SD Public Utilities

ANNUAL RECEIVING WATERS MONITORING & TOXICITY TESTING QUALITY ASSURANCE REPORT

2021

Environmental Monitoring and Technical Services
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CERTIFIED
Public Utilities Department
Continuous Improvement, Prevention of Pollution, Regulatory Compliance
ISO 14001

ANNUAL RECEIVING WATERS MONITORING & TOXICITY TESTING QUALITY ASSURANCE REPORT

2021

Prepared By:

City of San Diego
Ocean Monitoring Program
Public Utilities Department
Environmental Monitoring and Technical Services Division

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Introduction

The Environmental Monitoring and Technical Services (EMTS) Division of the City of San Diego Public Utilities Department (PUD) performs comprehensive Quality Assurance (QA)/Quality Control (QC) procedures. These procedures ensure the accuracy and reliability of data collected from receiving waters monitoring and toxicity testing, which are provided to regulatory agencies in compliance with the reporting requirements specified in several National Pollutant Discharge Elimination System (NPDES) permits (Table 1). Furthermore, these QA/QC procedures ensure the quality and consistency of field sampling, laboratory analysis, record keeping, data entry, and electronic data collection/transfer, as well as data analysis and reporting. The procedures are regularly reviewed and revised as necessary to reflect ongoing changes in permit requirements, sample collection methods, technology, and applicability of new analytical methods.

Details of the EMTS Division's QA/QC program for receiving waters monitoring are documented in a separate Quality Assurance Plan (QAP) (City of San Diego 2021a). Additionally, the EMTS Division maintains its certification through the International Organization for Standardization (ISO) 14001 Environmental Management Systems program. As a part of continuation of the ISO 14001 certification process, EMTS underwent and passed an external audit in 2020 conducted by a third-party auditor. The next audit will take place in 2023.

This report summarizes the QA/QC activities that were conducted during 2021 by City of San Diego staff in support of NPDES permit requirements for receiving waters monitoring and toxicity testing for the City's Point Loma Wastewater Treatment Plant (PLWTP) (Table 2) and South Bay Water Reclamation Plant (SBWRP) (Table 3), as well as similar ocean monitoring activities required for the South Bay International Wastewater Treatment Plant (SBIWTP), owned and operated by the International Boundary and Water Commission U.S. Section (USIBWC).

Facilities and Staff

The EMTS Division includes laboratories from three sections that participate in the receiving waters monitoring and toxicity testing activities associated with the above NPDES permits. These sections include: (1) the Marine Biology and Ocean Operations (MBOO) section; (2) the Microbiology section (Marine Microbiology Laboratory - MML, and Toxicology Laboratory - TL); (3) Environmental Chemistry Services (ECS) section.

MBOO, MML, and TL are located at the EMTS Division's laboratory facility at 2392 Kincaid Road, San Diego, CA 92101. Functions of these labs are described below. ECS comprises work groups located at other City laboratory facilities. Therefore, descriptions of the ECS laboratory functions and their QA procedures are presented in a separate QA report each year (City of San Diego 2021b).

Table 1

NPDES permits and associated orders issued by the San Diego Regional Water Quality Control Board for the City of San Diego's PLWTP and SBWRP, and the U.S. Section of the International Boundary and Water Commission's SBIWTP.

Facility	NPDES Permit	Order No.	Effective Dates
PLWTP	CA0107409	R9-2017-0007	October 1, 2017 – September 30, 2022
SBWRP	CA0109045	R9-2021-0011[a]	July 1, 2021 – June 30, 2026
SBIWTP	CA0108928	R9-2021-0001[b]	July 1, 2021 – June 30, 2026

[a] replaced Order No. R9-2013-0006, which was amended by Order Nos. R9-2014-0071 and R9-2017-0023
[b] replaced Order No. R9-2014-0009, which was amended by Order Nos. R9-2014-0094, R9-2017-0024, and R9-2019-0012

Marine Biology and Ocean Operations

Staff scientists from the MBOO section are responsible for conducting most field sampling operations, some laboratory analyses, and subsequent biological and oceanographic assessments associated with the City's Ocean Monitoring Program (water quality, benthic sediments and macrofauna, trawl caught fishes and invertebrates, and contaminant accumulation in marine fishes). Staff in this section are organized into different work groups based on primary responsibilities and areas of expertise. Brief descriptions of the areas of emphasis for each work group are provided below. Staff with overlapping expertise work across groups.

Program Coordination: One of the primary responsibilities of the Program Coordination supervisor is to oversee the assessment of receiving waters monitoring data. This includes data QA, data analysis, interpretation of results from the receiving waters monitoring activities, and other contract work. This supervisor works closely with other staff to perform QA of all receiving waters monitoring data. Various industry standard software packages for data management, data manipulation, statistical analysis, and presentation are used to manage and analyze data from every aspect of receiving waters monitoring. The results and interpretation of these analyses are reported to regulatory and contract agencies in the form of monthly and annual reports.

Environmental Management: This work group oversees MBOO compliance with environmental and laboratory management standards such as ISO 14001. Oversight includes document control and maintenance of the QAP, Standard Operating Procedures, Work Instructions, and ISO 14001 documentation using the division's compliance software, Qualtrax. Staff in this work group coordinate with members of other work groups and sections to produce an annual report of quality assurance activities. Furthermore, this group promotes lab and field safety through trainings, and environmental systems through hazardous materials and universal waste management. Environmental Management seeks to reduce resource use and exceed regulatory expectations by supporting process development and improvement, data management, and staff training, and to engage the public by supporting MBOO's and the division's outreach efforts.

Ocean Operations: This work group comprises two subsections, Ocean Operations and Vessel Operations. Ocean Operations staff oversee and conduct water quality sampling, benthic sediment and infauna sampling, trawling and rig-fishing, and ocean outfall inspections, including data collection and QA. These staff members maintain and calibrate all oceanographic instrumentation, including

the laboratory's remotely operated vehicle, remotely operated towed vehicle, and static/real-time oceanographic moorings. Vessel Operations staff (i.e., Boat Operators) are primarily responsible for the operation and maintenance of the City's two ocean monitoring vessels, the Oceanus, and the Monitor III. When the vessels are in port, the Boat Operators schedule and oversee all regular vessel maintenance, as well as any modifications that may become necessary. While at sea, they are responsible for ensuring the safety of the crew, locating and maintaining position at monitoring stations (Figure 1), and assisting with various deck activities during field operations, as appropriate. Members of this and other work groups participate as members of the Southern California Association of Ichthyological Taxonomists and Ecologists (SCAITE).

Laboratory Operations: The Laboratory Operations work group coordinates processing of all benthic infauna, trawl-caught fish and megabenthic invertebrates, and rig fishing samples including label preparation, sample login, and data entry. In addition, they maintain the taxonomic literature and voucher collections, produce in-house identification/materials and keys, and conduct taxonomic training. This group also oversees fish dissections to assess contaminants accumulation in marine fishes. Staff participate in regional taxonomic standardization programs and perform all QA/QC procedures to ensure the accuracy of the taxonomic identifications made by laboratory staff. Members of this and other work groups participate as members of the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT).

Marine Microbiology Laboratory

The MML is accredited by the California State Water Resources Control Board Environmental Laboratory Accreditation Program (ELAP)(EPA Lab ID: CA01393; ELAP Cert No.: 2185), which is renewed on a biennial basis. Microbiology staff are responsible for the identification and quantification of bacteria found in environmental samples. Responsibilities include preparation of microbiological media, reagents, sample bottles, collection of field samples along the shore, and laboratory analyses using accredited methods to measure concentrations of fecal indicator bacteria. Analyses include membrane filtration, multiple tube fermentation, Colilert/Colilert-18, and Enterolert chromogenic/fluorogenic substrate analyses as appropriate for the parameter and as required by the NPDES permits. In addition, the group is responsible for the physical maintenance, calibration, and QA of large equipment and instruments such as autoclaves, incubators, water baths, ultra-freezers, a biological safety cabinet, and reagent-grade water point-of-use systems. Members are also responsible for developing sampling, analytical, and QA protocols for special microbiological projects or studies. In addition to being summarized here, the MML maintains a separate, detailed Quality Manual that contains up-to-date revisions to reflect current laboratory practices and procedures and ensures timely document version control in accordance with ELAP requirements and ISO 14001 standards.

