SD Public Utilities

Annual Receiving Waters Monitoring & Toxicity Testing Quality Assurance Report

2024

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Annual Receiving Waters Monitoring & Toxicity Testing Quality Assurance Report

2024

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

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Table of Contents

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2024 Quality Assurance Report

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 2024a). The Toxicology and Marine Microbiology laboratories also maintain quality manuals with additional technical information specific to their work (City of San Diego 2023b and 2024b, respectively). Additionally, the EMTS Division maintains its certification through the International Organization for Standardization (ISO) 14001 Environmental Management Systems program.

This report summarizes the QA/QC activities that were conducted during 2024 by City of San Diego staff in support of NPDES Attachment E 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) the 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. The 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.

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 (OMP) including 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 (PC) supervisor is to support the Ocean Monitoring Program manager by facilitating collaborations with external entities such as Scripps Institution of Oceanography, Southern California Coastal Water Research Project (SCCWRP), regulatory agencies, and other publicly owned treatment works. Examples include managing contracts for supplemental monitoring (satellite imagery, aerial kelp surveys, kelp forest underwater surveys) as well as serving as Bight Coordinator, SCCWRP Commission's Technical Advisory Group (CTAG) alternate, and Region Nine Kelp Survey Consortium chair. The PC supervisor also works closely with City staff and contract vendors to ensure data collection efforts meet permit requirements. In addition, they help with compliance report management, production, and submission, manage data requests, manage OMP data available via the City's Open Data Portal, and help maintain the City's Ocean Monitoring Program Reports and Data webpages.

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, Ideagen. 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 training, 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 (ROV), remotely operated towed vehicle (ROTV), 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 the vessel's 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/voucher sheets and keys, and conduct taxonomic training. This group also oversees fish dissections as part of the analysis of contaminant 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, supplies, and equipment; collection of field samples along the shore; and laboratory analyses using approved and accredited methods to measure concentrations of fecal indicator bacteria. ELAP-accredited analyses used for samples collected as part of NPDES permits include membrane filtration and multiple tube fermentation. 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, biological safety cabinets, and reagent-grade water point-of-use systems. Members are also responsible for developing sampling, analytical, and QA protocols for routine and 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 (City of San Diego 2023b).

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 of all toxicology data. In addition to being summarized here, the TL maintains a separate, detailed Quality 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 (City of San Diego 2024b).

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 in Attachment E 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 toxicity 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 liver and muscle 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.

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.

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 began with the 1994 Southern California Bight Pilot Project and have included subsequent Bight regional monitoring efforts every five years from 1998 until the most recent survey in 2023. 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. However, planning documents for the current Bight'23 project, including its QAP, are available on SCCWRP's website (www.sccwrp.org).

Summary of Work Performed in 2024

During 2024, a total of 6116 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 10% (n = 602) were QC samples, such as lab or field duplicates. In addition, a total of 1659 QA analyses 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) instruments 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.

CTD Calibration and Maintenance

The MBOO section uses two Sea-Bird Electronics (SBE) SBE-25plus water column profiling CTDs integrated with modular sensors. Both systems may be configured with sensors to profile temperature, salinity, dissolved oxygen (DO), pH, transmissivity, chlorophyll a (chl a) and colored dissolved organic matter (CDOM) nearly continuously through the water column. Sea-Bird Scientific's SBE-55 mini carousel packages are integrated into both CTD's and may be configured with up to six 4-liter Niskin bottles. Typically, one CTD (Unit#5) is used for weekly monitoring with the other (Unit#6) as a functional standby in case of failure or loss, and for verification of sensor accuracy through intercalibration exercises.

Sea-Bird Scientific recommends annual factory calibration and service for many of their sensors, and other SBE sensors have even shorter service intervals. MBOO carries an inventory of sensors to rotate instruments out of service and back to the factory at the recommended intervals. Conductivity, temperature, pressure, pH and DO sensors are rotated out every six months, while fluorometers (CDOM and chl a sensors) and transmissometers are rotated annually. MBOO maintains an inventory of sensors sufficient to ensure that newly calibrated spares are available, and most sensors can have as many as three or four calibrated spares awaiting deployment or testing.

The SBE 25+ CTD can report most sensor readings in real-time as the cast is taken. These data are used to determine if sensors are reporting within their expected ranges during sampling cruises as well as during calibration exercises. If any probe is determined to be outside these normal ranges (for example, negative values, unchanging values, etc.) and a field repair cannot be completed, sampling may be terminated immediately, and the sensor replaced with a newly calibrated spare in the laboratory. In addition, periodic sensor calibrations are performed depending on the historical reliability of the various sensors. If any sensor malfunctions or drifts out of its accepted range, or is otherwise deemed unreliable, it is removed from the CTD and replaced with a newly calibrated spare.

