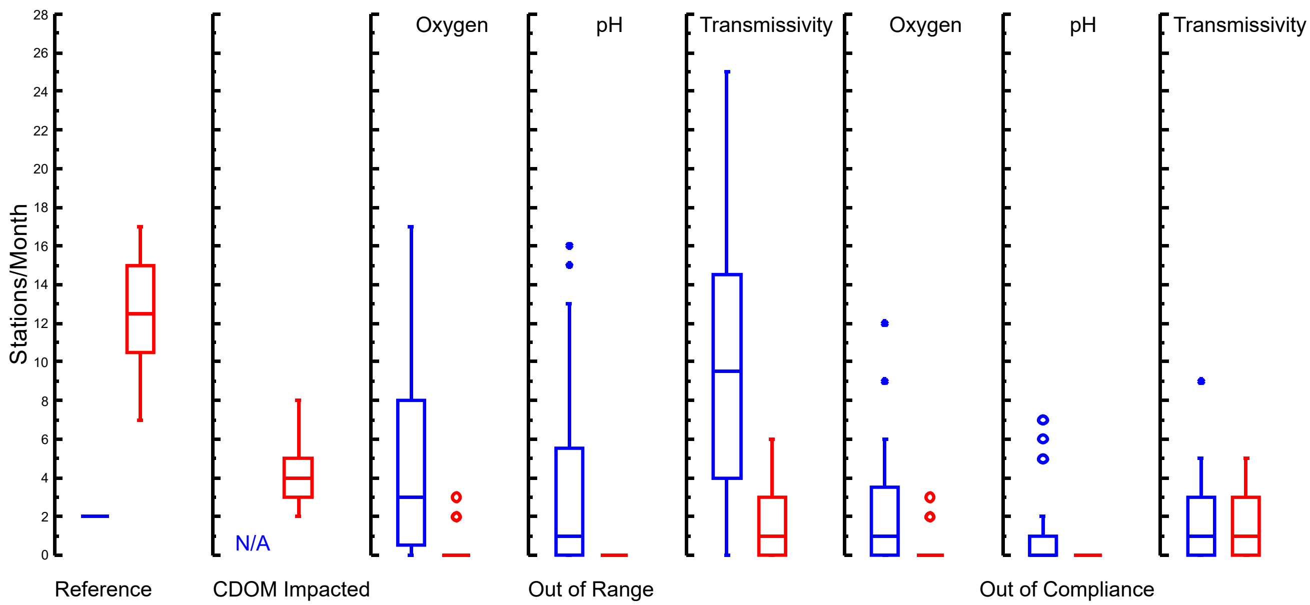

Figure 3–4 Comparison of monthly OCSD (blue) and SCCWRP (red) California Ocean Plan Compliance results for Program Years 2016-17 to 2018-19 (n=36). N/A = Not Applicable.

Fish Tracking Study

OCSD's OMP assesses discharge effects on marine communities, including bioaccumulation analyses of contamination levels in tissue samples of flatfishes (predominantly Hornyhead Turbot and 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. To assess this issue, OCSD contracted Professor Chris Lowe from California State University, Long Beach to conduct a fish tracking study using passive acoustic telemetry from 2017-18 to understand the site fidelity and potential risk exposure of sentinel fishes at the outfall and a reference area.

The results indicated that residencies to both areas were low for Hornyhead Turbot, English Sole and Pacific Sanddab (<10% of the study duration was spent in either site), whereas Vermilion Rockfish showed higher degrees of residency to the outfall site (nearly 40% of the study duration) (Burns et al. 2019). These results suggest that tissue samples of sentinel flatfishes likely reflect the accumulation of contaminants across individuals' ranges, not just the outfall site. In addition, Vermilion Rockfish may be the most susceptible sentinel species to wastewater effluent effects.

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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

<u>Offshore Zone</u>

Permit-specified water quality monitoring was conducted 6 times per quarter. Three surveys sampled the full 28 station grid for COP compliance determinations and 3 surveys sampled a subset of 8 stations located within 3 miles of the coast for water-contact (REC-1) compliance (Table A-1; Figure 2-1).

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 SBE911plus 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 ammonium (NH3-N) and fecal indicator bacteria (FIB) samples were collected at specified stations and depths using a Sea-Bird Electronics Carousel Water Sampler (SBE32) equipped with Niskin bottles. Six liters of surface seawater (control sample) were collected at Station 2106 during each survey for ammonium QA/QC analysis. All bottled samples were kept on ice in coolers and transported to OCSD's laboratory within 6 hours. A summary of the sampling and analysis methods is presented in Table A-1.

<u>Southern California Bight Regional Water Quality</u>

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

Table A–1 Water quality sample collection and analysis methods by parameter during 2018-19.

Parameter	# Sampling Events	Sampling Method	Method Reference	Field Preservation	Container	Holding Time	Sampling Depth	Field Replicates
Nearshore (Surfzone)								
Total Coliforms Fecal Coliforms Enterococci	1-2/week 1-2/week 1-2/week	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]	6/quarter	*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]	6/quarter	*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]	6/quarter	*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]	6/quarter	*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]	6/quarter	*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]	6/quarter	*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]	6/quarter	*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]	6/quarter	*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)	6/quarter	Niskin bottle	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]	5/quarter [8]	Niskin bottle	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	5/quarter [8]	Niskin bottle	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	6/quarter	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).
8 REC-1 surveys completed within 30 days for geomean calculations.
* Sampled continuously at 24 scans/second but data processed to 1 m intervals.
** APHA (2012).
*** Available online at: www.epa.gov.

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 3-2). 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.

<u>Nearshore Zone</u>

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 (QA/QC) 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 down-cast 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 down-cast data; if there were any missing 1 m depth values, then the up-cast 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 light transmissivity, floating particulates, oil and grease, water discoloration, beach grease, and excess nutrients.

<u>DO, pH, and Light Transmissivity</u>

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 light transmissivity were based on statistical comparisons to the corresponding Zone A or Zone B reference station located up-current of the outfall (OCSD 1999). For each survey, the depth of the pycnocline layer, if present, was calculated for each 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 (light transmissivity, DO, and pH) were binned by water column stratum: above, within, or below

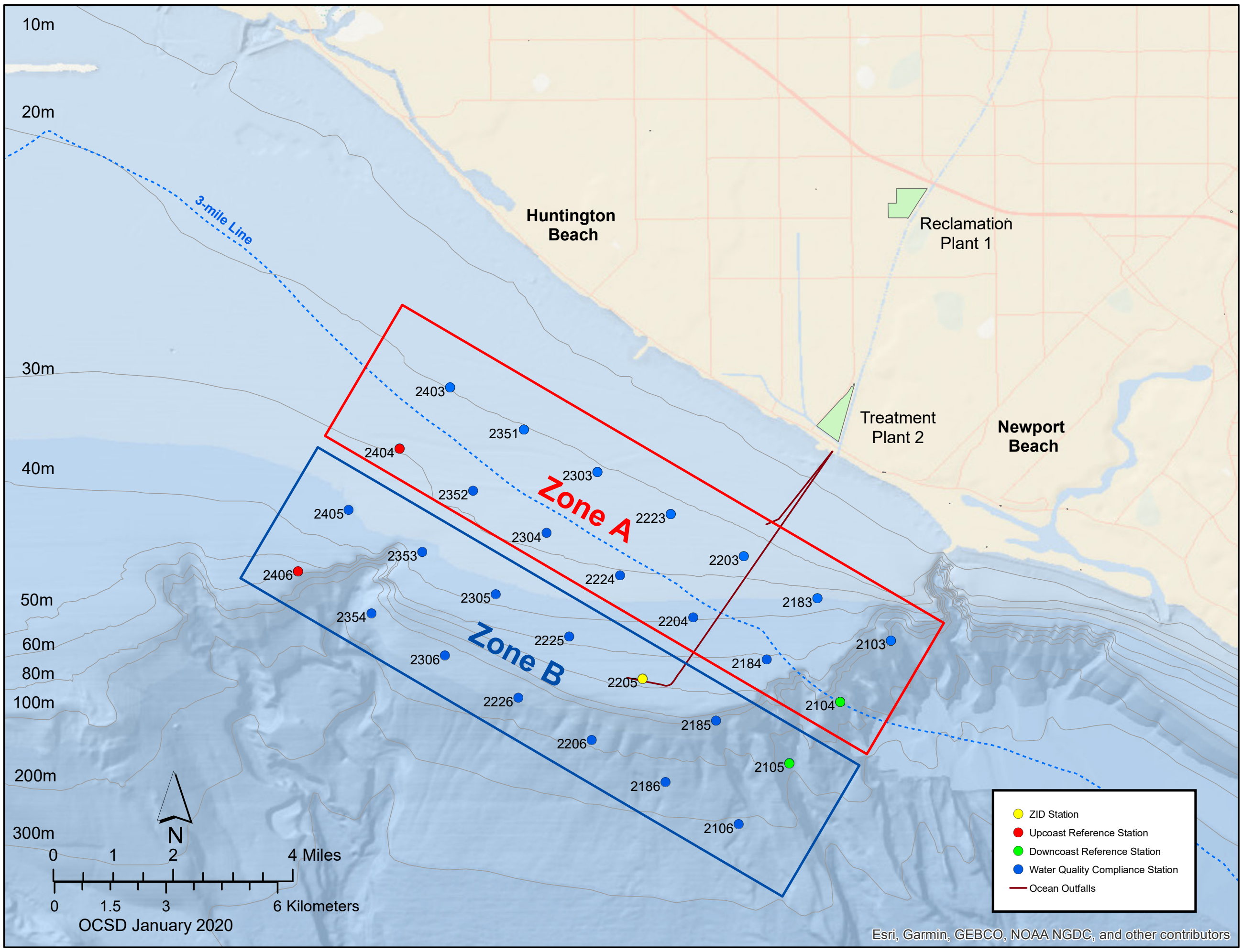

Figure A–1 Offshore water quality monitoring stations and zones used for California Ocean Plan compliance determinations.

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/or 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:

- DO: cannot be depressed >10% below the reference mean;
- pH: cannot exceed ±0.2 pH units of the reference mean; and
- Natural light (defined as light transmissivity): shall not be significantly reduced, where statistically different from the reference 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 (light transmissivity) that is unrelated to the wastewater discharge. An ORO can be in-compliance if, for example, a down-current 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 the 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 DO, 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., Stratum 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 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 Care 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-5 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 2018 (summer) and in January 2019 (winter) (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 2019 for sediment toxicity testing. Each station was assigned to 1 of 2 station groups: (1) Middle Shelf Zone 2, within-ZID (51–90 m) or (2) Middle Shelf Zone 2, non-ZID (51–90 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. The 39 NPDES permit-specified annual stations were not sampled during the 2018-19 monitoring period, as OCSD was given regulatory relief for participating in the Bight'18 regional monitoring program.