Toxicology Laboratory

The TL is also certified by ELAP (EPA Lab ID: CA01302; ELAP Cert No.: 1989), with renewal on a biennial basis. Toxicology staff are responsible for conducting or overseeing all acute, chronic, and sediment toxicity testing required by the City's NPDES permits (Table 4) and contractual obligations. Primary responsibilities include collection of wastewater effluent or marine sediment samples, maintaining test organisms and laboratory supplies, calibration of test instruments, conducting acute and chronic bioassays, record keeping, and the statistical evaluation, interpretation, and reporting

Table 2

Core receiving waters monitoring requirements for the Point Loma Ocean Outfall region. Sampling effort excludes FIB resamples, QA/QC activities, new plume tracking requirements, and special studies.

Monitoring Component	Location	No. of Stations/ Zones	Sample Type	Discrete No. Samples/Site	Sampling Frequency	Sampling Times/Yr	Discrete No. Samples/Yr	Parameters	No. "Samples" Analyzed/Yr	Notes
Water Quality, Microbiology, Oceanographic Conditions	shore	8	Seawater - FIB	1	1/Week	52	416	T, F, E[a]	1248	1 sample/station
	kelp/ nearshore	8	Seawater - FIB	3	1/Week	52	1248	T, F, E[a]	3744	3 depths/station
		8	CTD	1	1/Week	52	416	CTD profile[c]	3744	1 cast/station (1-m batch avg samples)
	offshore	3	Seawater - FIB	3	1/Quarter	4	36	E[b]	36	3 depths/station (18-m stns)
		11	Seawater - FIB	3	1/Quarter	4	132	E[b]	132	3 depths/station (60-m stns)
		11	Seawater - FIB	4	1/Quarter	4	176	E[b]	176	4 depths/station (80-m stns)
		11	Seawater - FIB	5	1/Quarter	4	220	E[b]	220	5 depths/station (98-m stns)
		36	CTD	1	1/Quarter	4	144	CTD profile[c]	1296	1 cast/station (1-m batch avg samples)
Sediment Chemistry	offshore	22	Grab	1	2/Year	2	44	sed chem[d]	352	1° and 2° core stations (Jan, Jul)
	offshore	12	Grab	1	2/Year	2	24	sed chem[e]	24	1° core stations (Jan, Jul)
	offshore	40	Grab	1	1/Year	1	40	sed chem[d]	320	Randomized stations (Jul)[g]
Benthic Infauna	offshore	22	Grab	1	2/Year	2	44	community structure	44	1° and 2° core stations (Jan, Jul)
	offshore	40	Grab	1	1/Year	1	40		40	Randomized stations (Jul)[g]
Sediment Toxicity	offshore	8-28	Grab	1	1/Year	1	8-28	acute toxicity	8-28	Rotating offshore stations[h]
Demersal Fishes & Invertebrates	offshore	6	Trawl	1	2/Year	2	12	community structure	12	1 trawl/station (Jan, Jul)
Bioaccumulation in Fish Tissues	offshore	4	Trawl/ Hook & Line	3	1/Year	1	12	liver tissue[f]	60	3 composites/zone (Oct)
	offshore	2	Hook & Line	3	1/Year	1	6	muscle tissue[f]	30	3 composites/zone (Oct)
Totals							**3038**		**11,506**	

[a] Fecal Indicator Bacteria (FIB) parameters = total coliform (T), fecal coliform (F), *Enterococcus* bacteria (E); n = 3 parameters required at shore and kelp water quality stations.
[b] *Enterococcus* = only FIB indicator required at offshore water quaility stations.
[c] CTD profile = temperature, depth, pH, salinity, dissolved oxygen, light transmittance (transmissivity), and chlorophyll *a* (n = 7 required parameters), plus density and CDOM (n = 9 parameters total)
[d] Sediment constituents = sediment particle size, total organic carbon, total nitrogen, sulfides, metals, PCBs, chlorinated pesticides, PAHs (n = 8 parameter categories; see NPDES permit for complete list of constituents).
[e] Sediment constituents = BOD at 12 primary core stations only (voluntary sampling per agreement with USEPA Region IX)
[f] Fish tissue constituents = lipids, metals, PCBs, chlorinated pesticides, and PAHs (n = 5 parameter categories; see NPDES permit for complete list of constituents)
[g] Random (regional) benthic survey = joint requirement of Point Loma and South Bay outfall monitoring programs (i.e., 40 stations/year total)
[h] Continued Sediment Toxicity Monitoring as recommended by the Final Project Report for the Sediment Toxicity Pilot Study for the San Diego Ocean Outfall Monitoring Regions (City of San Diego 2019)

Table 3

Core receiving waters monitoring requirements for the South Bay Ocean Outfall region. Sampling effort excludes FIB resamples, QA/QC activities, new plume tracking requirements, and special studies.

Monitoring Component	Location	No. of Stations/ Zones	Sample Type	Discrete No. Samples/Site	Sampling Frequency	Sampling Times/Yr	Discrete No. Samples/Yr	Parameters	No. "Samples" Analyzed/Yr	Notes
Water Quality,	shore	11	Seawater - FIB	1	1/Week	52	572	T, F, E[a]	1716	1 sample/station
Microbiology,										
Oceanographic	kelp/	7	Seawater - FIB	3	1/Week	52	1092	T, F, E[a]	3276	3 depths/station
Conditions	nearshore	7	CTD	1	1/Week	52	364	CTD profile[b]	3276	1 cast/station (1-m batch avg samples)
	offshore	21	Seawater - FIB	3	1/Quarter	4	252	T, F, E[a]	756	3 depths/station
		33	CTD	1	1/Quarter	4	132	CTD profile[b]	1188	1 cast/station (1-m batch avg samples)
		3	Seawater - pH/TA	2-3	1/Quarter	4	32	pH, TA[c]	64	2-3 depths/station
Sediment Chemistry	offshore	27	Grab	1	2/Year	2	54	sed chem[d]	432	1° and 2° core stations (Jan, Jul)
	offshore	40	Grab	1	1/Year	1	40	sed chem[d]	320	Randomized stations (Jul)[f]
Benthic Infauna	offshore	27	Grab	1	2/Year	2	54	community structure	54	1° and 2° core stations (Jan, Jul)
	offshore	40	Grab	1	1/Year	1	40		40	Randomized stations (Jul)[f]
Sediment Toxicity	offshore	8-28	Grab	1	1/Year	1	8-28	acute toxicity	8-28	Rotating offshore stations[g]
Demersal Fishes & Invertebrates	offshore	7	Trawl	1	1/Year	2	14	community structure	14	1 trawl/station (Jan, Jul)
Bioaccumulation in Fish Tissues	offshore	5	Trawl/Hook & Line	3	1/Year	1	15	liver tissue[e]	75	3 composites/zone (Oct)
	offshore	2	Hook & Line	3	1/Year	1	6	muscle tissue[e]	30	3 composites/zone (Oct)
Totals							**2695**		**11,269**	

[a] Fecal Indicator Bacteria (FIB) = total coliform (T), fecal coliform (F), and *Enterococcus* bacteria (E); n = 3 parameters required at all shore, kelp nearshore and offshore water quality stations