The pH, transmissivity, temperature, and pressure 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 >0.05 pH units, the probe is recalibrated. The transmissometer on each CTD is checked by cleaning the windows of the LED light path and recording the sensor output for obstructed (0% transmissivity) and unobstructed (100% transmissivity) light paths in air. If unblocked sensor readings deviate >5% of prior readings, then the sensor is recalibrated with the new blocked/unblocked readings. The temperature probe is checked for functionality and the temperature reading is recorded to inform the pH calibration. The pressure sensor is checked to report a near-zero value in air. The DO probe (model SBE43) is scheduled for monthly calibrations to check for sensor drift in an oxygen-saturated bath. If the sensor drift is ≥5% from factory calibration, the DO sensor coefficients are reset to compensate for this drift. If the DO sensor reading drifts >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.

MBOO 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. For calendar year 2024, the intercalibration exercises were conducted in January and September. During these exercises, the two CTDs configured with similar probes are attached to each other and deployed to a depth beyond 100 m and retrieved three separate times. For each cast, depths greater than 100 m are discarded to minimize bottom effects. After the three casts are completed, results for six different parameters (i.e., temperature, salinity, dissolved oxygen (DO), pH, transmissivity, chl a) are compared and deviations between the instrument assemblies reported. The results are summarized in Table 6A, and Figures 2 and 3, and compared to results from previous years in Table 6B.

In addition to intercalibration exercises, spectrophotometric pH/Total Alkalinity (pH/TA) water samples are collected quarterly to calibrate the pH results measured by the CTD profiler (Table 5). Though pH/TA samples have been collected for CTD pH calibration, results of sample analysis are not currently available but will be included in a future report as data become available and analyzed.

The data from the January 2024 intercalibration showed that most sensors from Unit#6 (temperature, salinity, DO, transmissivity) reported nominal values and were thus rotated into service (Table 6A, Figure 2). However, there was a mean difference of about 0.17 pH units in the pH readings between CTD units. While a discrepancy of this magnitude is outside our targeted calibration range, this difference is within the expected cumulative error associated with deploying these sensors in the field (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.

Additionally, the WETStar chl a sensor mounted on Unit#6 was found unresponsive during this intercalibration exercise, and thus was not rotated into service or used as a replacement. Sales and service for this sensor model (WETStar fluorometer) were discontinued in 2023 by the manufacturer, thus the sensor cannot be sent in for service or repair. To ensure continuity in chl a data, staff have been testing the SeaOWL fluorometer as a replacement for the WETStar chl a and CDOM fluorometers. Given the failure of the U6 WETStar during the January 2024 intercalibration exercise, the assessment of sensor condition on Unit#5 (CTD in active service) was made by comparing the currently reported WETStar chl a data to the SeaOWL measurements of chl a in Figure 2F. Despite the measurements of chl a coming from different sensor models, there was very good agreement between the WETStar and the SeaOWL chl a data (Figure 2F). The Unit#5 WETStar chl a Sensor (SN WS3S-1114) and the SeaOWL chl a /CDOM sensor were both kept in service on Unit#5 as there is currently no direct replacement for the SBE WETStar chl a and CDOM sensors. While the SeaOWL reports similar values, the data are not available in real-time through 25+ CTD and must be downloaded from the 25+ internal memory at the end of the cruise.

The intercalibration exercise in September 2024 identified a malfunctioning DO sensor before deployment in the field (Table 6A, Figure 3C), with all other sensors reporting within expected ranges and showing good agreement with currently deployed sensors (Figure 3). During this intercalibration, the DO sensor on Unit#6 was reporting outside the nominal range for this sensor type. This malfunction was not correctible in the field, so there is no intercalibration comparison for the DO sensor for that deployment. After diagnosing the failure of DO in Unit#6 in the lab, an alternate sensor was rotated into service. In this case, the continuity of DO data was verified independently using calibrations in an oxygen-saturated bath for all deployed DO sensors (Table 7).

2024 was full of challenges resulting from CTD instrumentation. WETStar sensors for chl a and CDOM, two stalwarts of the monitoring program for many years, have been discontinued. WETLab sensors that malfunctioned this year cannot be returned to service. Staff have been testing replacements for chl a and CDOM sensors through 2024. Currently, a promising replacement sensor package is the Sea-Bird SeaOWL, which reports chl a, CDOM, and diagnostic "backscatter" data. The SeaOWL was being parallel tested against the WETStar on Unit#5 and shows promising results, although it is not without its own challenges.