A single grab was collected at each station using a paired 0.1 m² 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) (OCSD 2016; Table A-2).

Table A–2 Sediment collection and analysis summary during 2018-19.

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. Total chlorinated pesticides (ΣPest) represents the summed values of 13 chlordane derivative compounds plus dieldrin.

Table A–3 Parameters measured in sediment samples during 2018-19.

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 *Eohaustorius estuarius* amphipod survival test (EPA 1994). Amphipods were exposed to test and home (control) sediments for 10 days, and the percent survival of amphipods in each treatment was determined.

Data Analyses

All analytes that were undetected (i.e., value below the method detection limit) are reported as ND (not detected). 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 ($p<0.05$) amphipod 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 ($p>0.05$) amphipod 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 amphipod survival less than 59% of the control was categorized as highly toxic.

BENTHIC INFAUNA MONITORING

Field Methods

A paired, 0.1 m² Van Veen grab sampler deployed from the M/V *Nerissa* was used to collect a sediment sample from the same stations (Figure 2-2) and frequencies as described above in the sediment geochemistry field methods section. The purpose of the semi-annual surveys was to determine long-term trends and potential effects along the 60-m depth contour.

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 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, 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 Aquatic Bioassay and Consulting, 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 was edited accordingly (see Appendix C). Species names used in this report follow those given in Cadien and Lovell (2018).

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

Table A–4 Benthic infauna taxonomic aliquot distribution for 2018-19.

Quarter	Survey (No. of samples)	Taxonomic Aliquots	Contractor	OCSD
Summer 2018	Semi-annual (29)	Annelida	16	13
		Arthropoda	7	22
		Echinodermata	29	0
		Mollusca	14	15
		Miscellaneous Phyla	7	22
Winter 2019	Semi-annual (29)	Annelida	29	0
		Arthropoda	29	0
		Echinodermata	29	0
		Mollusca	0	29
		Miscellaneous Phyla	29	0
		Totals	**189**	**101**

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 lower 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 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* (brittle star) 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 29 stations. 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 July 2018 (summer) and in February 2019 (winter) at Stations T23, T22, T1, T12, T17, and T11 in the Middle Shelf Zone 2 (60 m) stratum (Figure 2-3). The 8 NPDES permit-specified annual stations were not sampled during the 2018-19 monitoring period, as OCSD was given regulatory relief for participating in the Bight'18 regional monitoring program.

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 and bottom-time duration of the trawl should range from 0.77–1.0 m/s and 8–15 minutes, respectively. A minimum of 1 trawl was conducted from the M/V *Nerissa* at each station using a 7.6 m 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 stations 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 at each station, and usually in the same direction. 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. Fishes were sorted by species into separate containers; EMIs were placed together in one or more containers. The identity of individual fish in each container was checked for sorting accuracy. Fish samples collected at Stations T1 and T11 were processed as follows: (1) up to 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 some species); and (2) if a trawl catch contained more than 15 individuals of a species, then the excess specimens were enumerated in 1 cm size classes and a bulk weight was recorded. Fish samples collected at the other stations were enumerated in 1 cm size classes and a bulk weight was recorded for each species. EMIs were sorted to species, counted, and batch weighed. For each invertebrate species with large abundances (n>100),100 individuals were counted and then 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 taxonomic analysis in the laboratory.

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 (2018).

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 lower 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 6 stations. 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 TISSUE CONTAMINANTS 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 also 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 2018-19 monitoring period. Five hauls were conducted at each station in July 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 April and May 2019 (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 (OCSD 2016; Table A-5).

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.

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).

Table A–5 Fish tissue handling and analysis summary during 2018-19.

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.

Table A–6 Parameters measured in fish tissue samples during 2018-19.

	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.

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 2018-19 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

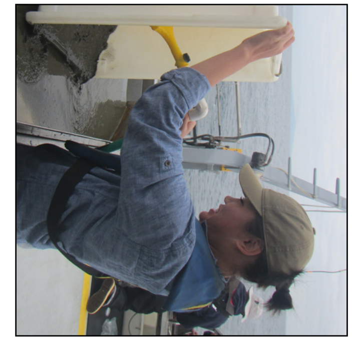

Table B–1 Percent of fecal indicator bacteria by quarter and depth strata for the 2018-19 REC-1 water quality surveys (5 surveys/quarter; 8 stations/survey).

			Total Coliforms				Fecal Coliforms				Enterococci			
Quarter	**Depth Strata (m)**	**n**	**<10**	**10-1,000**	**1,001-10,000 ***	**>10,000 ****	**<10**	**10-200**	**201-400 ***	**>400 ****	**<10**	**10-35**	**36-104 ***	**>104 ****
Summer	1-15	80	67.5%	28.8%	3.8%	0.0%	96.3%	2.5%	1.3%	0.0%	93.8%	3.8%	0.0%	2.5%
	16-30	65	63.1%	32.3%	4.6%	0.0%	96.9%	3.1%	0.0%	0.0%	89.2%	9.2%	1.5%	0.0%
	31-45	20	60.0%	40.0%	0.0%	0.0%	90.0%	10.0%	0.0%	0.0%	90.0%	10.0%	0.0%	0.0%
	46-60	30	66.7%	33.3%	0.0%	0.0%	93.3%	6.7%	0.0%	0.0%	90.0%	10.0%	0.0%	0.0%
	Water Column	**195**	**65.1%**	**31.8%**	**3.1%**	**0.0%**	**95.4%**	**4.1%**	**0.5%**	**0.0%**	**91.3%**	**7.2%**	**0.5%**	**1.0%**
Fall	1-15	79	58.8%	41.3%	0.0%	0.0%	90.0%	10.0%	0.0%	0.0%	90.0%	6.3%	1.3%	2.5%
	16-30	65	56.9%	43.1%	0.0%	0.0%	90.8%	9.2%	0.0%	0.0%	92.3%	3.1%	4.6%	0.0%
	31-45	20	70.0%	30.0%	0.0%	0.0%	90.0%	10.0%	0.0%	0.0%	95.0%	5.0%	0.0%	0.0%
	46-60	30	76.7%	23.3%	0.0%	0.0%	86.7%	13.3%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
	Water Column	**194**	**62.1%**	**37.9%**	**0.0%**	**0.0%**	**89.7%**	**10.3%**	**0.0%**	**0.0%**	**92.8%**	**4.1%**	**2.1%**	**1.0%**
Winter	1-15	80	46.3%	53.8%	0.0%	0.0%	87.5%	12.5%	0.0%	0.0%	86.3%	11.3%	1.3%	1.3%
	16-30	65	49.2%	50.8%	0.0%	0.0%	81.5%	18.5%	0.0%	0.0%	92.3%	7.7%	0.0%	0.0%
	31-45	20	30.0%	70.0%	0.0%	0.0%	55.0%	45.0%	0.0%	0.0%	70.0%	25.0%	5.0%	0.0%
	46-60	30	40.0%	53.3%	6.7%	0.0%	63.3%	30.0%	0.0%	6.7%	73.3%	16.7%	3.3%	6.7%
	Water Column	**195**	**44.6%**	**54.4%**	**1.0%**	**0.0%**	**78.5%**	**20.5%**	**0.0%**	**1.0%**	**84.6%**	**12.3%**	**1.5%**	**1.5%**
Spring	1-15	80	93.7%	6.3%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	87.3%	12.7%	0.0%	0.0%
	16-30	65	61.5%	36.9%	1.5%	0.0%	83.1%	15.4%	0.0%	1.5%	87.7%	7.7%	4.6%	0.0%
	31-45	20	45.0%	50.0%	5.0%	0.0%	60.0%	35.0%	0.0%	5.0%	85.0%	5.0%	10.0%	0.0%
	46-60	30	53.3%	46.7%	0.0%	0.0%	73.3%	26.7%	0.0%	0.0%	83.3%	10.0%	6.7%	0.0%
	Water Column	**195**	**71.6%**	**27.3%**	**1.0%**	**0.0%**	**86.1%**	**12.9%**	**0.0%**	**1.0%**	**86.6%**	**9.8%**	**3.6%**	**0.0%**
Annual	1-15	80	66.5%	32.6%	0.9%	0.0%	93.4%	6.3%	0.3%	0.0%	89.3%	8.5%	0.6%	1.6%
	16-30	65	57.7%	40.8%	1.5%	0.0%	88.1%	11.5%	0.0%	0.4%	90.4%	6.9%	2.7%	0.0%
	31-45	20	51.3%	47.5%	1.3%	0.0%	73.8%	25.0%	0.0%	1.3%	85.0%	11.3%	3.8%	0.0%
	46-60	30	59.2%	39.2%	1.7%	0.0%	79.2%	19.2%	0.0%	1.7%	86.7%	9.2%	2.5%	1.7%
	Water Column	**195**	**60.8%**	**37.9%**	**1.3%**	**0.0%**	**87.4%**	**11.9%**	**0.1%**	**0.5%**	**88.8%**	**8.3%**	**1.9%**	**0.9%**

*Geomean; **Single sample.

Table B–2 Depth-averaged total coliform bacteria (MPN/100 mL) collected in offshore waters and used for comparison with California Ocean Plan Water-Contact (REC-1) Standards, July 2018 through June 2019.