[b] CTD profile = temperature, depth, pH, salinity, dissolved oxygen, light transmittance (transmissivity), chlorophyll *a* (n = 7 required parameters), plus density and CDOM (n = 9 parameters total)

[c] As of July 1, 2021, samples were collected and analyzed for pH/TA at offshore stations (see SBWRP and SBIWTP NPDES permits for details)

[d] Sediment constituents = sediment particle size, total organic carbon, total nitrogen, sulfides, metals, PCBs, chlorinated pesticides, PAHs (n = 8 parameter categories; see NPDES permits for complete list of constituents)

[e] Fish tissue constituents = lipids, metals, PCBs, chlorinated pesticides, and PAHs (n = 5 parameter categories; see NPDES permits for complete list of constituents)

[f] Random (regional) benthic survey = joint requirement of Point Loma and South Bay outfall monitoring programs (i.e., 40 stations/year total)

[g] Continued Sediment Toxicity Monitoring as recommended by the Final Project Report for the Sediment Toxicity Pilot Study for the San Diego Ocean Outfall Monitoring Regions (City of San Diego 2019)

Table 4

Toxicity testing required in accordance with various NPDES permits. Listed effort excludes accelerated testing requirements (e.g., triggered by Notice of Violation), additional QA/QC procedures, and special studies.

Testing Component	Location/ Project	Sample Type	No. samples	Sampling Frequency	Sampling Times/Yr	No. test Species	Effluent/Ref Tox Tests/Yr[b]	Total Tests/Yr	Endpoints[c]	Dilutions per bioassay	Notes
Point Loma Chronic toxicity	PLWTP	Final effluent	1	Monthly	12	1	12 + 12 Ref Tox	24	Sensitive lifestage	1[a] + control	Species: giant kelp
	(Biennial screening)	Final effluent	1	3 x per 2 yrs	3 x per 2 yrs	3	9 + 9 Ref Tox per 2 yrs	18 per 2 yrs	Sensitive lifestage	1[a] + control	Screening spp: giant kelp, red abalone, and topsmelt
South Bay Chronic toxicity	SBWRP	Final effluent	1	Quarterly	4	1	4 + 4 Ref Tox	8	Sensitive lifestage	1[d] + control	Species: giant kelp
	(Biennial screening)	Final effluent	1	3 x per 2 yrs	3 x per 2 yrs	3	9 + 9 Ref Tox per 2 yrs	18 per 2 yrs	Sensitive lifestage	1[d] + control	Screening spp: giant kelp, red abalone, and topsmelt

[a] The In-stream Waste Concentration (IWC) of 0.49% effluent, using the of Test of Significant Toxicity (TST)

[b] Ref Tox = Reference Toxicant Test

[c] Sensitive lifestage endpoints: (1) red abalone = development; (2) giant kelp = germination and growth; (3) topsmelt = survival and growth

[d] As of July 1, 2021, the IWC of 1.06% effluent for the SBWRP, using the TST; this reflects a change from Order No. R9-2017-0023 requirements (see NPDES permit for details)

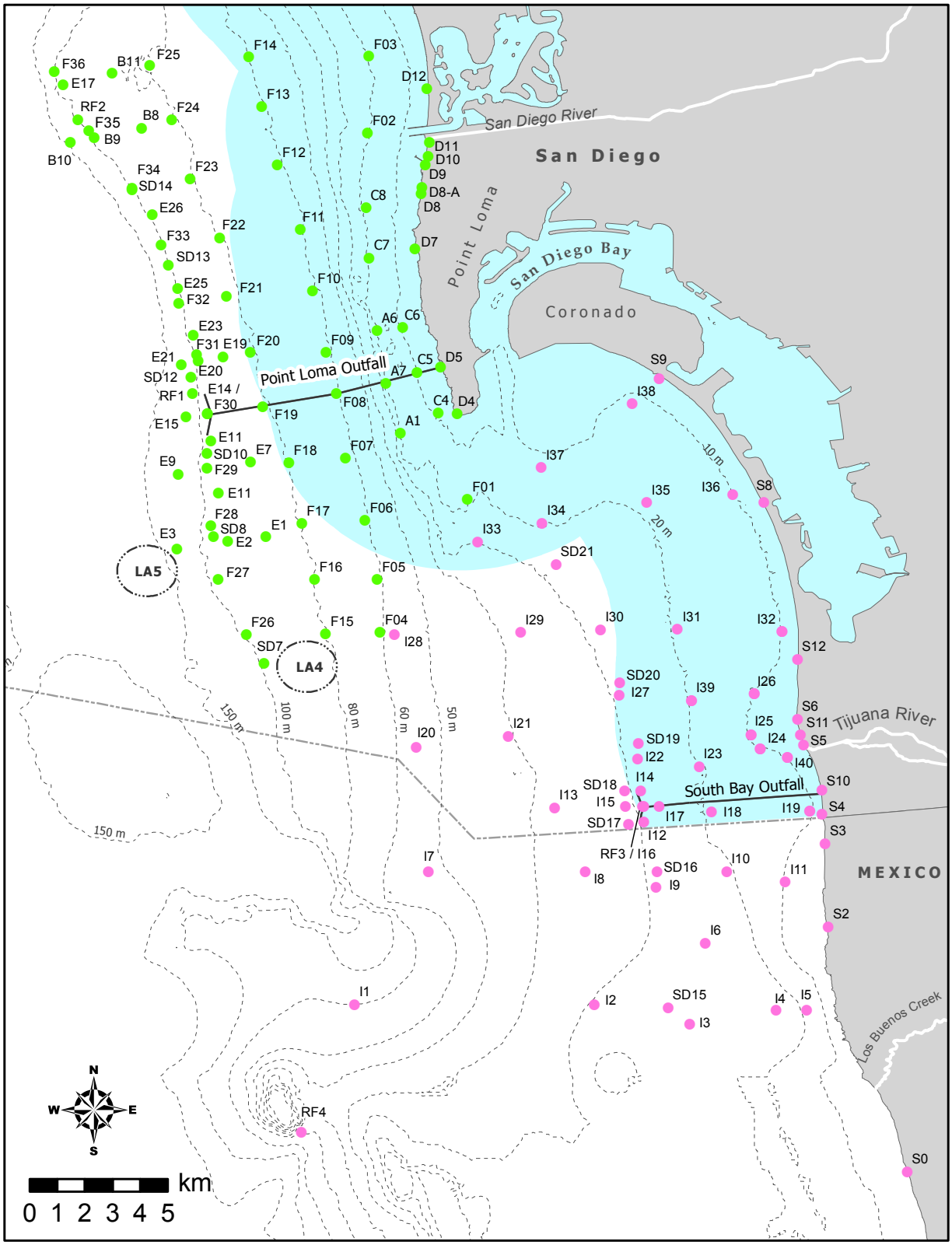

Figure 1

Core receiving waters monitoring stations for the PLOO (green) and SBOO (pink) sampled as part of the City of San Diego's Ocean Monitoring Program. Light blue shading represents State jurisdictional waters.

of all toxicology data. In addition to being summarized here, the TL maintains a separate, detailed Quality Assurance Manual that contains up-to-date revisions reflecting current laboratory practices and procedures and ensures timely document version control in accordance with ELAP requirements and ISO 14001 standards.

Scope of Work

The City of San Diego Ocean Monitoring Program is responsible for monitoring the coastal San Diego area to document and analyze possible effects on the marine environment due to the discharge of treated municipal wastewater (effluent) to the Pacific Ocean via the Point Loma Ocean Outfall (PLOO) and the South Bay Ocean Outfall (SBOO). Treated effluent from the PLWTP is discharged to the ocean through the PLOO, whereas commingled effluent from the SBWRP and SBIWTP is discharged through the SBOO. The separate orders and permits associated with these treatment facilities define the requirements for receiving waters monitoring and toxicity testing including sampling plans, compliance criteria, laboratory and statistical analyses, and reporting guidelines.