Due to hardware limitations of the SBE 25+ CTD, the SeaOWL does not report data in "real time" via the ship's live wire to the current deck based CTD computing station, but rather, must be downloaded from the SBE 25+ on-board memory and "pre-processed" before use. The SBE 25+ downloading procedure involves opening the CTD housing and is not advisable under field conditions and so is performed in the lab after the end of the sampling cruise. The WETStar, in contrast, displays data in real-time to the sampling biologist as the cast is being taken. This real-time data is used to ensure that the CTD is functioning properly and to immediately diagnose errors in many cases. The sampling biologist depends on this data to decide to accept a cast or reject it and re-cast before leaving the station. Thus, the WETStar sensors continue to be deployed alongside the SeaOWL sensor because it provides valuable real-time information to the sampling biologist.

Staff are exploring a 3rd party sensor manufacturer for chl a and CDOM (Seapoint sensors Fluorometer) with analog output that can report data to the deck unit in real-time. This makes the Seapoint viable as direct replacement for the discontinued WETStar sensors. These Seapoint sensors are in the initial setup and CTD integration phase and data from the Seapoint sensors will be compared to other instrumentation in future reports.

Dissolved oxygen sensor failure in Unit#6 during the September intercalibration highlights the need for consistently testing instrumentation prior to deployment. Based on the data from the intercalibration, the unresponsive DO sensor was not rotated into service, and an alternate sensor was deployed instead. The alternate sensor's accuracy was verified using in-house calibration tests, as staff continue to periodically test DO to ensure accuracy of the sensor. Regular testing and calibration of all instrumentation is essential in ensuring monitoring data collected are accurate enough to satisfy regulatory requirements.

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 (https://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 8) based on gross sensor ranges, climatological ranges built from 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 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 annual reports.

To help identify possible mooring sensor failures, validation CTD casts are completed as near to the mooring as possible on a quarterly basis, and at the beginning and end of each deployment. Relevant CTD parameters are compared to the same RTOMS parameters at the same depths to check for gross offsets, drift, or sensor malfunctions on the moorings. Due to sharing the same sensor technology between the CTD and the RTOMS, temperature, salinity, and dissolved oxygen measurements are summarized for 2024 (Tables 9 and 10, Figures 4–7). A total of five CTD validation casts were completed near the PLOO RTOMS (Table 9) and four total CTD casts were completed near the SBOO RTOMS (Table 10). An example of a CTD cast profile during a period when surface waters were relatively well-mixed (February 2024 for PLOO and SBOO) is shown for each mooring (Figures 4 and 5), as well as an example profile during a stratified period (August 2024 for PLOO and SBOO) for each mooring (Figures 6 and 7). Both downcast and upcast CTD data are shown to provide context for variability of ocean conditions. In general, when moorings were operational and functioning as expected, RTOMS temperature, salinity, and dissolved oxygen were within reasonable ranges of CTD cast measurements at similar depths.

Some differences between RTOMS and CTD observations are expected due to spatial and temporal differences in water masses measured by each instrument, particularly when ocean conditions are not well mixed and are rapidly changing. One notable example is the difference between PLOO RTOMS salinity compared to CTD salinity at deeper depths (45–90 m), which occurs on a frequent basis (Table 9, Figures 4B and 6B). These differences in salinity may likely be due to detection of the PLOO effluent plume by the RTOMS, where the RTOMS may have been closer to the effluent plume. Additionally, salinity differences could be due to a potential reduction in mixing between the freshwater effluent plume and ocean water masses by the equipment itself (see Chapter 4 in City of San Diego 2022). For example, the mooring instruments are suspended passively in the water column at a fixed location, while large profiling packages such as the CTD rosette may result in turbulence and additional mixing as moved through the water (e.g., Paver et al. 2020). Given these factors, these differences in PLOO RTOMS salinity at deep depths are within reasonable ranges and are not used to assess mooring functionality in most cases. However, in spring 2024, salinity at 20 m depth at the PLOO RTOMS began to drift lower than values at all other depths and continued to drift outside of reasonable ranges (Table 9). Upon recovery, it was discovered that the conductivity (salinity) cell guard was missing, and the sensor was damaged. In addition, salinity at the 26 m depth at the SBOO RTOMS was lower than expected in February and May 2024 when compared to the CTD casts and 18m depth sensor readings (Table 10, Figure 5). Therefore, PLOO and SBOO RTOMS data will be carefully assessed for potential sensor drift and any suspect data will be flagged. Where possible, salinity data will be drift corrected if errors are systematic and if post calibration information is available from the manufacturer after mooring recovery.