Station	Date					Meets 30-day Geometric Mean of ≤1,000/100 mL	Meets Single Sample Standard of ≤10,000/100 mL	Meets Single Sample Standard of ≤1,000/100 mL *
	7/10/2018	*7/11/2018*	*7/12/2018*	*8/6/2018*	*8/7/2018*			
2103	<10	<10	<10	33	52	YES	YES	YES
2104	<10	<10	10	17	66	YES	YES	YES
2183	10	<10	<10	<10	138	YES	YES	YES
2203	<10	<10	<10	81	156	YES	YES	YES
2223	<10	<10	<10	<10	<10	YES	YES	YES
2303	<10	<10	<10	130	251	YES	YES	YES
2351	<10	<10	<10	1216	512	YES	YES	YES
2403	<10	<10	<10	778	159	YES	YES	YES
	10/16/2018	*10/17/2018*	*10/18/2018*	*11/5/2018*	*11/6/2018*			
2103	<10	15	12	<10	<10	YES	YES	YES
2104	<10	<10	<10	<10	<10	YES	YES	YES
2183	14	22	13	<10	<10	YES	YES	YES
2203	19	11	14	<10	<10	YES	YES	YES
2223	94	13	18	<10	<10	YES	YES	YES
2303	69	11	31	<10	15	YES	YES	YES
2351	113	38	72	<10	<10	YES	YES	YES
2403	316	178	29	<10	<10	YES	YES	YES
	1/23/2019	*1/24/2019*	*2/6/2019*	*2/7/2019*	*2/19/2019*			
2103	16	18	17	21	16	YES	YES	YES
2104	93	61	31	17	62 **	YES	YES	YES **
2183	36	17	40	29	27	YES	YES	YES
2203	<10	<10	60	74	<10	YES	YES	YES
2223	<10	<10	134	40	<10	YES	YES	YES
2303	<10	<10	54	45	<10	YES	YES	YES
2351	<10	<10	127	58	<10	YES	YES	YES
2403	<10	<10	235	38	<10	YES	YES	YES
	4/23/2019	*4/24/2019*	*4/25/2019*	*5/6/2019*	*5/8/2019*			
2103	10	<10	<10	56	54 **	YES	YES	YES **
2104	13	<10	12	21	118 **	YES	YES	YES **
2183	<10	<10	<10	14	39	YES	YES	YES
2203	<10	<10	<10	11	16	YES	YES	YES
2223	<10	<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 (2/19/19, 5/8/19).

Table B–3 Depth-averaged fecal coliform bacteria (MPN/100 mL) collected in offshore waters and used for comparison with California Ocean Plan Water-Contact (REC-1) Standards, July 2018 through June 2019.

Station	Date					Meets 30-day Geometric Mean ≤200/100 mL	Meets single sample standard of ≤400/100 mL
	7/10/2018	*7/11/2018*	*7/12/2018*	*8/6/2018*	*8/7/2018*		
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	11	YES	YES
2351	<10	<10	<10	<10	<10	YES	YES
2403	<10	<10	<10	<10	24	YES	YES
	10/16/2018	*10/17/2018*	*10/18/2018*	*11/5/2018*	*11/6/2018*		
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	18	<10	<10	<10	<10	YES	YES
2351	14	11	<10	<10	<10	YES	YES
2403	28	<10	<10	<10	<10	YES	YES
	1/23/2019	*1/24/2019*	*2/6/2019*	*2/7/2019*	*2/19/2019*		
2103	10	10	<10	<10	<10	YES	YES
2104	35	17	<10	<10	26 *	YES	YES *
2183	17	10	<10	<10	<10	YES	YES
2203	<10	<10	14	<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	11	<10	<10	YES	YES
	4/23/2019	*4/24/2019*	*4/25/2019*	*5/6/2019*	*5/8/2019*		
2103	<10	<10	<10	15	16 *	YES	YES *
2104	10	<10	<10	<10	42 *	YES	YES *
2183	<10	<10	<10	<10	21	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

* Depths combined, meet single sample standard (2/19/19, 5/8/19).

Table B–4 Depth-averaged enterococci bacteria (MPN/100 mL) collected in offshore waters and used for comparison with California Ocean Plan Water-Contact (REC-1) Standards and EPA Primary Recreation Criteria in Federal Waters, July 2018 through June 2019.

Station	Date					Meets COP 30-day Geometric Mean of ≤35/100 mL	Meets COP single sample standard of ≤104/100 mL	Meets EPA single sample standard of ≤501/100 mL *
	7/10/2018	*7/11/2018*	*7/12/2018*	*8/6/2018*	*8/7/2018*			
2103	<10	<10	<10	<10	<10	YES	YES	YES
2104	<10	11	<10	17 **	<10	YES	YES **	YES **
2183	<10	<10	<10	<10	<10	YES	YES	YES
2203	<10	<10	<10	<10	<10	YES	YES	YES
2223	<10	<10	<10	<10	<10	YES	YES	YES
2303	<10	<10	<10	<10	<10	YES	YES	YES
2351	21 **	<10	<10	<10	<10	YES	YES **	YES
2403	<10	<10	<10	<10	<10	YES	YES	YES
	10/16/2018	*10/17/2018*	*10/18/2018*	*11/5/2018*	*11/6/2018*			
2103	<10	<10	<10	<10	10	YES	YES	YES
2104	<10	<10	<10	<10	<10	YES	YES	YES
2183	<10	<10	<10	<10	<10	YES	YES	YES
2203	<10	<10	15	<10	<10	YES	YES	YES
2223	<10	<10	12	<10	<10	YES	YES	YES
2303	20 **	<10	16	14	<10	YES	YES **	YES
2351	<10	<10	<10	10	<10	YES	YES	YES
2403	<10	<10	25 **	<10	<10	YES	YES **	YES
	1/23/2019	*1/24/2019*	*2/6/2019*	*2/7/2019*	*2/19/2019*			
2103	<10	<10	<10	<10	<10	YES	YES	YES
2104	12	<10	<10	<10	17 **	YES	YES **	YES
2183	<10	<10	10	<10	10	YES	YES	YES
2203	<10	13	10	<10	<10	YES	YES	YES
2223	<10	<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	32 **	10	<10	<10	YES	YES **	YES **
	4/23/2019	*4/24/2019*	*4/25/2019*	*5/6/2019*	*5/8/2019*			
2103	<10	10	<10	<10	11	YES	YES	YES
2104	<10	<10	<10	<10	21	YES	YES	YES
2183	<10	10	<10	<10	<10	YES	YES	YES
2203	<10	<10	<10	<10	10	YES	YES	YES
2223	10	<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 area of infrequent use.

** Depths combined, meet single sample standard (7/10/18, 8/6/18, 10/16/18, 10/18/18, 1/24/19, 2/19/19).

Table B–5 Summary of floatable material by station group observed during the 28-station grid water quality surveys, July 2018 through June 2019. 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	0	0	0	0	1	3
Biological Material (kelp)	1	1	0	0	0	0	0	2
Material of Sewage Origin	0	0	0	0	0	0	0	0
Totals	**1**	**3**	**0**	**0**	**0**	**0**	**1**	**5**

Table B–6 Summary of floatable material by station group observed during the REC-1 water quality surveys, July 2018 through June 2019. Total number of station visits = 108.

Surface Observation	Station Group				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	1	0	0	0	1
Biological Material (kelp)	4	1	0	1	6
Material of Sewage Origin	0	0	0	0	0
Totals	**5**	**1**	**0**	**1**	**7**

Table B–7 Summary of Core water quality compliance parameters by quarter and depth strata for 2018-19 (3 surveys/quarter; 28 stations/survey).

Quarter	Depth Strata (m)	Dissolved Oxygen (mg/L)				pH				Light Transmissivity (%)			
		Minimum	Mean	Maximum	Std. Dev.	Minimum	Mean	Maximum	Std. Dev.	Minimum	Mean	Maximum	Std. Dev.
Summer	1-15	5.64	7.86	11.23	0.70	7.96	8.05	8.16	0.05	55.18	84.73	87.73	3.06
	16-30	5.20	8.04	11.40	0.69	7.65	7.98	8.18	0.07	50.51	82.40	87.85	5.86
	31-45	4.24	6.74	8.37	1.14	7.54	7.83	7.98	0.12	74.10	85.35	87.78	1.68
	46-60	3.79	5.79	7.62	1.00	7.47	7.72	7.91	0.12	81.25	86.41	88.63	1.72
	61-75	3.87	5.22	6.99	0.73	7.47	7.65	7.85	0.10	82.13	86.85	88.86	1.85
	Water Column	**3.79**	**7.09**	**11.40**	**1.34**	**7.47**	**7.90**	**8.18**	**0.17**	**50.51**	**84.73**	**88.86**	**3.93**
Fall	1-15	7.05	7.50	8.29	0.31	7.89	7.95	8.01	0.03	71.26	85.53	88.21	3.32
	16-30	7.07	7.58	8.32	0.27	7.82	7.92	7.98	0.03	75.45	85.56	88.22	2.93
	31-45	6.42	7.33	8.12	0.32	7.76	7.87	7.95	0.04	81.58	86.33	88.19	1.19
	46-60	6.19	6.95	7.86	0.42	7.74	7.81	7.91	0.04	81.29	86.70	88.56	1.02
	61-75	5.73	6.55	7.45	0.44	7.69	7.76	7.85	0.03	83.06	87.17	88.68	1.28
	Water Column	**5.73**	**7.30**	**8.32**	**0.48**	**7.69**	**7.89**	**8.01**	**0.07**	**71.26**	**86.04**	**88.68**	**2.55**
Winter	1-15	6.56	7.82	8.50	0.27	7.83	7.95	8.02	0.03	25.44	80.06	86.19	6.54
	16-30	5.30	7.31	8.16	0.51	7.73	7.90	7.98	0.05	66.69	83.66	88.04	2.36
	31-45	4.67	6.49	7.82	0.89	7.62	7.83	7.97	0.10	81.13	85.68	88.89	1.50
	46-60	4.15	5.56	7.52	0.81	7.56	7.72	7.94	0.09	82.09	87.17	89.33	1.86
	61-75	3.76	4.93	6.35	0.71	7.52	7.65	7.80	0.08	79.21	87.23	89.40	2.52
	Water Column	**3.76**	**6.78**	**8.50**	**1.19**	**7.52**	**7.85**	**8.02**	**0.13**	**25.44**	**83.89**	**89.40**	**4.86**
Spring	1-15	4.05	8.15	9.89	1.00	7.59	7.99	8.26	0.13	57.92	76.56	85.71	4.95
	16-30	3.89	5.63	8.71	1.05	7.49	7.72	8.03	0.13	69.51	81.18	87.50	3.63
	31-45	3.72	4.48	6.40	0.45	7.45	7.60	7.82	0.08	70.99	84.77	88.38	2.40
	46-60	3.37	4.13	5.08	0.33	7.41	7.56	7.69	0.07	80.97	86.14	88.48	1.51
	61-75	3.32	3.88	4.72	0.27	7.39	7.52	7.66	0.06	74.97	86.57	89.05	1.72
	Water Column	**3.32**	**5.75**	**9.89**	**1.85**	**7.39**	**7.73**	**8.26**	**0.21**	**57.92**	**81.80**	**89.05**	**5.26**
Annual	1-15	4.05	7.83	11.23	0.68	7.59	7.98	8.26	0.08	25.44	81.72	88.21	5.93
	16-30	3.89	7.14	11.40	1.14	7.49	7.88	8.18	0.12	50.51	83.20	88.22	4.25
	31-45	3.72	6.26	8.37	1.32	7.45	7.78	7.98	0.14	70.99	85.53	88.89	1.84
	46-60	3.37	5.61	7.86	1.22	7.41	7.70	7.94	0.13	80.97	86.61	89.33	1.61
	61-75	3.32	5.13	7.45	1.10	7.39	7.65	7.85	0.11	74.97	86.96	89.40	1.92
	Water Column	**3.32**	**6.73**	**11.40**	**1.44**	**7.39**	**7.84**	**8.26**	**0.17**	**25.44**	**84.11**	**89.40**	**4.55**

Table B–8 Summary of Core water quality ammonium (mg/L) receiving water criteria by quarter and depth strata for 2018-19 (3 surveys/quarter; 22 stations/survey).