Core receiving waters monitoring activities include: (1) weekly sampling of ocean waters from recreational areas located along the shoreline and within the Point Loma and Imperial Beach kelp beds to assess nearshore water quality conditions; (2) quarterly sampling of ocean waters at offshore sites to document water quality conditions throughout the region; (3) semi-annual benthic sampling to monitor sediment conditions and the status of resident macrobenthic invertebrate communities; (4) semi-annual trawl surveys to monitor the ecological health of demersal fish and megabenthic invertebrate communities; (5) annual collection of fish tissue samples to monitor levels of chemical constituents that may have ecological or human health implications.

The results of the above receiving waters monitoring activities, and effluent and sediment toxicity tests, are analyzed and presented in various regulatory reports that are submitted to the San Diego Regional Water Quality Control Board (SDRWQCB) and United States Environmental Protection Agency (USEPA) on an ongoing basis. From 2016 through 2018, the City conducted a three-year sediment toxicity pilot study, and presented monitoring recommendations in the final project report that was submitted to the SDRWQCB and USEPA on June 30, 2019 (City of San Diego 2019). As these recommendations have since been incorporated into permit-required monitoring, additional sediment samples were collected and analyzed in 2021.

In addition to the above core monitoring efforts, the City may conduct “strategic process studies” (special projects) as part of its regulatory requirements and as defined by the Model Monitoring Program developed for large ocean dischargers in southern California (Schiff et al. 2002). These special studies are determined by the City in coordination with the SDRWQCB and USEPA and are generally designed to address recommendations for enhanced environmental monitoring of the San Diego coastal region as put forth in a peer-reviewed report coordinated by scientists at the Scripps Institution of Oceanography (SIO 2004). Data for such studies are typically subject to the same QA/QC procedures as the routine monitoring data, although the analysis and reporting schedules will likely be customized to meet the targeted study goals. Thus, details and results of ongoing QA/QC activities associated with these special studies are not included in this report unless otherwise indicated.

As a part of its regulatory requirements, the City also participates in regional monitoring activities for the entire Southern California Bight, coordinated by the Southern California Coastal Water Research Project (SCCWRP). The intent of these regional programs is to optimize the efforts of the various partner agencies, such as municipal dischargers and research agencies, and leverage their considerable scientific expertise and resources to survey the entire southern California coastal region using a cost-effective monitoring design. These bight-wide surveys have included the 1994 Southern California Bight Pilot Project and subsequent Bight regional monitoring efforts that have taken place every five years from 1998 until the most recent survey in 2018. During these programs, the City's regular sampling and analytical efforts may be reallocated as necessary with approval from the SDRWQCB and USEPA. As with special studies, the regional monitoring efforts are typically subject to QA/QC procedures like those for routine monitoring data, although the analysis and reporting schedules may vary. Thus, the details and results of the bight-wide monitoring efforts are not included in these annual QA reports unless otherwise indicated. However, planning documents for the current Bight'18 project, including its QAP, are available on SCCWRP's website (www.sccwrp.org).

Summary of Work Performed in 2021

During 2021, a total of 6365 discrete samples were collected by EMTS staff as part of the above scope of work and as part of permit-mandated special studies (Table 5). Of these, about 9% (n = 579) were QC samples, such as lab or field duplicates. In addition, a total of 1602 QA tests pertaining to macrofauna sorting, microbiological analyses, and toxicity tests were conducted to validate the quality of specific analyses. The results of the QA/QC activities presented in the following sections support the precision and accuracy of the resultant data and validate their use in permit-mandated monitoring, environmental testing, and reporting. These include: (1) intercalibration of the Conductivity-Temperature-Depth (CTD) instrument package or platform used to sample water quality parameters; (2) real-time mooring data quality, drift correction, and data acceptance criteria; (3) results of the bacteriological QA procedures; (4) results of the macrofaunal community sample re-sorts and re-IDs; (5) results of toxicology QA procedures. New orders for the SBWRP and SBIWTP permits went into effect on July 1, 2021, therefore, the results of QA/QC activities presented herein represent past and present order requirements of these permits.

CTD Calibration and Maintenance

The MBOO section uses two Sea-Bird Scientific SBE-25plus CTDs integrated with modular sensors. Both systems are configured with Sea-Bird's SBE-55 mini carousel package and outfitted with six 4-liter Niskin bottles. Laboratory staff carry out semi-annual in-house CTD intercalibration exercises to ensure consistency between the two CTD instruments used to collect water column profiling data for the City's Ocean Monitoring Program. In 2021, the intercalibration exercises were conducted in June and December. During these exercises, two CTDs configured with similar probes were attached to each other and deployed three separate times to a depth of 120 m. For each cast, data from depths greater than 100 m were discarded to minimize bottom effects. After the three casts were completed, comparisons of results for temperature, salinity, dissolved oxygen (DO), pH, transmissivity, and chlorophyll *a* fluorescence were performed to assess whether deviations between the instrument assemblies were within acceptable limits. The results are summarized in Table 6A, and Figures 2 and 3, and compared to

Table 5

Number of discrete samples collected and analyzed by EMTS staff for NPDES permit-related activities during 2021. NA = not applicable.

	Number of Samples Collected		Number of Analyses per Sample Type	
Sample Type	**Regular**	**QC**	**Regular**	**QA**
Sediment Grab				
Particle Size Subsample	138	NA	(performed by ECS)	
Chemistry Subsample	576 [a]	NA	(performed by ECS)	
Benthic Infauna Grab	138	NA	138	6
Otter Trawl	26	NA	26	NA
Fish Tissue	39	NA	(performed by ECS)	
Water Quality				
CTD Cast	1055	NA	9495 [c]	NA
Microbiology	4249 [b]	570	11,574 [d]	1582 [d]
Toxicology				
Sediment Toxicity	8	NA	8	1
Chronic Bioassay	17	NA	17	13
Bight'18 Ocean Acidification				
CTD Cast	29	NA	261 [c]	NA
pH/TA	78	9	(performed by Dickson Lab)	
Coccolithophore	4	NA	(performed by UCLA)	
Pteropod RNA	4	NA	(performed by SCCWRP)	
Pteropod Shell Condition	4	NA	(performed by SCCWRP)	
Totals	**6365**	**579**	**21,519**	**1602**

[a] PLOO primary core stations had five subsamples per grab; all other stations had four subsamples per grab
[b] Includes resamples
[c] Includes up to nine parameters per cast (depth, temperature, salinity, DO, light transmittance, chlorophyll *a*, pH, density, CDOM)
[d] Includes up to three types of fecal indicator bacteria (total coliform, fecal coliform, *Enterococcus*)

results from previous years in Table 6B. Instruments used in the intercalibration exercise conducted in 2021 demonstrated acceptable variability between CTDs for all measured parameters. There was ~0.2 difference in the pH readings during the June intercalibration. While a discrepancy of this magnitude is outside our targeted calibration range, this difference is within the expected cumulative error associated with these sensors (McLaughlin et al. 2017). Both sensors responded well to oceanographic features in the cast and tracked each other well within the limitations of the instrument. As part of the new orders for the SBWRP and SBIWTP permits, program improvements include verifying potentiometric field measurements with chemical analysis of collected lab samples to calibrate and center the offsets, and the use of customized TRIS buffers that bracket our measurement range more tightly.