In addition to data QA, both nitrate + nitrite water samples and spectrophotometric pH/Total Alkalinity (pH/TA) water samples are taken from CTD validation casts on a quarterly basis to provide an additional comparison of sensor performance and to inform sensor calibration offsets and drift. During CTD validation casts, these water samples are collected at the same depths as RTOMS sensors and may be used to provide drift corrections to sensor data as appropriate. For in-situ SUNA nitrate sensors in particular, lamp drift (loss of light intensity over time), as well as fouling drift and interference from organic matter and turbidity, 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). In addition, negative reported nitrate data typically indicate downward drift of the sensor. 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 the best professional judgement, and any drift corrections are documented in the flagging table curated by the RTOMS coordinator. For 2024, water samples analyzed for nitrate + nitrite were compared to mooring SUNA nitrate sensor data on similar depth and time scales (Table 11). Where possible, sensor drift corrections will be applied using water samples for three of the four total location/depths for SUNA sensors deployed in 2024. Some corrections are not possible where ocean conditions were too variable, or where problems occurred with water samples or mooring SUNA sensors. For the PLOO sensor at 30 m, values showed an initial negative offset followed by linear upward drift throughout the deployment, when compared to water samples (Table 11). For the PLOO sensor at 89 m, values showed an initial positive offset when compared to water samples, followed by noise and step changes for the remainder of the year where drift corrections were not possible. For the SBOO sensor at 1m, values for the SBOO-5 deployment (January – May 2024) were not possible to correct due to inconsistent downward drift; however, values for the SBOO-6 deployment (July – December 2024) showed a small negative offset that was corrected using minimum SUNA values and verified with water samples. For the SBOO sensor at 26m, the sensor was not operational for most of the year. Details on drift corrections are shown in Table 11 and will be further documented in the flagging Table (QC log) for the annual report. Though pH/TA samples at the RTOMS have been collected, analyses have been delayed, and not all results are available for 2024, but will be included in future reports as data become available and analyzed.

Bacteriological Quality Assurance Analyses

Duplicate analyses are run throughout the year as QA checks on 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 whether analysts can replicate their own results and consist of two samples that are processed from a single sample container by a single analyst to measure analyst precision. During 2024, a total of 587 QA/QC water samples were collected, which comprised 478 laboratory and 109 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 (City of San Diego 2025).

The sign test (Gilbert 1987) was used to compare the results from the paired laboratory and field duplicate analyses performed in 2024 (Table 12). When matched pairs of regular and duplicate laboratory or field samples are used, the sign test sets the null hypothesis 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) differences. Samples that do not differ (i.e., A - B = 0) are not included in the test. During 2024, results from duplicate field and laboratory samples were not significantly different ($p > 0.05$) for each of the three tested indicator bacteria (i.e., total coliforms, fecal coliforms, *Enterococcus*), indicating low variability between samples and high repeatability of laboratory measurements.

In addition to the above QA analyses, the Marine Microbiology Lab conducts monthly comparisons of bacterial colony counts to quantify the counting precision of each analyst. 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 2024, 270 count comparisons were performed. For total coliform counts, 11 out of 94 count comparisons had a greater than 10% RPD. For fecal coliform counts, 6 out of 89 comparisons had an RPD exceeding 10%. For *Enterococcus* counts, 2 out of 87 count comparisons had an RPD greater than 10%. 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 completed 2024 surveys met the acceptance QA criteria for sorting (Table 13).

Additionally, the laboratory performs re-identifications (re-IDs) as a QA measure to maintain consistency among taxonomists. For 2024, these were performed on six of the 147 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 2024 met acceptance criteria as specified in the Bight'23 benthic laboratory manual (SCCWRP 2023).

Toxicology Quality Assurance Analyses

All required whole effluent toxicity and sediment toxicity analyses in 2024 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 San Diego RWQCB in a Self-Monitoring Report, as defined in each NPDES permit. In 2024, 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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FIGURES & TABLES

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 [a]	October 1, 2017 – September 30, 2022
SBWRP	CA0109045	R9-2021-0011	July 1, 2021 – June 30, 2026
SBIWTP	CA0108928	R9-2021-0001	July 1, 2021 – June 30, 2026

[a] As amended by Order No. R9-2022-0078; administratively extended until superseded by another Order.

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 Analyzed	Samples/Yr x No. Parameters	Notes
Water Quality,	shore	8	Seawater - FIB	1	1/Week	52	416	T, F, E [a]	1248	1 sample/station
Microbiology,										
Oceanographic	kelp/	8	Seawater - FIB	3	1/Week	52	1248	T, F, E [a]	3744	3 depths/station
Conditions	nearshore	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	—	Grab	1	1/Year	1	—		—	Randomized stations (Jul) [g]
Sediment Toxicity	offshore	8-28	Grab	1	1/Year	1	8-28	acute toxicity	8-28	Rotating offshore stations
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							**2998**		**11,466**	

[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)

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 Analyzed	Samples/Yr x No. Parameters	Notes
Water Quality, Microbiology,	shore	11	Seawater - FIB	1	1/Week	52	572	T, F, E[a]	1716	1 sample/station
Oceanographic Conditions	kelp/ nearshore	7	Seawater - FIB	3	1/Week	52	1092	T, F, E[a]	3276	3 depths/station
		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
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)