Quarter	Depth Strata (m)	n	<MDL *	MDL-3.9	4-5.9 **	≥6 ***
Summer	1-15	180	83.3%	16.7%	0.0%	0.0%
	16-30	169	77.5%	22.5%	0.0%	0.0%
	31-45	55	76.4%	23.6%	0.0%	0.0%
	46-60	96	71.9%	28.1%	0.0%	0.0%
	Water Column	**500**	**78.4%**	**21.6%**	**0.0%**	**0.0%**
Fall	1-15	183	76.0%	24.0%	0.0%	0.0%
	16-30	153	80.4%	19.6%	0.0%	0.0%
	31-45	60	65.0%	35.0%	0.0%	0.0%
	46-60	106	54.7%	45.3%	0.0%	0.0%
	Water Column	**502**	**71.5%**	**28.5%**	**0.0%**	**0.0%**
Winter	1-15	138	86.2%	13.8%	0.0%	0.0%
	16-30	142	77.5%	22.5%	0.0%	0.0%
	31-45	52	80.8%	19.2%	0.0%	0.0%
	46-60	91	73.6%	26.4%	0.0%	0.0%
	Water Column	**423**	**79.9%**	**20.1%**	**0.0%**	**0.0%**
Spring	1-15	150	100.0%	0.0%	0.0%	0.0%
	16-30	134	92.5%	7.5%	0.0%	0.0%
	31-45	52	69.2%	30.8%	0.0%	0.0%
	46-60	78	85.9%	14.1%	0.0%	0.0%
	Water Column	**414**	**91.1%**	**8.9%**	**0.0%**	**0.0%**
Annual	1-15	651	85.7%	14.3%	0.0%	0.0%
	16-30	598	81.6%	18.4%	0.0%	0.0%
	31-45	219	72.6%	27.4%	0.0%	0.0%
	46-60	371	70.4%	29.6%	0.0%	0.0%
	Water Column	**1839**	**79.7%**	**20.3%**	**0.0%**	**0.0%**

* MDL range 0.014-0.04; ** COP chronic crteria; *** COP acute criteria.

Table B–9 Species richness and abundance values of the major taxonomic groups collected in the Middle Shelf Zone 2 stratum (51-90 m) for the 2018-19 infauna surveys. Values represent the mean and range (in parentheses).

Quarter	Parameter	Area	Annelida	Arthropoda	Echinodermata	Misc. Phyla	Mollusca
Summer	Number of Species	Within-ZID	52 (43-62)	19 (13-23)	5 (2-9)	6 (3-13)	7 (4-12)
		Non-ZID	52 (39-63)	18 (9-26)	5 (2-8)	6 (3-12)	9 (5-15)
	Abundance	Within-ZID	223 (148-313)	52 (41-66)	12 (5-25)	8 (3-22)	19 (6-37)
		Non-ZID	258 (158-394)	58 (30-133)	14 (6-28)	14 (3-26)	21 (10-32)
Winter	Number of Species	Within-ZID	53 (52-55)	16 (10-20)	4 (3-6)	11 (9-14)	6 (1-10)
		Non-ZID	57 (31-73)	16 (8-27)	3 (0-6)	9 (3-13)	7 (2-13)
	Abundance	Within-ZID	309 (187-407)	42 (31-55)	6 (3-10)	17 (11-24)	12 (1-18)
		Non-ZID	377 (171-638)	51 (15-107)	7 (0-19)	15 (7-32)	13 (3-22)

Table B–10 Abundance and species richness of epibenthic macroinvertebrates by station and species for the Summer 2018 and Winter 2019 trawl surveys.

Station	T23		T22		T1		T12		T17		T11			
Nominal Depth	58		60		55		57		60		60			
Quarter	S	W	S	W	S	W	S	W	S	W	S	W	Total	%
Ophiura luetkenii	18	64	12	46		482	980	3982		8	1484	969	8045	59.1
Lytechinus pictus	645	1194	405	196	86	64	67	14	129		8	1	2809	20.6
Sicyonia penicillata		12		18	1	10		10		816		36	903	6.6
Thesea sp B	21	60	16	42	67	176	27	94	5	34	31	78	651	4.8
Hamatoscalpellum californicum	10	12	2	4	11	30	5	126		24	49	53	326	2.4
Pleuroncodes planipes				4		322							326	2.4
Sicyonia ingentis		4		20	17	16	48	12	42	12	30		201	1.5
Astropecten californicus	7	24	3	28	12	50	19	36	10		1	4	194	1.4
Luidia foliolata	2	2	2	4	3	4	6	4		2	2	1	32	0.2
Ophiothrix spiculata				4	7	10	1				1	9	32	0.2
Luidia asthenosoma	3	10	2	2			1				1	2	21	0.2
Heterogorgia tortuosa	1		1		1			6			1		10	0.1
Pleurobranchaea californica	1		4						1		4		10	0.1
Octopus rubescens		2	2	2	1		1						8	0.1
Strongylocentrotus fragilis			5								3		8	0.1
Acanthoptilum sp						4			1				5	<0.1
Pyromaia tuberculata				2								1	3	<0.1
Rossia pacifica		2	1										3	<0.1
Apostichopus californicus					1						1		2	<0.1
Coryrhynchus lobifrons												2	2	<0.1
Doryteuthis opalescens		2											2	<0.1
Flabellinopsis iodinea											1	1	2	<0.1
Lamellaria diegoensis												2	2	<0.1
Megasurcula carpenteriana										2			2	<0.1
Neverita draconis		2											2	<0.1
Paguristes bakeri						2							2	<0.1
Philine auriformis			1								1		2	<0.1
Simnia sp		2											2	<0.1
Baptodoris mimetica												1	1	<0.1
Calliostoma turbinum											1		1	<0.1
Ericerodes hemphillii					1								1	<0.1
Muricidae												1	1	<0.1
Orthopagurus minimus												1	1	<0.1
Stylasterias forreri												1	1	<0.1
Tritonia festiva											1		1	<0.1
Total Abundance	**708**	**1392**	**456**	**372**	**208**	**1170**	**1155**	**4284**	**188**	**898**	**1620**	**1163**	**13614**	**100**
Total No. of Species	**9**	**14**	**13**	**13**	**12**	**12**	**10**	**9**	**6**	**7**	**17**	**17**	**35**	

Table B–11 Biomass (kg) of epibenthic macroinvertebrates by station and species for the Summer 2018 and Winter 2019 trawl surveys.

Station	T23		T22		T1		T12		T17		T11			
Nominal Depth	58		60		55		57		60		60			
Quarter	S	W	S	W	S	W	S	W	S	W	S	W	Total	%
Sicyonia penicillata		0.154		0.270	0.019	0.112		0.116		10.620		0.693	11.984	33.8
Ophiura luetkenii	0.010	0.040	0.004	0.028		0.650	1.500	5.296		0.002	1.900	0.998	10.428	29.4
Lytechinus pictus	1.310	2.006	0.830	0.360	0.205	0.098	0.153	0.022	0.273		0.020	0.001	5.278	14.9
Pleuroncodes planipes				0.050		3.696							3.746	10.6
Apostichopus californicus					0.545						0.903		1.448	4.1
Thesea sp B	0.015	0.070	0.011	0.032	0.095	0.210	0.025	0.114	0.003	0.030	0.029	0.060	0.694	2.0
Sicyonia ingentis		0.002		0.018	0.053	0.028	0.163	0.002	0.263	0.008	0.103		0.640	1.8
Astropecten californicus	0.010	0.030	0.010	0.066	0.026	0.162	0.105	0.096	0.039		0.002	0.004	0.550	1.6
Octopus rubescens		0.080	0.020	0.110	0.006		0.009						0.225	0.6
Pleurobranchaea californica	0.011		0.028						0.020		0.140		0.199	0.6
Luidia foliolata	0.002	0.002	0.001	0.002	0.025	0.002	0.012	0.002		0.002	0.017	0.001	0.068	0.2
Luidia asthenosoma	0.011	0.014	0.012	0.002			0.011				0.002	0.001	0.053	0.1
Hamatoscalpellum californicum	0.003	0.002	0.001	0.002	0.006	0.002	0.001	0.008		0.002	0.009	0.002	0.038	0.1
Strongylocentrotus fragilis			0.011								0.014		0.025	0.1
Ophiothrix spiculata				0.002	0.007	0.006	0.001				0.001	0.001	0.018	0.1
Rossia pacifica		0.002	0.014										0.016	<0.1
Megasurcula carpenteriana										0.008			0.008	<0.1
Heterogorgia tortuosa	0.001		0.001		0.001			0.002			0.001		0.006	<0.1
Muricidae												0.005	0.005	<0.1
Paguristes bakeri						0.004							0.004	<0.1
Acanthoptilum sp						0.002			0.001				0.003	<0.1
Pyromaia tuberculata				0.002								0.001	0.003	<0.1
Doryteuthis opalescens		0.002											0.002	<0.1
Flabellinopsis iodinea											0.001	0.001	0.002	<0.1
Neverita draconis		0.002											0.002	<0.1
Philine auriformis			0.001								0.001		0.002	<0.1
Simnia sp		0.002											0.002	<0.1
Stylasterias forreri												0.002	0.002	<0.1
Baptodoris mimetica												0.001	0.001	<0.1
Calliostoma turbinum											0.001		0.001	<0.1
Coryrhynchus lobifrons												0.001	0.001	<0.1
Ericerodes hemphillii					0.001								0.001	<0.1
Lamellaria diegoensis												0.001	0.001	<0.1
Orthopagurus minimus												0.001	0.001	<0.1
Tritonia festiva											0.001		0.001	<0.1
Total	**1.373**	**2.408**	**0.944**	**0.944**	**0.989**	**4.972**	**1.980**	**5.658**	**0.599**	**10.672**	**3.145**	**1.774**	**35.458**	**100**

Table B–12 Abundance and species richness of demersal fishes by station and species for the Summer 2018 and Winter 2019 trawl surveys.