In addition to the semi-annual CTD intercalibration exercises, manufacturers of various probes recommend annual recalibrations at their factories. Since four sets of conductivity, temperature, pressure, pH, and DO probes, as well as pumps, are inventoried in-house, each instrument is rotated out of service and sent back to the factory every six months for recalibration along with the system pump. Fluorometers (chlorophyll *a*), transmissometers, and colored dissolved organic matter (CDOM) probes, are rotated out for external/factory recalibration service on an annual basis, due to limited numbers of these sensors

Table 6

Summary of the CTD intercalibration results for casts conducted during 2021, including (A) mean difference (MeanΔ) and max difference (MaxΔ) between Unit #5 and Unit #6 across casts and depths, and the cast number (1, 2, 3) and depth (0–100 m) at which the maximum difference occurred and (B) results of CTD intercalibration exercises conducted during the last five years. Values are the MeanΔ between Unit #5 and Unit #6.

A

	June 2021				December 2021			
Parameter	**MeanΔ**	**MaxΔ**	**Cast**	**Depth (m)**	**MeanΔ**	**MaxΔ**	**Cast**	**Depth (m)**
Temperature (°C)	0.04	0.46	3	9	0.01	0.07	3	33
Salinity (ppt)	0.01	0.05	3	9	0.01	0.05	1	36
DO (mg/L)	0.16	0.54	3	10	0.18	0.43	1	28
pH	0.05	0.08	3	10	0.22	0.23	3	93
Transmissivity (%)	1.96	4.86	2	1	0.80	1.55	1	76
Chlorophyll *a* (µg/L)	0.28	1.74	2	3	0.13	0.59	2	24

B

Parameter	**Dec 2016**	**Aug 2017**	**Jan 2018**	**Nov 2018**	**Jul 2019**	**Dec 2019**	**Jul 2020**	**Jan 2021**	**Jun 2021**	**Dec 2021**
Temperature (°C)	0.02	0.10	0.04	0.03	0.02	0.01	0.01	0.01	0.04	0.01
Salinity (ppt)	0.01	0.04	0.02	0.02	0.00	0.02	0.01	0.01	0.01	0.01
DO (mg/L)	0.12	0.14	0.03	0.11	0.31	0.39	0.06	0.29	0.16	0.18
pH	0.02	0.22	0.03	0.06	0.11	0.06	0.18	0.07	0.05	0.22
Transmissivity (%)[a]	2.41	1.84	—	2.39	2.84	3.88	3.97	5.56	1.96	0.80
Chlorophyll *a* (µg/L)[b]	—	—	0.11	0.11	0.22	0.74	0.30	0.08	0.28	0.13

[a]Transmissivity results not available from January 2018 intercalibration casts due to probe failure
[b]Chlorophyll *a* results not available from December 2016 and August 2017 intercalibration casts due to probe failure

available. Any time an in-house calibration identifies a problematic probe, that probe is factory serviced earlier than scheduled. The rotation of probes between CTDs is staggered by six months to ensure that each instrument receives a replacement set within the annual calibration period.

The probes actively in use on each CTD undergo further in-house evaluations prior to and during each field survey. The DO probe on each CTD is calibrated monthly to check for sensor drift using a standardized protocol. If the sensor drift is ≥ 5% from factory calibration, the DO sensor coefficients are changed. If the DO sensor drift reaches 10% from factory calibration, it is removed from service, returned to the manufacturer for servicing or repair, and replaced with a newly factory-calibrated probe. The pH and transmissivity probes are inspected in the morning prior to each sampling cruise to ensure proper function. For pH calibrations, three buffer solutions (pH = 7.0, 8.0, 9.0) are used to bracket the expected pH range. If the reading of any buffer solution deviates by more than 0.05 pH units, the probe is recalibrated and the configuration file for the CTD unit is adjusted. The transmissometer on each CTD is checked by cleaning the windows of the LED light path, noting the zero reading by blocking the light path, then noting the maximum-value reading after removing the obstruction. If any specific probe fails to calibrate or has drifted out of its accepted range, it is removed from the CTD and replaced with a newly-calibrated spare. Additionally, the results from each probe are evaluated by reviewing the data across parameters following each cast. If any probe is determined to be faulty and a field repair cannot be completed, sampling will be terminated immediately so that the needed repairs can be completed back at the laboratory. During 2021, there was one event during which a sensor was removed from service before the 6-month rotation; a pH

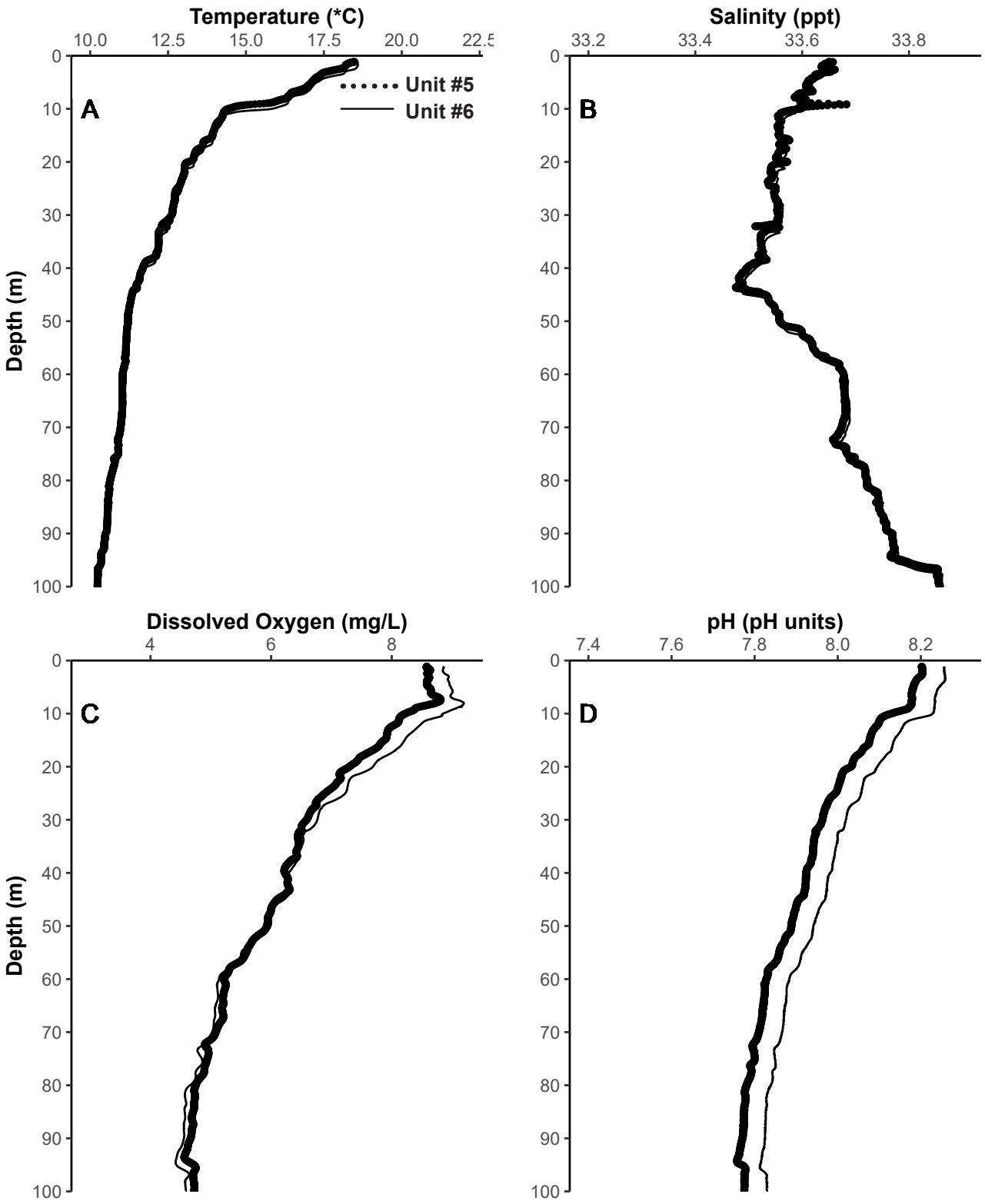

Figure 2

Comparison of results from CTD Unit #5 and Unit #6 from one representative cast made during the June 2021 CTD intercalibration exercise. Data include 1 m bin-averaged cast profiles for (A) temperature, (B) salinity, (C) dissolved oxygen, (D) pH, (E) transmissivity, and (F) chlorophyll *a*.