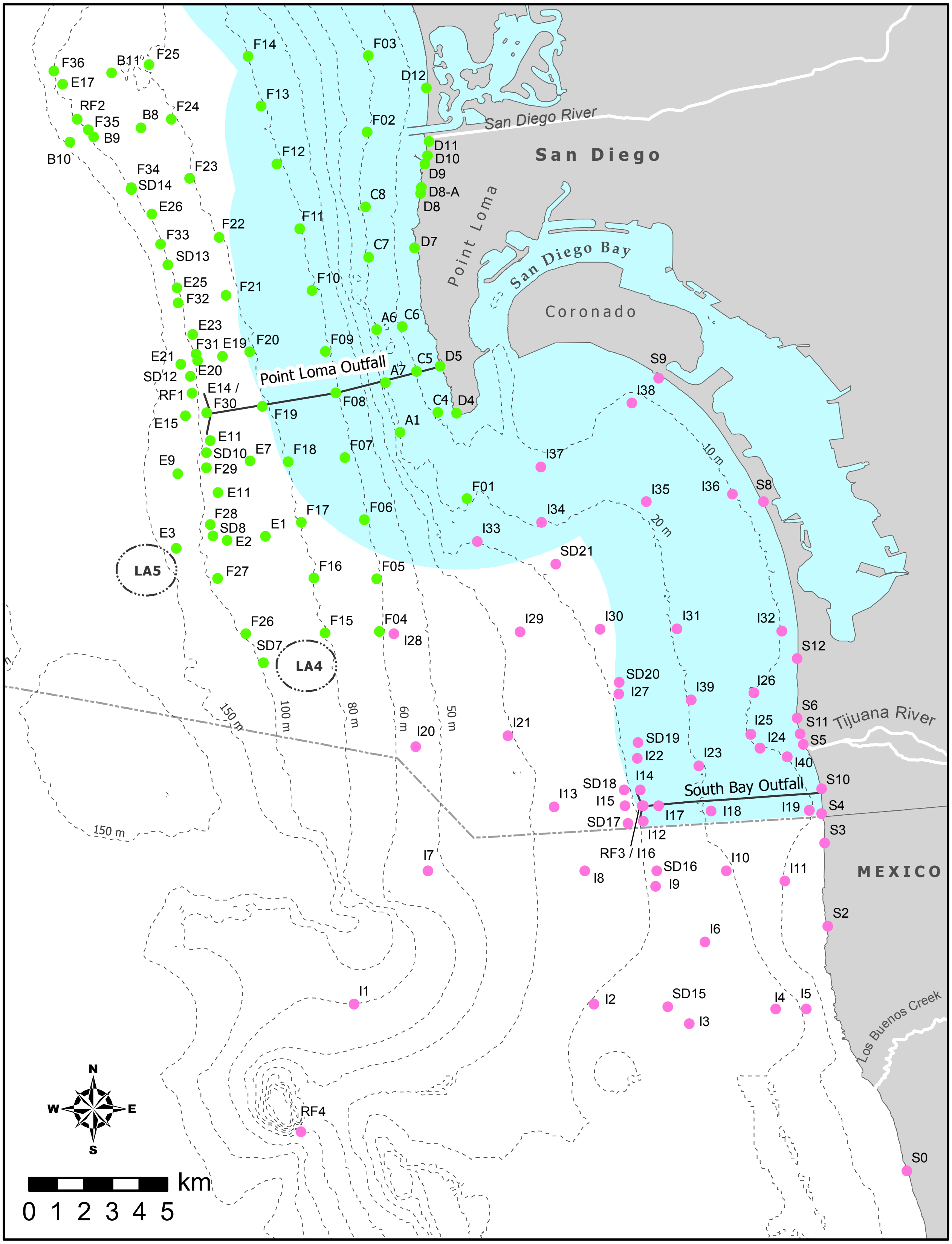

Figure 1
Core receiving waters monitoring stations for the PLOO (green) and SBOO (pink) sampled as part of the City of San Diego's Ocean Monitoring Program. Light blue shading represents State jurisdictional waters.

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] The IWC of 1.06% effluent, using the test of significant toxicity (TST)

Table 5

Number of discrete samples collected and analyzed by EMTS staff for NPDES permit-related activities during 2024. NA = not applicable.

	Number of Samples Collected		Number of Analyses per Sample Type	
Sample Type	**Regular**	**QC**	**Regular**	**QA**
Sediment Grab				
Particle Size Subsample	98	NA	(performed by ECS)	
Chemistry Subsample	416[a]	NA	(performed by ECS)	
Benthic Infauna Grab	147	NA	147	6
Otter Trawl	26	NA	26	NA
Fish Tissue	39	NA	(performed by ECS)	
Water Quality				
CTD Cast	1070	NA	9608[c]	NA
Microbiology	4206[b]	587	11,474[d]	1633[d]
pH/TA	81[e]	15[e]	(performed by SCCWRP)	
Toxicology				
Sediment Toxicity	8	NA	8	1
Chronic Bioassay	25	NA	25	19
Totals	**6116**	**602**	**21,288**	**1659**

[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*)
[e] Includes samples collected quarterly for both CTD and RTOMS pH sensor calibration. Not all pH/TA samples have yet been analyzed, see text for details.