Station	T23		T22		T1		T12		T17		T11			
Nominal Depth	58		60		55		57		60		60			
Quarter	S	W	S	W	S	W	S	W	S	W	S	W	Total	%
Sebastes semicinctus	2	4	1	7	2		9	3	6	15		2189	2238	27.8
Citharichthys sordidus	202	232	248	210	208	132	94	141	59	134	105	129	1894	23.5
Zaniolepis latipinnis	101	57	13	33	18	94	81	127	35	410	19	131	1119	13.9
Icelinus quadriseriatus	8	26	47	80	159	87	149	4	55	9	151	8	783	9.7
Symphurus atricaudus	18	67	18	42	26	61	10	53	7	124	6	129	561	7.0
Zalembius rosaceus	18	30	15	130		34	4	18	4	62	4	56	375	4.7
Parophrys vetulus	5	15	5	3	1	20	2	51	3	14	10	31	160	2.0
Chitonotus pugetensis	9		22		26	9	41	7	24		11	1	150	1.9
Synodus lucioceps	15	15	9	2	18	40		17	6	3	18	4	147	1.8
Citharichthys xanthostigma	5	10	1	1	42	36	20	1	18		10		144	1.8
Microstomus pacificus	4	19	14	18	1	1	6	19	15	16	4	11	128	1.6
Hippoglossina stomata	2	39	5	22	3	23	1	16			1	9	121	1.5
Pleuronichthys verticalis	4	12	4	7		4	3	12	3	13		19	81	1.0
Porichthys notatus		7		2		1	1	9	2	20		1	43	0.5
Sebastes saxicola									25				25	0.3
Scorpaena guttata		1				2		3		2	1	8	17	0.2
Odontopyxis trispinosa	1		1			1	2	1		1		3	10	0.1
Genyonemus lineatus			5			3		1					9	0.1
Lycodes pacificus								1		7			8	0.1
Zaniolepis frenata		3	2	2						1			8	0.1
Sebastes sp					1		3						4	<0.1
Argentina sialis										3			3	<0.1
Sebastes hopkinsi												3	3	<0.1
Citharichthys stigmaeus					1						1		2	<0.1
Lyopsetta exilis		2											2	<0.1
Paralichthys californicus						1				1			2	<0.1
Sebastes miniatus						1	1						2	<0.1
Xystreurys liolepis			1									1	2	<0.1
Ophiodon elongatus	1												1	<0.1
Paralabrax clathratus							1						1	<0.1
Podothecus accipenserinus												1	1	<0.1
Porichthys myriaster		1											1	<0.1
Raja inornata												1	1	<0.1
Scomber japonicus				1									1	<0.1
Sebastes dallii				1									1	<0.1
Sebastes jordani												1	1	<0.1
Squatina californica								1					1	<0.1
Total Abundance	**395**	**540**	**411**	**561**	**506**	**550**	**428**	**485**	**262**	**835**	**341**	**2736**	**8050**	**100**
Total No. of Species	**15**	**17**	**17**	**16**	**13**	**18**	**17**	**19**	**14**	**17**	**13**	**20**	**37**	

Table B–13 Biomass (kg) of demersal fishes by station and species for the Summer 2018 and Winter 2019 trawl surveys.

Station	T23		T22		T1		T12		T17		T11			
Nominal Depth	**58**		**60**		**55**		**57**		**60**		**60**			
Quarter	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**S**	**W**	**Total**	**%**
Citharichthys sordidus	17.720	10.910	5.596	3.210	1.057	3.378	0.418	2.810	0.778	1.333	1.583	6.840	55.633	30.0
Sebastes semicinctus	0.003	0.118	0.002	0.053	0.005		0.016	0.014	0.007	0.150		38.597	38.965	21.0
Zaniolepis latipinnis	2.073	1.048	0.075	0.598	0.138	1.977	1.348	0.900	0.288	3.095	0.316	2.384	14.240	7.7
Parophrys vetulus	0.548	1.500	0.898	0.358	0.062	1.850	0.228	3.300	0.098	0.688	1.020	1.698	12.248	6.6
Squatina californica								9.500					9.500	5.1
Citharichthys xanthostigma	0.598	0.694	0.065	0.029	2.350	0.989	1.328	0.160	1.648		0.903		8.764	4.7
Symphurus atricaudus	0.298	0.948	0.298	0.613	0.441	0.970	0.188	0.868	0.143	1.748	0.098	1.924	8.537	4.6
Synodus lucioceps	1.098	0.673	0.673	0.098	1.110	0.783		0.455	0.048	0.096	0.370	0.204	5.608	3.0
Pleuronichthys verticalis	0.648	0.574	0.393	0.318		0.240	0.428	0.850	0.128	0.530		0.853	4.962	2.7
Hippoglossina stomata	0.088	1.348	0.318	0.948	0.027	0.591	0.008	0.460			0.063	0.669	4.520	2.4
Zalembius rosaceus	0.428	0.268	0.648	0.673		0.822	0.173	0.033	0.188	0.228	0.160	0.302	3.923	2.1
Microstomus pacificus	0.238	0.518	0.948	0.594	0.083	0.052	0.048	0.498	0.173	0.290	0.020	0.262	3.724	2.0
Icelinus quadriseriatus	0.048	0.096	0.203	0.298	0.582	0.284	0.568	0.010	0.218	0.007	0.540	0.016	2.870	1.5
Scorpaena guttata		0.088				0.120		0.750		0.180	0.280	1.234	2.652	1.4
Paralichthys californicus						1.810				0.798			2.608	1.4
Chitonotus pugetensis	0.056		0.253		0.236	0.043	0.418	0.060	0.248		0.089	0.007	1.410	0.8
Porichthys notatus		0.248		0.103		0.110	0.013	0.085	0.038	0.598		0.027	1.222	0.7
Genyonemus lineatus			0.608			0.276		0.120					1.004	0.5
Raja inornata												0.750	0.750	0.4
Xystreurys liolepis			0.500									0.014	0.514	0.3
Sebastes miniatus						0.290	0.016						0.306	0.2
Porichthys myriaster		0.290											0.290	0.2
Lycodes pacificus								0.045		0.223			0.268	0.1
Zaniolepis frenata		0.088	0.098	0.012									0.205	0.1
Lyopsetta exilis		0.103											0.103	0.1
Sebastes saxicola									0.088				0.088	<0.1
Scomber japonicus				0.073									0.073	<0.1
Sebastes hopkinsi												0.048	0.048	<0.1
Ophiodon elongatus	0.040												0.040	<0.1
Argentina sialis										0.024			0.024	<0.1
Odontopyxis trispinosa	0.003		0.002			0.001	0.004	0.002		0.001		0.005	0.018	<0.1
Sebastes jordani												0.011	0.011	<0.1
Sebastes sp					0.004		0.007						0.011	<0.1
Citharichthys stigmaeus					0.003						0.008		0.011	<0.1
Podothecus accipenserinus												0.009	0.009	<0.1
Sebastes dallii				0.008									0.008	<0.1
Paralabrax clathratus							0.002						0.002	<0.1
Total Biomass	**23.887**	**19.512**	**11.578**	**7.986**	**6.098**	**14.586**	**5.211**	**20.920**	**4.091**	**9.996**	**5.450**	**55.854**	**185.169**	**100**

Table B–14 Summary statistics of OCSD's legacy nearshore stations for total coliform, fecal coliform, and enterococci bacteria (CFU/100 mL) by station and quarter during 2018-19.

	Summer				Fall				Winter				Spring				Annual			
Station	**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	19	170	2.04	<17	18	67	1.7	<17	29	>5000	6.41	<17	16	120	1.85	<17	20	>5000	2.91
33N	<17	15	33	1.43	<17	15	33	1.31	<17	35	>5500	6.52	<17	18	400	2.57	<17	19	>5500	3.01
27N	<17	15	33	1.34	<17	16	33	1.41	<17	34	>4300	6.33	<17	16	50	1.45	<17	19	>4300	2.72
21N	<17	17	67	1.7	<17	16	67	1.65	<17	31	3400	5.62	<17	14	17	1.13	<17	18	3400	2.62
15N	<17	20	100	1.84	<17	18	350	2.48	<17	46	3400	5.61	<17	14	33	1.31	<17	22	3400	2.99
12N	<17	16	83	1.67	<17	19	50	1.75	<17	48	1800	4.8	<17	18	33	1.46	<17	22	1800	2.65
9N	<17	21	180	1.92	<17	18	83	1.69	<17	67	>20000	7.75	<17	15	33	1.39	<17	25	>20000	3.41
6N	<17	32	580	2.88	<17	28	470	2.61	<17	104	>20000	6.93	<17	22	1100	2.71	<17	38	>20000	4.12
3N	<17	39	1000	3.81	<17	42	5900	4.76	<17	92	>20000	8.31	<17	26	500	2.65	<17	44	>20000	4.95
0	<17	20	330	2.46	<17	28	1600	3.4	<17	229	>20000	9.08	<17	22	1200	2.7	<17	40	>20000	5.52
3S	<17	15	33	1.31	<17	19	33	1.6	<17	88	>2400	5.44	<17	21	67	1.84	<17	27	>2400	3.18
6S	<17	15	33	1.31	<17	17	83	1.84	<17	85	1900	3.9	<17	14	17	1.13	<17	23	1900	2.89
9S	<17	13	<17	1	<17	19	83	1.85	<17	49	800	3.67	<17	15	67	1.58	<17	20	800	2.46
15S	<17	13	17	1.11	<17	20	330	2.5	<17	43	600	3.02	<17	15	33	1.31	<17	20	600	2.34
21S	<17	13	17	1.11	<17	14	17	1.13	<17	30	200	2.83	<17	26	67	1.87	<17	19	200	2.02
27S	<17	13	<17	1	<17	14	17	1.13	<17	32	500	2.79	<17	14	50	1.46	<17	17	500	1.93
29S	<17	22	>100	2.14	<17	30	11000	5.91	<17	61	>1400	5.42	<17	16	33	1.42	<17	28	11000	3.91
39S	<17	14	>17	1.25	<17	16	100	1.76	<17	50	>20000	9.22	<17	15	33	1.43	<17	20	>20000	3.48
All	**<17**	**18**	**1000**	**0.73**	**<17**	**20**	**11000**	**1.27**	**<17**	**64**	**>20000**	**2.03**	**<17**	**18**	**1200**	**0.55**	**<17**	**25**	**>20000**	**0.95**
Fecal Coliforms																				
39N	<17	17	100	1.91	<17	16	83	1.67	<17	16	200	2.14	<17	17	170	2.11	<17	16	200	1.93
33N	<17	14	17	1.13	<17	13	17	1.08	<17	19	130	2.22	<17	17	400	2.59	<17	16	400	1.87
27N	<17	14	17	1.13	<17	13	17	1.08	<17	19	300	2.49	<17	14	67	1.58	<17	15	300	1.69
21N	<17	14	17	1.16	<17	16	67	1.65	<17	17	150	2.02	<17	14	33	1.31	<17	15	150	1.57
15N	<17	18	67	1.82	<17	17	200	2.13	<17	17	150	2.02	<17	13	17	1.08	<17	16	200	1.81
12N	<17	17	130	1.95	<17	17	50	1.72	<17	22	83	2.09	<17	15	33	1.31	<17	18	130	1.79
9N	<17	19	330	2.1	<17	15	50	1.56	<17	37	>20000	5.64	<17	15	33	1.29	<17	20	>20000	2.75
6N	<17	29	520	2.93	<17	21	100	1.92	6	60	>20000	6.3	<17	19	860	2.4	6	29	>20000	3.55
3N	<17	33	1200	3.5	<17	32	3200	4.15	<17	40	>20000	5.52	<17	23	600	2.45	<17	32	>20000	3.85
0	<17	18	300	2.3	<17	21	230	2.44	<17	67	5600	5.47	<17	20	1000	2.43	<17	26	5600	3.42
3S	<17	15	33	1.31	<17	18	50	1.77	<17	31	200	3.11	<17	15	67	1.58	<17	19	200	2.09
6S	<17	13	17	1.11	<17	16	67	1.65	<17	29	150	2.52	<17	14	33	1.31	<17	17	150	1.85
9S	<17	13	<17	1	<17	15	33	1.42	<17	22	100	2.13	<17	13	<17	1	<17	15	100	1.59
15S	<17	14	33	1.31	<17	17	150	1.96	<17	27	120	2.3	<17	13	17	1.08	<17	17	150	1.84
21S	<17	15	83	1.68	<17	13	<17	1	<17	21	83	1.79	<17	18	50	1.66	<17	16	83	1.64
27S	<17	13	<17	1	<17	13	17	1.11	<17	17	50	1.65	<17	14	17	1.13	<17	14	50	1.32
29S	<17	14	17	1.13	<17	26	9500	5.87	<17	28	1000	3.92	<17	14	17	1.13	<17	19	9500	3.18
39S	<17	13	<17	1	<17	13	17	1.08	<17	32	>20000	7.94	<17	13	<17	1	<17	16	>20000	2.95
All	**<17**	**17**	**1200**	**0.72**	**<17**	**17**	**9500**	**1.22**	**6**	**29**	**>20000**	**1.91**	**<17**	**16**	**1000**	**0.56**	**6**	**19**	**>20000**	**0.79**