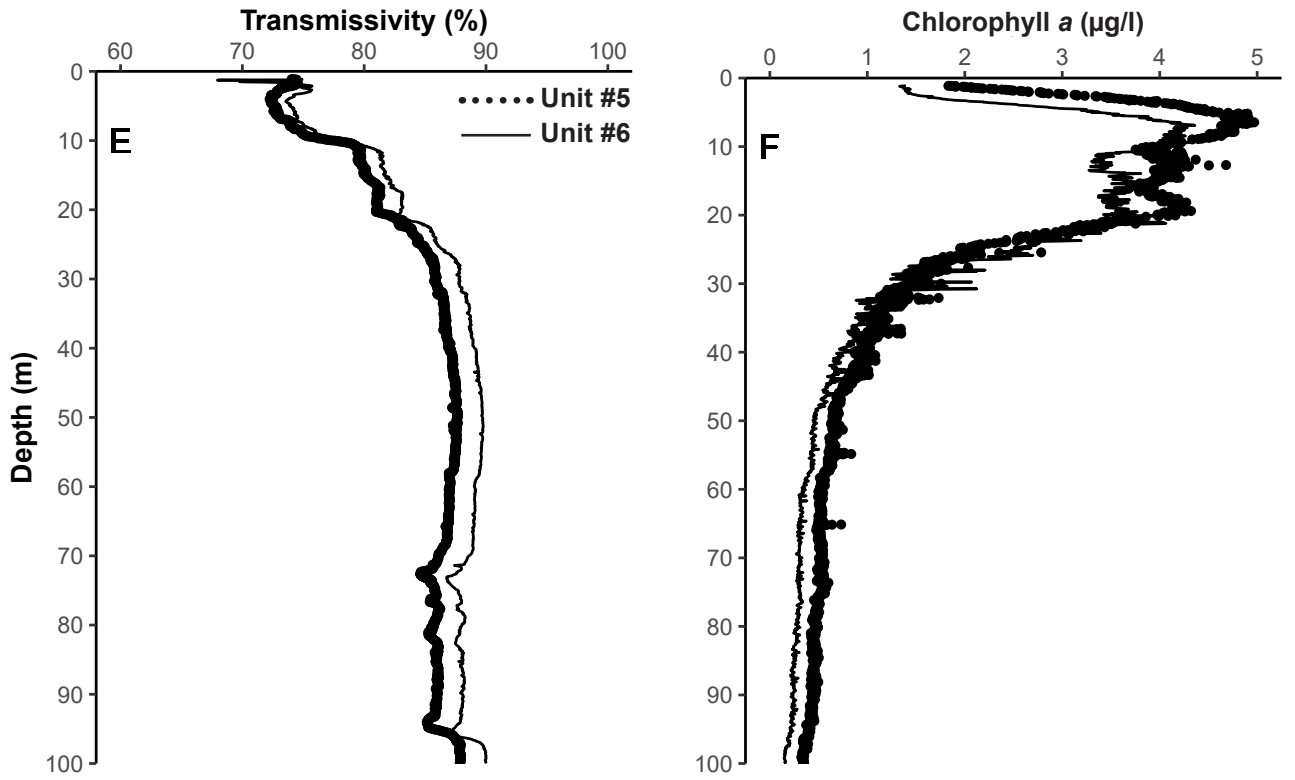

Figure 2 *continued*

sensor was changed on Unit #5 in May due to slow and inconsistent response to the calibration buffers. The replacement sensor was only in service from May 10 through June 29, 2021, and was rotated out with the rest of the sensor package at the regular 6-month interval.

Real-Time Mooring Data Quality Assessment

Real-time oceanographic mooring systems (RTOMS) are anchored unattended buoys with a suite of sensors that provide nearly continuous physical and biogeochemical measurements. The City maintains RTOMS near both the PLOO and SBOO for up to one year deployments. Real-time data management and integration support are provided by Scripps Institution of Oceanography (SIO). On an annual basis, and prior to any data analysis, all data are subject to a comprehensive suite of QA/QC procedures following Quality Assurance of Real-Time Oceanographic Data (QARTOD) methodologies (US IOOS 2020). These methodologies are a collaborative effort formed to address the data quality issues of the U.S. Integrated Ocean Observing System (US IOOS) community.

Data broadcast in real time by the RTOMS are processed by SIO personnel prior to publication on the SIO website (http://mooring.ucsd.edu) to remove pre/post deployment data and warmup data from burst sensors, and to apply calibrations. City staff assign a QC flag to each datapoint (Table 7) based on gross sensor ranges, climatological ranges based on historical data for each site and depth range, and additional manual data review, per national data standards following QARTOD methodologies. Additional QC includes visual assessment and multi-parameter comparison to identify common sensor failure modes such as biofouling, interference from bubbles or debris, electronic sensor drift, and other