Table 6

Summary of the CTD intercalibration results for casts conducted during 2024, 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

	January 2024				September 2024			
Parameter	**MeanΔ**	**MaxΔ**	**Cast**	**Depth (m)**	**MeanΔ**	**MaxΔ**	**Cast**	**Depth (m)**
Temperature (°C)	0.01	0.09	2	3	0.02	0.27	2	21
Salinity (ppt)	0.00	0.02	1	72	0.01	0.07	1	9
DO (mg/L)	0.19	0.34	3	8	8.65	10.64	1	26
pH	0.17	0.21	3	86	0.08	0.11	2	92
Transmissivity (%)	0.31	1.63	3	71	1.13	5.48	2	1
Chlorophyll *a* (µg/L)[a]	0.24	0.62	3	27	0.07	0.77	3	51

B

Parameter	**Dec 2019**	**Jul 2020**	**Jan 2021**	**Jun 2021**	**Dec 2021**	**Jun 2022**	**Dec 2022**	**Jul 2023**	**Jan 2024**	**Sep 2024**
Temperature (°C)	0.01	0.01	0.01	0.04	0.01	0.02	0.01	0.09	0.07	0.22
Salinity (ppt)	0.02	0.01	0.01	0.01	0.01	0.003	0.003	0.01	0.02	0.06
DO (mg/L)	0.39	0.06	0.29	0.16	0.18	0.04	0.12	0.08	0.32	9.26
pH	0.06	0.18	0.07	0.05	0.22	0.06	0.07	0.10	0.20	0.10
Transmissivity (%)	3.88	3.97	5.56	1.96	0.80	11.10	0.14	1.66	1.39	4.01
Chlorophyll *a* (µg/L)[a]	0.74	0.30	0.08	0.28	0.13	0.86	0.12	0.06	0.49	0.49

[a] During the January intercalibration, the Unit#6 Chlorophyll *a* sensor experienced malfunction in the field, thus data presented are a comparison between the Unit#5 WETStar chl a and SeaOWL chl a /CDOM sensors. See text for details.