Table B–14 continues.

Table B–14 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	5	16	2.24	<2	5	130	3.99	<2	4	280	4.28	<2	2	8	1.87	<2	4	280	3.16
33N	<2	4	14	2.33	<2	5	70	3.26	<2	9	350	4.89	<2	5	24	2.8	<2	5	350	3.29
27N	<2	4	10	2.29	<2	3	20	2.26	<2	10	>400	6.82	<2	3	10	2.03	<2	4	>400	3.57
21N	<2	3	14	1.93	<2	5	96	2.98	<2	8	256	5.35	<2	3	12	2.04	<2	4	256	3.12
15N	<2	5	14	1.86	<2	5	42	3.03	<2	7	294	5.26	<2	2	6	1.67	<2	4	294	3.09
12N	<2	4	136	3.51	<2	5	36	3.21	<2	8	144	4.44	<2	4	16	2.33	<2	5	144	3.35
9N	<2	7	74	2.7	<2	5	58	3.15	<2	10	>400	6.1	<2	6	40	2.73	<2	6	>400	3.61
6N	<2	11	176	3.77	<2	6	78	3.7	<2	14	>400	5.48	<2	5	256	3.6	<2	8	>400	4.28
3N	<2	10	230	4.33	<2	14	>400	4.56	<2	16	>400	6.03	<2	8	128	4.02	<2	12	>400	4.7
0	<2	4	22	2.41	<2	7	136	4.53	2	24	>400	5.53	<2	4	>400	3.77	<2	7	>400	4.74
3S	<2	2	6	1.65	<2	5	42	3.29	<2	20	>400	6.68	<2	3	34	2.89	<2	5	>400	4.62
6S	<2	3	10	1.98	<2	4	38	3.52	<2	18	>400	4.51	<2	2	24	2.44	<2	5	>400	3.94
9S	<2	2	8	1.69	<2	5	42	3.14	<2	10	164	4.57	<2	2	16	1.9	<2	4	164	3.34
15S	<2	2	2	1.16	<2	3	138	3.58	<2	7	72	4.7	<2	2	8	1.71	<2	3	138	3.1
21S	<2	2	4	1.55	<2	2	12	2.18	<2	9	184	6	<2	3	8	1.83	<2	3	184	3.32
27S	<2	2	8	1.67	<2	2	24	2.18	<2	5	118	4.7	<2	2	8	1.81	<2	3	118	2.66
29S	2	5	34	2.71	<2	6	66	3.63	2	13	>400	7.81	<2	8	28	2.23	<2	8	>400	4.02
39S	<2	2	12	1.93	<2	3	40	3.27	<2	7	>400	5.89	<2	2	6	1.47	<2	3	>400	3.32
All	**<2**	**4**	**230**	**0.83**	**<2**	**5**	**>400**	**0.68**	**<2**	**11**	**>400**	**0.96**	**<2**	**4**	**>400**	**0.76**	**<2**	**5**	**>400**	**0.62**

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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 tissue contaminant concentrations (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 referred to as the Summer (July–September), Fall (October–December), Winter (January–March), and Spring (April–June) quarters, 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 2018-19 Core OMP.

WATER QUALITY NARRATIVE

OCSD's Laboratory, Monitoring, and Compliance (LMC) staff collected 650, 654, 735, and 654 quarterly ammonium samples between July 1, 2018 and June 30, 2019. Twelve surface seawater samples were also collected at a control site (Station 2106) in each quarter. All samples were iced upon collection. Ammonium samples were preserved with 1:1 sulfuric acid upon receipt by the

LMC laboratory staff, and then 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 of the Summer, Fall, and Winter quarters of the 2018-19 monitoring period. In the 2019 Spring quarter, 174 samples were collected. 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 salicylate and dichloroisocyanuric 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.

For each batch, a blank and a spike in a seawater control were analyzed every 20 or fewer samples. In addition, a matrix spike and matrix spike replicate were analyzed every 10 or fewer samples. An external reference sample was analyzed once each month. 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 Spring quarter

Table C–1 Method detection limits (MDLs) and reporting limits (RLs), July 2018–June 2019.

Receiving waters					
Parameter	**MDL (MPN/100mL)**	**RL (MPN/100mL)**	**Parameter**	**MDL (mg/L)**	**RL (mg/L)**
Total coliform	10	10	Ammonium (effective to 12/17/2018)	0.014 *	0.040
E. coli	10	10	Ammonium (effective on 12/18/2018)	0.040 *	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	0.61	1.00	Endosulfan-alpha	0.78	1.00
2,4'-DDE	0.62	1.00	Endosulfan-beta	0.75	1.00
2,4'-DDT	0.71	1.00	Endosulfan-sulfate	1.01	2.00
4,4'-DDD	1.14	2.00	Endrin	0.61	1.00
4,4'-DDE	0.68	1.00	*gamma*-BHC	0.67	1.00
4,4'-DDT	0.56	1.00	Heptachlor	2.64	5.00
4,4'-DDMU	0.84	1.00	Heptachlor epoxide	0.80	1.00
Aldrin	1.97	2.00	Hexachlorobenzene	0.80	1.00
cis-Chlordane	0.70	1.00	Mirex	0.43	1.00
trans-Chlordane	0.76	1.00	*trans*-Nonachlor	0.82	1.00
Dieldrin	0.48	1.00			
PCB Congeners					
PCB 18	0.19	0.50	PCB 126	0.53	1.00
PCB 28	0.43	0.50	PCB 128	0.61	1.00
PCB 37	0.47	0.50	PCB 138	0.71	1.00
PCB 44	0.47	0.50	PCB 149	0.60	1.00
PCB 49	0.61	1.00	PCB 151	0.35	0.50
PCB 52	0.51	1.00	PCB 153/168	0.75	1.00
PCB 66	0.62	1.00	PCB 156	0.67	1.00
PCB 70	0.74	1.00	PCB 157	0.70	1.00
PCB 74	0.61	1.00	PCB 167	0.55	1.00
PCB 77	0.52	1.00	PCB 169	0.28	0.50
PCB 81	0.39	0.50	PCB 170	0.36	0.50
PCB 87	0.43	0.50	PCB 177	0.61	1.00
PCB 99	0.41	0.50	PCB 180	0.38	0.50
PCB 101	0.47	0.50	PCB 183	0.57	1.00
PCB 105	0.58	1.00	PCB 187	0.55	1.00
PCB 110	0.58	1.00	PCB 189	0.34	0.50
PCB 114	0.49	0.50	PCB 194	0.29	0.50
PCB 118	0.76	1.00	PCB 201	0.58	1.00
PCB 119	0.32	0.50	PCB 206	0.36	0.50
PCB 123	0.43	0.50			

Table C–1 continues.

Table C–1 continued.