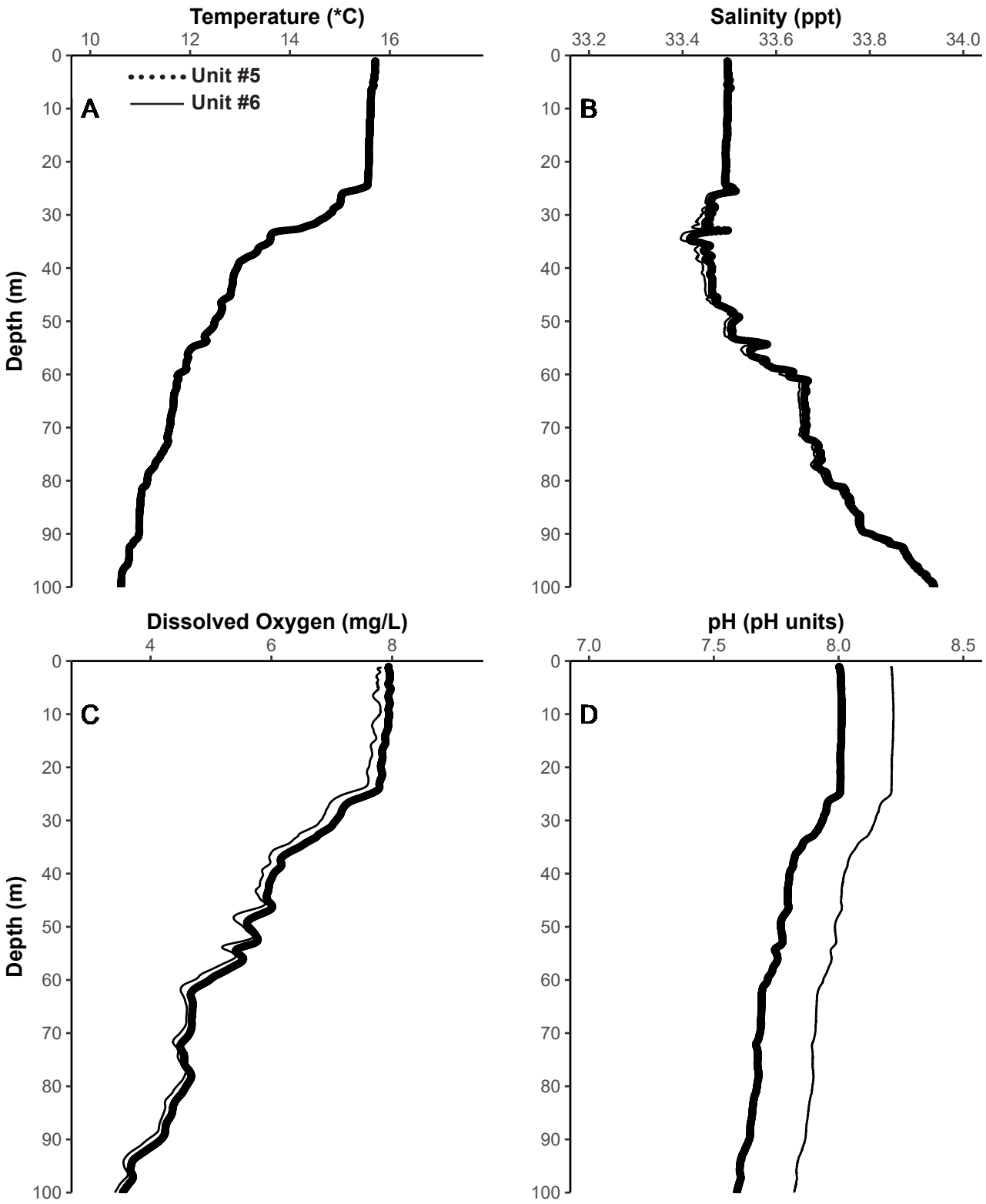

Figure 3

Comparison of results from CTD Unit #5 and Unit #6 from one representative cast made during the December 2021 CTD intercalibration exercise. Data include 1 m bin-averaged cast profiles for (A) temperature, (B) salinity, (C) dissolved oxygen, (D) pH, (E) transmissivity, and (F) chlorophyll *a*.

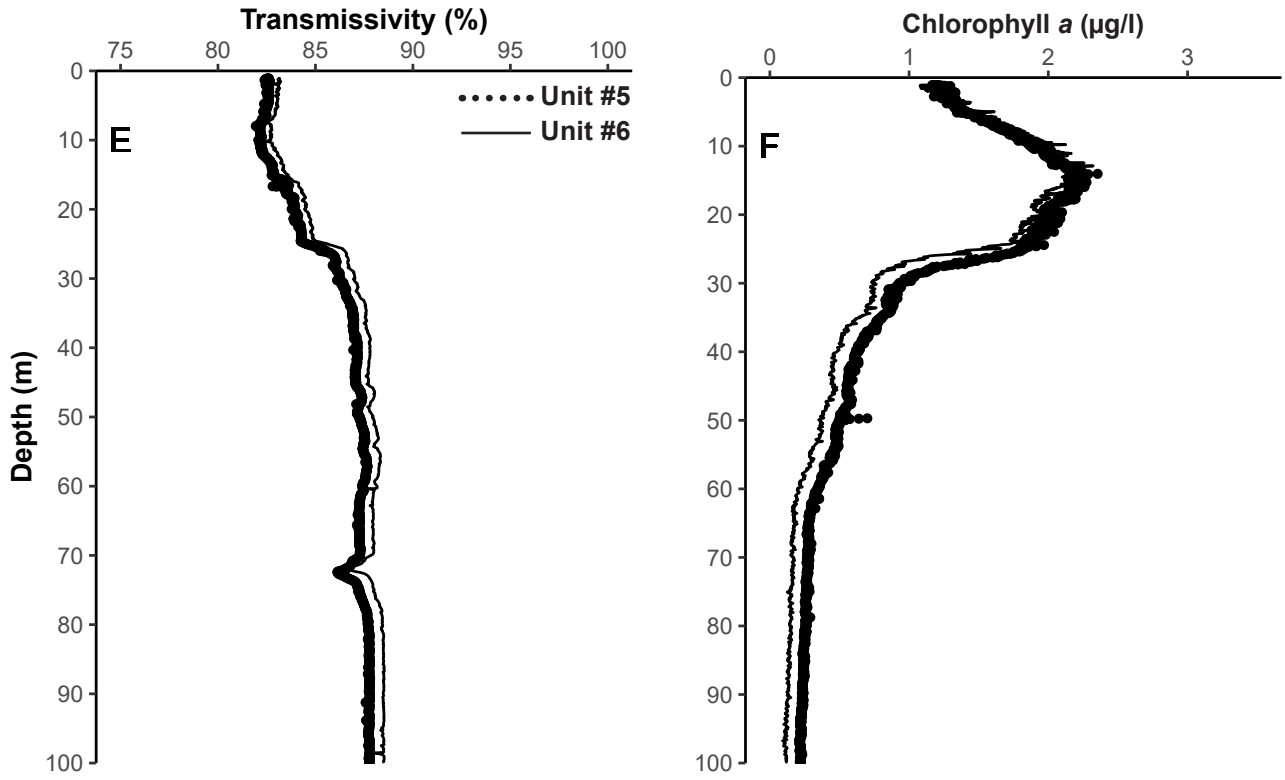

Figure 3 *continued*

malfunctions. These issues can also be identified by spike tests, rate of change tests, and flat line tests. Any data that have been adjusted to accommodate for sensor drift are assigned a unique flag, as are data that are determined to be bad or suspect. Parameters that are associated (i.e., read from the same sensor or otherwise covarying) are cross-referenced when flags are assigned. Notes about suspect data and flagging decisions are recorded in a table that is curated by the RTOMS coordinator and included in reports.

In addition, CTD casts, nitrate samples, and spectrophotometric pH/Total Alkalinity (pH/TA) samples are taken on a quarterly basis to provide an additional comparison of sensor performance and to inform sensor calibration offsets and drift. A CTD cast is completed as near to the mooring as possible, and CTD parameters are compared to the same RTOMS parameters at the same depths to check for gross offsets or sensor malfunctions on the moorings. This comparison is summarized in a table by year and used to inform flagging decisions. Water samples for nitrate (plus nitrite) and for pH/TA are also collected at the same depths as RTOMS sensors and may be used to provide drift corrections to sensor data as appropriate. For in-situ nitrate sensors in particular, lamp drift (loss of light intensity over time), as well as fouling drift, can result in the need for periodic field data corrections (Pellerin et al. 2013). Data-correction criteria are based on the uncertainty of the manufacturer-stated accuracy, and correction is recommended for the nitrate SUNA sensor if the sum of the total error is greater than 2 µM or 10% of the measured concentration, whichever is greater (Pellerin et al. 2013). However, data correction from discrete field samples is only possible if conditions are well mixed at a given depth, are not changing rapidly in time, and sensors are performing as expected. Decisions are left to best professional judgement and documented in the flagging table curated by the RTOMS coordinator. For much of 2021, RTOMS were not deployed due to logistics challenges stemming from the COVID-19

Table 7

RTOMS data qualifier definitions for QC flag columns. Follows national data standards for summary real-time data flagging (UNESCO/QARTOD), and post-processing flagging (NOAA/Argo program)(US IOOS 2020).

QC_Flag	Designation	Use
1	Pass/good	For data reviewed both automatically and manually
2	Provisional/unreviewed	For data that is not reviewed; or data received review but quality could not be determined
3	Suspect/questionable	Failed automated test but not unreasonable (such as climatology test) or manually flagged as possible instrument drift (such as due to biofouling)
4	Bad	Failed automated test (such as out of range test) or manually flagged as clearly bad (such as due to instrument malfunction)
5	Value changed/drift-corrected	Used only in post-processing. Values have been corrected based on new information, such as water sample results to correct for drift or new calibration factors. For data use purposes, this flag can be treated as a "pass." Original data are also to be retained separately.
9	Missing	Placeholder to show missing real-time data; may be able to be filled in later by downloaded data when available and after mooring recovery

pandemic, delays in instrument returns from manufacturers, and lack of a suitable deployment platform after the engine failure on the City's larger sampling vessel. As such, the CTD-RTOMS comparison table and flagging tables described previously are excluded from this report, but will be included in future QA reports. In addition, pH/TA sample analyses have been delayed and results are not available, but will be included in future reports as data become available.