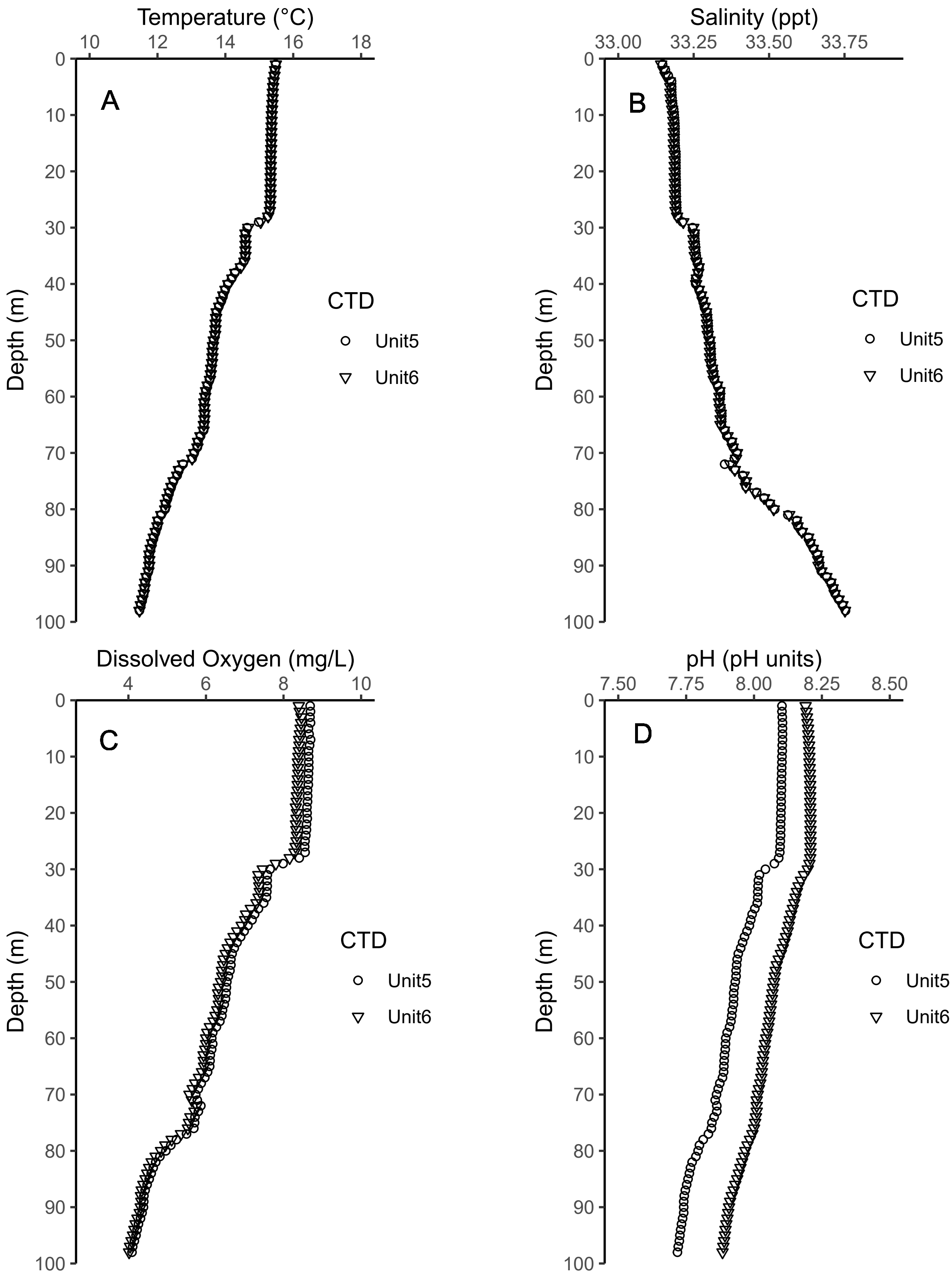

Figure 2

Comparison of results from CTD Unit #5 and Unit #6 from one representative cast made during the January 2024 CTD intercalibration exercise. Data include 1 m bin-averaged cast profiles for (A) temperature, (B) salinity, (C) dissolved oxygen, (D) pH, and (E) transmissivity. Due to a chlorophyll *a* sensor malfunction on Unit#6 during the January 2024 intercalibration, (F) represents a comparison of chlorophyll *a* between the Unit#5 WETStar and SeaOWL sensors. See text for details.