Parameter	MDL (ng/g dry)	RL (ng/g dry)	Parameter	MDL (ng/g dry)	RL (ng/g dry)
			PAH Compounds		
1,6,7-Trimethylnaphthalene	0.87	1.00	Benzo[g,h,i]perylene	2.34	5.00
1-Methylnaphthalene	1.15	2.00	Benzo[k]fluoranthene	1.07	2.00
1-Methylphenanthrene	1.09	2.00	Biphenyl	1.22	2.00
2,3,6-Trimethylnaphthalene	1.03	2.00	Chrysene	1.09	2.00
2,6-Dimethylnaphthalene	1.01	2.00	Dibenz[a,h]anthracene	2.96	5.00
2-Methylnaphthalene	1.64	2.00	Dibenzothiophene	0.69	1.00
Acenaphthene	0.70	1.00	Fluoranthene	0.98	1.00
Acenaphthylene	0.79	1.00	Fluorene	1.26	2.00
Anthracene	0.83	1.00	Indeno[1,2,3-c,d]pyrene	2.19	5.00
Benz[a]anthracene	1.07	2.00	Naphthalene	2.80	5.00
Benzo[a]pyrene	0.98	1.00	Perylene	1.33	2.00
Benzo[b]fluoranthene	0.95	1.00	Phenanthrene	0.87	1.00
Benzo[e]pyrene	1.20	2.00	Pyrene	1.27	2.00

Parameter	MDL (µg/kg dry)	RL (µg/kg dry)	Parameter	MDL (µg/kg dry)	RL (µg/kg dry)
			Metals		
Antimony	0.116	0.200	Lead	0.040	0.100
Arsenic	0.054	0.100	Mercury	0.038	0.040
Barium	0.151	0.200	Nickel	0.114	0.200
Beryllium	0.030	0.100	Selenium	0.481	0.500
Cadmium	0.089	0.100	Silver	0.139	0.200
Chromium	0.058	0.100	Zinc	0.862	1.500
Copper	0.138	0.200			

Parameter	MDL (mg/kg dry)	RL (mg/kg dry)	Parameter	MDL (%)	RL (%)
			Miscellaneous Parameters		
Dissolved Sulfides	1.03	1.03	Total Organic Carbon	0.02	0.10
Total Nitrogen (Summer)	0.52	65.00	Grain Size	0.01	0.01
Total Nitrogen (Winter)	0.49	120.00			
Total Phosphorus (Summer)	0.36	7.90			
Total Phosphorus (Winter)	0.18	3.80			

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	1.22	2.00	*cis*-Chlordane	1.40	2.00
2,4'-DDE	1.41	2.00	*trans*-Chlordane	0.94	1.00
2,4'-DDT	1.58	2.00	Oxychlordane	2.64	5.00
4,4'-DDD	2.16	5.00	Heptachlor	2.25	5.00
4,4'-DDE	1.12	2.00	Heptachlor epoxide	1.26	2.00
4,4'-DDT	1.20	2.00	*cis*-Nonachlor	1.21	2.00
4,4'-DDMU	1.28	2.00	*trans*-Nonachlor	1.13	2.00
Dieldrin	2.41	5.00			
			PCB Congeners		
PCB 18	1.89	1.89	PCB 126	0.91	1.00
PCB 28	1.33	1.33	PCB 128	1.07	1.07
PCB 37	1.64	1.64	PCB 138	0.79	1.00
PCB 44	1.19	1.19	PCB 149	0.89	1.00
PCB 49	0.62	1.00	PCB 151	0.93	1.00
PCB 52	0.69	1.00	PCB 153/168	1.46	1.46
PCB 66	0.85	1.00	PCB 156	0.72	1.00
PCB 70	1.35	1.35	PCB 157	0.75	1.00
PCB 74	2.06	2.06	PCB 167	0.70	1.00
PCB 77	1.06	1.06	PCB 169	0.69	1.00
PCB 81	0.70	1.00	PCB 170	0.70	1.00
PCB 87	0.78	1.00	PCB 177	1.12	1.12
PCB 99	0.61	1.00	PCB 180	1.13	1.13
PCB 101	1.45	1.45	PCB 183	0.66	1.00
PCB 105	1.17	1.17	PCB 187	0.59	1.00
PCB 110	0.92	1.00	PCB 189	0.94	1.00
PCB 114	0.72	1.00	PCB 194	0.71	1.00
PCB 118	0.76	1.00	PCB 201	0.86	1.00
PCB 119	0.70	1.00	PCB 206	0.57	1.00
PCB 123	1.12	1.12			

Parameter	MDL (µg/kg wet)	RL (µg/kg wet)	Parameter	MDL (µg/kg wet)	RL (µg/kg wet)
			Metals		
Arsenic	0.054	0.100	Mercury	0.008	0.020
Selenium	0.481	0.500			

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

(Table C-2). This exception was found to be caused by analyst error; a repeat analysis met the QA/QC criteria.

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, Standard Methods 9222B and 9222D were used, respectively. 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. At least one duplicate sample was analyzed in each sample batch; additional duplicates were analyzed based on the number of samples in the batch. At a minimum, duplicate analyses were performed on 10% of samples per sample batch. All equipment, reagents, and dilution waters 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

Table C–2 Water quality QA/QC summary, July 2018-June 2019.

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 *
			Blank	38	1	38	100
			Blank Spike	38	1	38	100
Summer	Ammonium	650 (8)	Matrix Spike	69	1	69	100
			Matrix Spike Dup	69	1	69	100
			Matrix Spike Precision	69	1	69	100
			Blank	39	1	39	100
			Blank Spike	39	1	39	100
Fall	Ammonium	654 (10)	Matrix Spike	71	1	71	100
			Matrix Spike Dup	71	1	71	100
			Matrix Spike Precision	71	1	71	100
			Blank	44	1	44	100
			Blank Spike	44	1	44	100
Winter	Ammonium	735 (10)	Matrix Spike	79	1	79	100
			Matrix Spike Dup	79	1	79	100
			Matrix Spike Precision	79	1	79	100
			Blank	38	1	38	100
			Blank Spike	38	1	38	100
Spring	Ammonium	654 (8)	Matrix Spike	69	1	69	100
			Matrix Spike Dup	69	1	69	100
			Matrix Spike Precision	69	1	68	99

* 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%.

	Total Coliforms	35 (5)	Duplicate	35	1	33	94
Summer	Fecal Coliforms	35 (5)	Duplicate	35	1	33	94
	Enterococci	35 (5)	Duplicate	35	1	28	80
	Total Coliforms	35 (5)	Duplicate	35	1	33	94
Fall	Fecal Coliforms	35 (5)	Duplicate	35	1	31	89
	Enterococci	35 (5)	Duplicate	35	1	32	91
	Total Coliforms	35 (5)	Duplicate	35	1	33	94
Winter	Fecal Coliforms	35 (5)	Duplicate	35	1	32	91
	Enterococci	35 (5)	Duplicate	35	1	29	83
	Total Coliforms	35 (5)	Duplicate	35	1	32	91
Spring	Fecal Coliforms	35 (5)	Duplicate	35	1	32	91
	Enterococci	35 (5)	Duplicate	35	1	31	89
	Total Coliforms	140 (20)	Duplicate	140	1	131	94
Annual	Fecal Coliforms	140 (20)	Duplicate	140	1	128	91
	Enterococci	140 (20)	Duplicate	140	1	120	86

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

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 commercially purchased dilution blanks 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 all 4 quarters for 2 of the 3 fecal indicator bacteria (Table C-2). The lowest analytical pass rate of 80% and 83% were observed in the Summer and Winter quarters, respectively, for enterococci.

SEDIMENT CHEMISTRY NARRATIVE

OCSD's LMC laboratory received 29 sediment samples from LMC's OMP staff in July 2018, and 29 samples in January 2019. 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 gas chromatography–mass spectrometry (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, and 1 matrix spike 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). The only QC samples with a percentage of passing compounds lower than 80% occurred in the summer PCB and pesticides analyses, where the matrix spike and matrix spike duplicate passed for 58% and 57% of compounds, respectively. This lower percentage of passing compounds was most likely caused by matrix interference. When constituent concentrations exceeded the calibration range of the instrument, dilutions were made and the samples were 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, matrix spikes, and matrix spike duplicates were analyzed at least once for every 10 sediment samples. The analysis of the blank spike and SRM provided a measure

Table C–3 Acceptance criteria for standard reference materials, July 2018-June 2019.

Parameter	Sediments		
	True Value	Acceptance Range (ng/g)	
	(ng/g)	Minimum	Maximum
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	11.86
PCB 138	62.1	37.26	86.94
PCB 149	49.7	29.82	69.58
PCB 151	16.93	10.16	23.70
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	17.07
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	5.53	12.89
PCB 209	6.81	4.09	9.53
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	9.91	23.11
trans-Chlordane *	19.0	11.4	26.6
gamma-BHC *	2.0	1.2	2.8
Hexachlorobenzene	6.03	3.62	8.44
trans-Nonachlor	8.20	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	594
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	98.7	–	–

Table C–3 continues.

Table C–3 continued.

Parameter	True Value (mg/kg)	Acceptance Range (mg/kg) Minimum	Acceptance Range (mg/kg) Maximum
	Metals (CRM-540 ERA Metals in Soil; Lot No. D099-540)		
Antimony	75.5	14.5	199
Arsenic	161	113	209
Barium	260	195	325
Beryllium	97.6	73.2	112
Cadmium	211	158	264
Chromium	136	95.2	177
Copper	166	124	207
Lead	111	78.8	143
Mercury	11.5	6.87	16
Nickel	91.9	64.3	119
Selenium	191	131	252
Silver	43.3	30.1	56.5
Zinc	199	139	259

Fish Tissue

Parameter	True Value (ng/g)	Acceptance Range (ng/g) Minimum	Acceptance Range (ng/g) Maximum
	Organochlorine Pesticides and PCB Congeners (SRM1946, Lake Superior Fish Tissue; National Institute of Standards and Technology)		
PCB 18 *	0.840	0.504	1.176
PCB 28 *	2.0	1.2	2.8
PCB 44	4.66	2.796	6.524
PCB 49	3.80	2.28	5.32
PCB 52	8.10	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	9.40	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	0.380	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	13.0	7.8	18.2
PCB 201 *	2.83	1.698	3.962
PCB 206	5.40	3.24	7.56
2,4’-DDD	2.20	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	18.90	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

Parameter	True Value (%)	Acceptance Range (%) Minimum	Acceptance Range (%) Maximum
	Lipid (SRM1946, Lake Superior Fish Tissue; National Institute of Standards and Technology)		
Lipid *	10.17	6.1	14.2

Parameter	True Value (mg/kg)	Acceptance Range (mg/kg) Minimum	Acceptance Range (mg/kg) Maximum
	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, July 2018-June 2019.