Bacteriological Quality Assurance Analyses

Duplicate analyses are run throughout the year as QC for bacteriological data reported by the City. Field duplicates are two separate samples taken from the same station at the same time and then processed by a single analyst to measure variability between samples. Laboratory duplicates are designed to test an analyst's precision, and consist of two samples that are diluted, filtered, and plated from a single sample container. During 2021, a total of 570 QC water samples were collected, comprising 462 laboratory and 108 field duplicates (Table 5). The results from analyses performed on these samples have been reported previously in the Point Loma and South Bay monthly receiving waters monitoring reports, which are available online (City of San Diego 2022).

The sign test (Gilbert 1987) was used to compare the results from the paired laboratory and field duplicate analyses performed in 2021 (Table 8). When matched pairs of samples are used, the sign test assumes that the probability of observing samples with differing plate counts is equally distributed among positive (sample A > sample B) and negative (sample A < sample B) results. Samples that do not differ (A – B = 0) are excluded from the test. During 2021, results from duplicate field and laboratory samples were not significantly different ($p > 0.05$) for each of the three tested indicator bacteria (total coliforms, fecal coliforms, *Enterococcus*), indicating low variability between samples and high repeatability of laboratory measurements.

Table 8

Summary of bacteriological QA analyses conducted during 2021 for the City of San Diego's Ocean Monitoring Program. n = number of sample pairs with different colony counts (samples without differences are not included); B = the number of positive differences between pairs; Z_b = sign test outcome; H_o = the probability of observing positive and negative differences in plate counts between paired samples is equal (see text). Paired samples were compared using the sign test (see Gilbert 1987) at a $p = 0.05$ level of significance.

Sample Type	Parameter	n	B	Z_b	p	H_o
Lab Duplicate	Total Coliform	199	98	-0.2127	> 0.05	Fail to reject
	Fecal Coliform	127	74	1.8634	> 0.05	Fail to reject
	Enterococcus	133	67	0.0867	> 0.05	Fail to reject
Field Duplicate	Total Coliform	53	26	-0.1374	> 0.05	Fail to reject
	Fecal Coliform	45	20	-0.7454	> 0.05	Fail to reject
	Enterococcus	41	16	-1.4056	> 0.05	Fail to reject

In addition to the above QA analyses, the MML conducts monthly comparisons of bacterial colony counts to quantify the counting precision across analysts. Counts are performed on a single plate by pairs of analysts with the requirement that counts by any two analysts must fall within 10% of each other. This calculation is known as the Relative Percent Difference (RPD). During 2021, 341 count comparisons were performed. Of 119 total coliform count comparisons, 6 had an RPD greater than 10%, 2 of 121 fecal coliform comparisons exceeded 10% RPD, and 6 out of 111 *Enterococcus* comparisons exceeded 10% RPD. In addition to these QA procedures, all analysts maintain their competency to perform ELAP certified methods through regular proficiency tests or demonstrations of capability.

Macrofaunal Community Quality Assurance Analysis

Laboratory analyses of benthic macrofaunal samples involve three processes: (1) sample washing and preservation; (2) sample sorting; (3) identification and enumeration of all invertebrate organisms down to species level or the lowest taxon possible. Sorting QC is essential to ensuring the validity of the subsequent steps in the sample analysis process. The sorting of benthic samples into major taxonomic groups is contracted to an outside laboratory, with the contract specifying an expected 95% removal efficiency (i.e., at least 95% of organisms must be removed from the mixed invertebrate/sediment sample). Ten percent of the sorted samples from each sorter at the contract lab are subjected to re-sorting as QA for the contract. The original sorting of a sample fails the QA criterion if the abundance in the re-sorted sample deviates more than 5.0% from the total abundance of all animals from that sample. If more than one failure occurs, the contract requires the re-sorting of all samples previously sorted by an individual contract sorter. All samples re-sorted from the 2021 surveys met the acceptance QA criteria for sorting (Table 9).

Additionally, the laboratory performs re-identifications (re-IDs) as a QA measure to maintain consistency among taxonomists. For 2021, these were performed on six of the 138 grabs, and are included in the total count for Benthic Infauna Grab QA (Table 5). All re-identification sample analyses are conducted by taxonomists other than those who originally analyzed the samples and are completed without access to original results. All re-IDs conducted in 2021 met acceptance criteria as specified in the Bight′18 benthic laboratory manual (SCCWRP 2018).

Table 9

Results of benthic macrofauna sample re-sort analyses conducted during 2021 by the City of San Diego's Ocean Monitoring Program. Percent = (# of animals found in the resorted sample/total sample abundance) X 100.

PLOO			SBOO			REGIONAL		
Survey	**Station**	**Percent**	**Survey**	**Station**	**Percent**	**Survey**	**Station**	**Percent**
Jan-21	B10	0.0%	**Jan-21**	I10	0.0%	**Jul-21**	9201	0.0%
	E5	0.0%		I12	0.0%		9206	0.0%
	E7	0.0%		I15	0.0%		9216	0.0%
	E15	0.0%		I18	0.0%		9225	0.0%
	E21	0.0%		I21	0.0%		9235	0.0%
							9237	0.0%
Jul-21	B8	0.0%	**Jul-21**	I6	0.0%		9244	0.0%
	E5	0.0%		I14	0.4%			
	E8	0.0%		I18	0.0%			
	E17	0.3%		I29	0.0%			
	E26	0.0%						

Toxicology Quality Assurance Analyses

All required whole effluent toxicity and sediment toxicity analyses in 2021 were performed by the TL, which conducts routine reference toxicant testing as a part of its quality assurance program. A reference toxicant is a standard chemical used to measure the sensitivity of the test organisms and test precision. Consistency among the reference toxicant test results enhances confidence in the toxicity data concurrently obtained from the test material (wastewater effluent or marine sediment). A specific reference toxicant is used for each combination of test material, test species, test conditions and endpoints, and the material is chosen from a list developed by the USEPA. The reference toxicant is purchased from an approved supplier in aqueous form (stock solution), and the supplier must verify the concentration of the stock solution and provide written documentation of such analysis.

In most instances, a reference toxicant test is performed at the same time the test material is evaluated. A control chart for each test method is maintained by the division QA Manager or Laboratory Supervisor using results from no fewer than 20 of the most recent reference toxicant tests when available. The charted parameters that may be used include effect concentrations (LC_{50}, EC_{50}), control performance, percent minimum significant difference, and coefficient of variability.

Using a nominal error rate of 5.0%, results from 19 of the most recent 20 reference toxicant tests are expected to fall within two standard deviations of the simple moving average (unweighted running mean), while one of these tests may fall outside the control chart limits by chance alone. Additionally, a series of USEPA-recommended quality control limits are used to further evaluate test sensitivity.

Each run that is in violation of control limits would trigger an investigation of animal supply, reference toxicant stock quality, and laboratory practices. Additional testing may also be conducted to determine whether an exceedance is anomalous or if corrective actions are needed. All NPDES-mandated tests conducted with the affected animals are flagged, reviewed for anomalous responses, and in certain

cases, tests are repeated with a new batch of animals. Results for each toxicity test are reported regularly to the RWQCB in a Self-Monitoring Report, as defined in each NPDES permit. In 2021, all reference toxicant control charts for bioassays conducted by the TL met the acceptability criteria as specified in Standard Operating Procedures and USEPA Methods.

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