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	29 (2)	Blank	2	26	52	100
			Blank Spike	2	26	52	100
			Matrix Spike	2	26	52	100
			Matrix Spike Duplicate	2	26	52	100
			Matrix Spike Precision	2	26	52	100
			SRM Analysis	2	21	36	86
Winter	PAHs	29 (2)	Blank	2	25	50	100
			Blank Spike	2	25	49	98
			Matrix Spike	2	25	50	100
			Matrix Spike Duplicate	2	25	50	100
			Matrix Spike Precision	1	25	25	100
			SRM Analysis	2	21	37	88

* 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 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	29 (2)	Blank	2	60	120	100
			Blank Spike	2	60	110	92
			Matrix Spike	2	60	70	58
			Matrix Spike Duplicate	2	60	68	57
			Matrix Spike Precision	2	60	120	100
			SRM Analysis	2	33	56	85
Winter	PCBs and Pesticides	29 (2)	Blank	2	60	120	100
			Blank Spike	2	60	100	83
			Matrix Spike	2	60	119	99
			Matrix Spike Duplicate	2	60	120	100
			Matrix Spike Precision	2	60	120	100
			SRM Analysis	2	33	55	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 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	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	43	90
			SRM Analysis	1	12	12	100
Summer	Mercury	29 (1)	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	1	1	1	100
Winter	Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Lead, Nickel, Selenium, Silver, Zinc	29 (1)	Blank	4	12	47	98
			Blank Spike	2	12	24	100
			Matrix Spike	3	12	33	92
			Matrix Spike Dup	3	12	33	92
			Matrix Spike Precision	3	12	36	100
			Duplicate	3	12	36	100
			SRM Analysis	1	12	12	100
Winter	Mercury	29 (1)	Blank	2	1	2	100
			Blank Spike	2	1	2	100
			Matrix Spike	3	1	2	100
			Matrix Spike Dup	3	1	2	100
			Matrix Spike Precision	3	1	2	100
			Duplicate	3	1	2	67
			SRM Analysis	1	1	1	100

* An analysis passed if the following criteria were met.
For blank - Target amount <3X MDL or < 10% of sample result, whichever is greater.
For blank spike - Target accuracy % recovery 90-110 for mercury and 85-115 for other metals.
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 <20% at 3X MDL of sample mean.
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	29 (2)	Blank	2	1	2	100
			Blank Spike	2	1	0	0
			Matrix Spike	3	1	3	100
			Matrix Spike Dup	3	1	3	100
			Matrix Spike Precision	3	1	3	100
			Duplicate	3	1	0	N/A
Winter	Dissolved Sulfides	29 (3)	Blank	3	1	3	100
			Blank Spike	3	1	2	67
			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 duplicate - 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. N/A represents result <3X MDL.							
Summer	TOC	29 (1)	Blank	2	1	2	100
			Blank Spike	2	1	2	100
			Matrix Spike	2	1	2	100
			Matrix Spike Dup	2	1	2	100
			Matrix Spike Precision	2	1	2	100
			Duplicate	3	1	3	100
Winter	TOC	29 (1)	Blank	2	1	2	100
			Blank Spike	2	1	2	100
			Matrix Spike	2	1	2	100
			Matrix Spike Dup	2	1	2	100
			Matrix Spike Precision	2	1	2	100
			Duplicate	3	1	3	100
* An analysis passed if the following criteria were met: For blank - Target accuracy % recovery <10X MDL. For blank spike, matrix spike, and matrix spike duplicate - 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.							
Summer	Grain Size	29 (1)	Duplicate	3	1	3	100
Winter	Grain Size	29 (1)	Duplicate	3	1	3	100
* An analysis passed if the following criterion was met: For duplicate - Target precision mean % RPD <10% of mean phi.							
Summer	Total N	29 (1)	Blank	5	1	5	100
			Blank Spike	5	1	5	100
			Matrix Spike	6	1	4	67
			Matrix Spike Dup	6	1	4	67
			Matrix Spike Precision	6	1	5	83
			Duplicate	3	1	2	67
Winter	Total N	29 (1)	Blank	5	1	5	100
			Blank Spike	5	1	5	100
			Matrix Spike	5	1	2	40
			Matrix Spike Dup	5	1	2	40
			Matrix Spike Precision	5	1	5	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 - Target accuracy % recovery 90-110. For 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.							
Summer	Total P	29 (1)	Blank	2	1	2	100
			Blank Spike	2	1	2	100
			Matrix Spike	2	1	1	50
			Matrix Spike Dup	2	1	1	50
			Matrix Spike Precision	2	1	2	100
			Duplicate	4	1	4	100
Winter	Total P	29 (1)	Blank	2	1	2	100
			Blank Spike	2	1	2	100
			Matrix Spike	2	1	0	0
			Matrix Spike Dup	2	1	1	50
			Matrix Spike Precision	2	1	1	50
			Duplicate	3	1	3	100

* An analysis passed if the following criteria were met:
For blank - Target accuracy % recovery <3X MDL.
For blank spike - Target accuracy % recovery 80-120.
For matrix spike and matrix spike duplicate - Target accuracy % recovery 75-125.
For matrix spike precision - Target precision % RPD <20%.
For duplicate - Target precision % RPD <20% at 10X MDL of sample mean.

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. Duplicate sample precision failed in 5 of 48 compounds analyzed in the Summer quarter, possibly due to matrix interference (Table C-4). One of the 48 blanks analyzed in the Winter quarter produced a result for selenium which was slightly higher than the allowable range. Antimony displayed low recovery in the matrix spikes and matrix spike duplicates, due to sediment matrix interferences. All other samples met the QA/QC criteria for all compounds tested (Table C-4).

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, matrix spike, and matrix 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 the mercury SRM is presented in Table C-3. All samples met the QA/QC criteria guidelines for accuracy and precision, except for one duplicate analysis with a precision value slightly higher (20.8%) than the acceptance criterion (20%) (Table C-4).

DS

DS samples were analyzed in accordance with methods described in the LMC SOPs. The MDL for DS is presented in Table C-1. All QC samples in both quarters met the QC acceptance criteria, except for the blank spike (Table C-4). The blank spike failed in both summer batches, with recoveries of 79% and 74%, just below the acceptance limit of 80%. One winter batch blank spike failed, with a recovery of 75%. In all batches where the blank spike failed, the matrix spike and matrix spike duplicate not only passed the acceptance criterion of 70–130% recovery, but also the stricter blank spike criterion of 80–120%. A corrective action was implemented to prevent blank spike failures in the future.

TOC

TOC samples were analyzed by ALS Environmental Services, Kelso, WA. The MDL for TOC is presented in Table C-1. All analyzed TOC QC samples passed the QA/QC acceptance 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 QC samples passed the QA/QC criteria of RPD ≤10% (Table C-4).

TN

TN samples were analyzed by Weck Laboratories, Inc., City of Industry, CA. The MDL for TN is presented in Table C-1. Most matrix spike precisions and their duplicate analyses had an RPD of less than 20% in the Summer quarter, while the analyses in the Winter quarter resulted in 100% of matrix spike precisions and their duplicates passing (Table C-4). All blank and blank spikes met the acceptance criteria; only 55% of matrix spikes and matrix spike duplicates met the recovery criteria of 80–120% for the year due to matrix interferences in the analyses (Table C-4).

TP

TP samples were analyzed by Weck Laboratories. The MDL for TP is presented in Table C-1. Most (75%) matrix spike precisions and all their duplicate analyses had an RPD of less than 20% for the year (Table C-4). All associated blank spikes met the acceptance criteria; only 25% and 50% of matrix spikes and matrix spike duplicates, respectively, met the recovery criteria of 75–125% for the year due to matrix interferences in the analyses (Table C-4).

FISH TISSUE CHEMISTRY NARRATIVE

For the 2018-19 monitoring year, the LMC laboratory received 35 trawl fish samples in July 2018, and 20 rig-fish samples in April 2019. All 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 are 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, blank spike (using tilapia), sample duplicates, matrix spike, matrix spike duplicate, and SRM. 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). One sample was lost due to insufficient sample for a second extraction during the Summer quarter. 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 air dry. 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 (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 sample duplicates, matrix spikes, and matrix spike duplicates, which were run approximately once every 10 samples.

Table C–5 Fish tissue QA/QC summary, July 2018-June 2019.

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	70 (4)	Blank	8	54	432	100
			Blank Spike	7	54	356	94
			Matrix Spike	4	54	201	93
			Matrix Spike Dup	4	54	197	91
			Matrix Spike Precision	4	54	204	94
			Duplicate	2	54	108	100
			SRM	4	38	128	84
Spring	PCBs and Pesticides	20 (2)	Blank	4	54	216	100
			Blank Spike	4	54	191	88
			Matrix Spike	2	54	100	93
			Matrix Spike Dup	2	54	92	85
			Matrix Spike Precision	2	54	102	94
			Duplicate	2	54	107	99
			SRM	2	41	69	84

* 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 <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.

Summer	Percent Lipid - Liver	35 (2)	Duplicate	2	1	2	100
			SRM	2	1	2	100
	Percent Lipid - Muscle	35 (2)	Duplicate	2	1	2	100
			SRM	2	1	2	100
Spring	Percent Lipid - Muscle	20 (2)	Duplicate	2	1	2	100
			SRM	2	1	2	100

* An analysis passed if the following criteria were met:
For duplicate - Target precision % RPD <25%.
For SRM - Target % recovery 60-140.

Summer	Mercury	70 (2)	Blank	4	1	4	100
			Blank Spike	4	1	4	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
			SRM Analysis	2	1	2	100
Spring	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	4	100
			SRM Analysis	1	2	2	100
Spring	Mercury	20 (1)	Blank	1	1	1	100
			Blank Spike	1	1	1	100
			Matrix Spike	2	1	2	100
			Matrix Spike Dup	2	1	2	100
			Matrix Spike Precision	2	1	2	100
			Duplicate	2	1	2	100
			SRM Analysis	1	1	1	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 70-130 or certified value, whichever is greater.

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).

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 a sample duplicate, a matrix spike, and a matrix spike duplicate, 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 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 2018 (summer) from 29 semi-annual stations (52–65 m) and in January 2019 (winter) from the same 29 semi-annual stations (Table A-4).

Sorting

The sorting procedure involved removal by 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 (i.e., specimens with a head) per station was recorded. After ABC's in-house sorting efficiency criteria were met, the organisms and remaining particulates (grunge) were returned to OCSD. Ten percent of these samples (6 of 58) were randomly selected for re-sorting by OCSD staff. A tally was made of any countable organisms missed by 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 taxon. 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 2018-19 (Table C-6). The SDR revealed some differences in application of names when compared with OCSD's internal data. While every attempt was made to standardize name application for non-specific names, i.e., specimens not identifiable to genus and species due to condition or developmental stage, the contractors differed in a few cases. We were able to identify these discrepancies and make the changes to the final dataset. The use of provisional taxa familiar to the contractors but not OCSD's taxonomists was reconciled by sharing information by both parties to ensure there was no overlap with known taxa and to improve intercalibration between the taxonomists. No other changes to the 2018-19 infauna dataset was made as a result of the SDR.

Table C–6 Percent error rates calculated for the July 2018 infauna QA samples.

Error Type	Station				Mean
	0	85	86	C	
1. %Error # Individuals	1.1	1.8	1.6	2.4	1.7
2. %Error # ID Taxa	11.0	2.2	0.9	7.4	5.4
3. %Error # ID Individuals	3.4	1.1	0.3	3.2	2.0

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