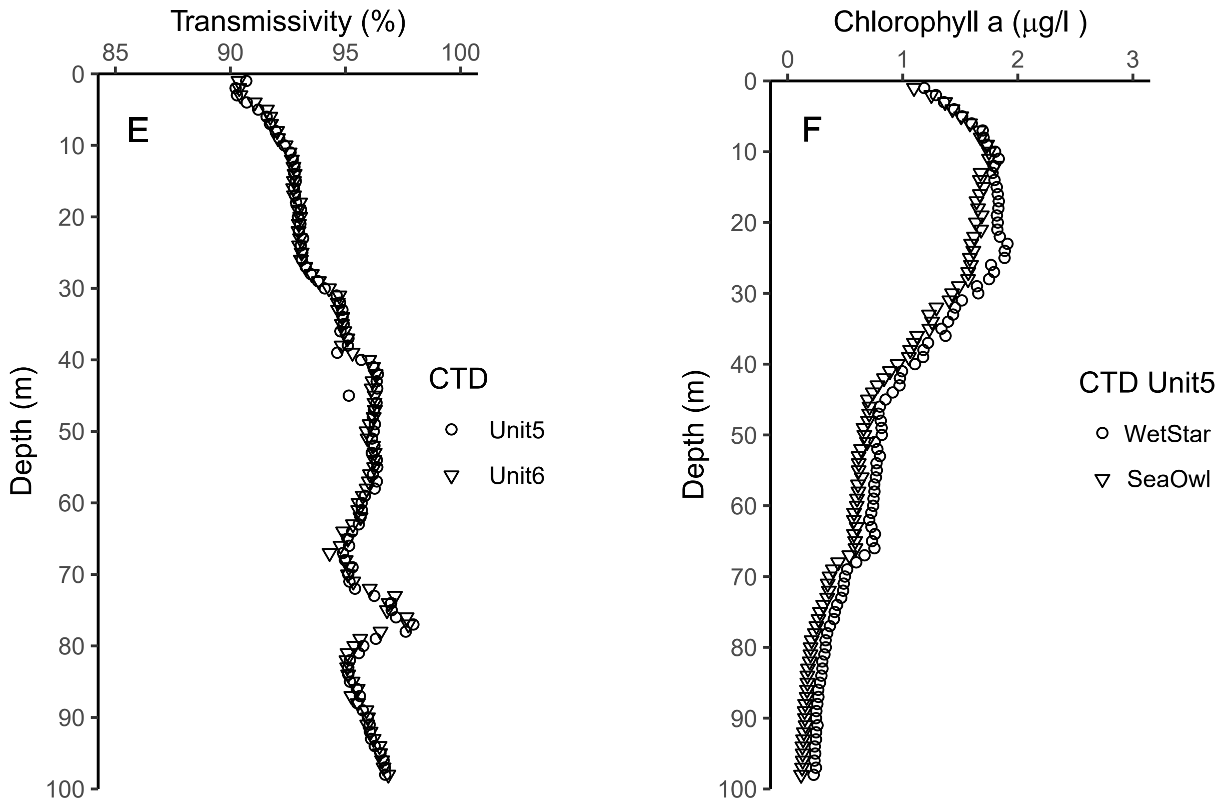

Figure 2 *continued*

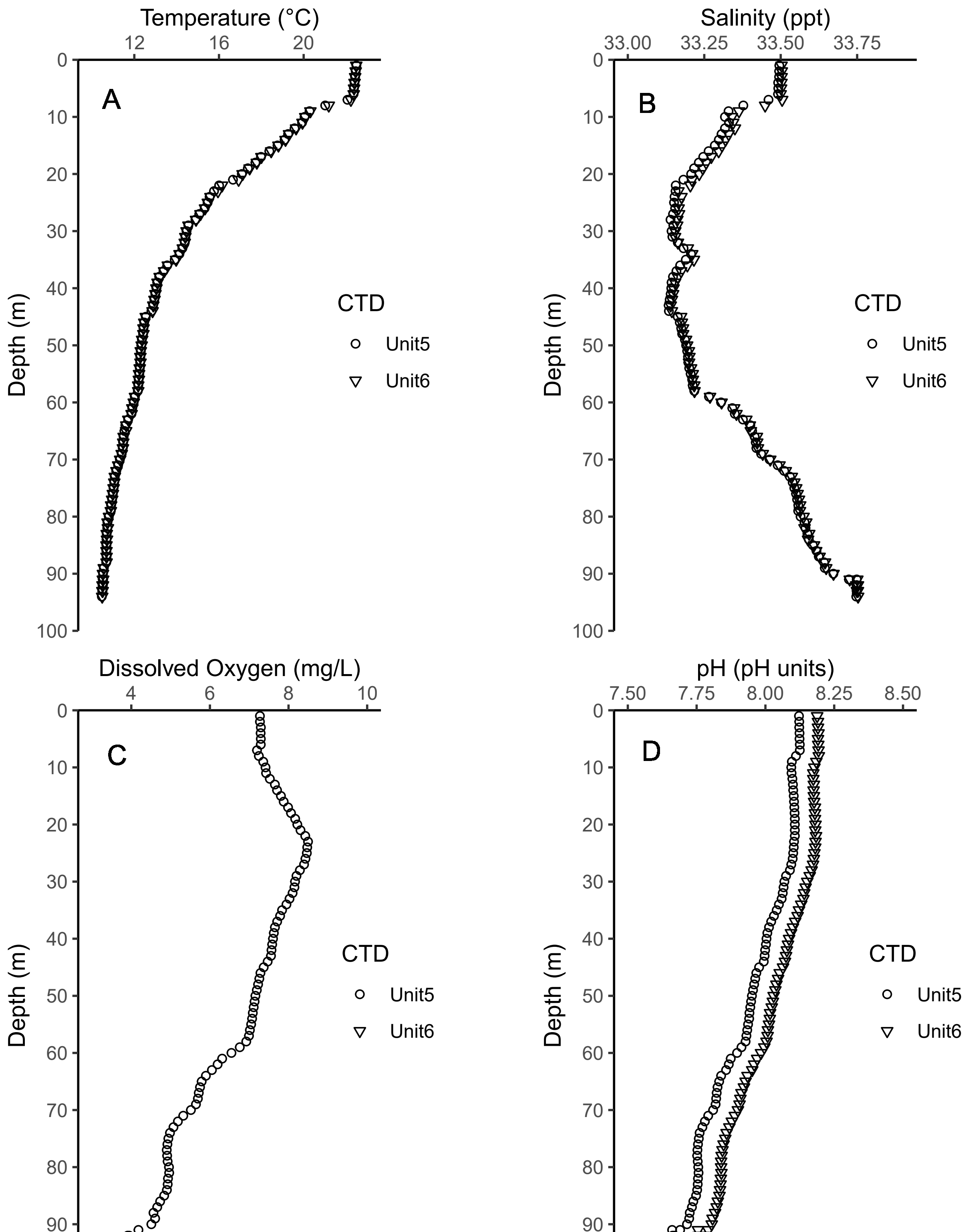

Figure 3

Comparison of results from CTD Unit #5 and Unit #6 from one representative cast made during the September 2024 CTD intercalibration exercise. Data include 1 m bin-averaged cast profiles for (A) temperature, (B) salinity, (C) dissolved oxygen, (D) pH, and (E) transmissivity. Due to a chlorophyll *a* sensor malfunction on Unit#6 during the January 2024 intercalibration, (F) represents a comparison of chlorophyll *a* between the Unit#5 WETStar and SeaOWL sensors. See text for details.

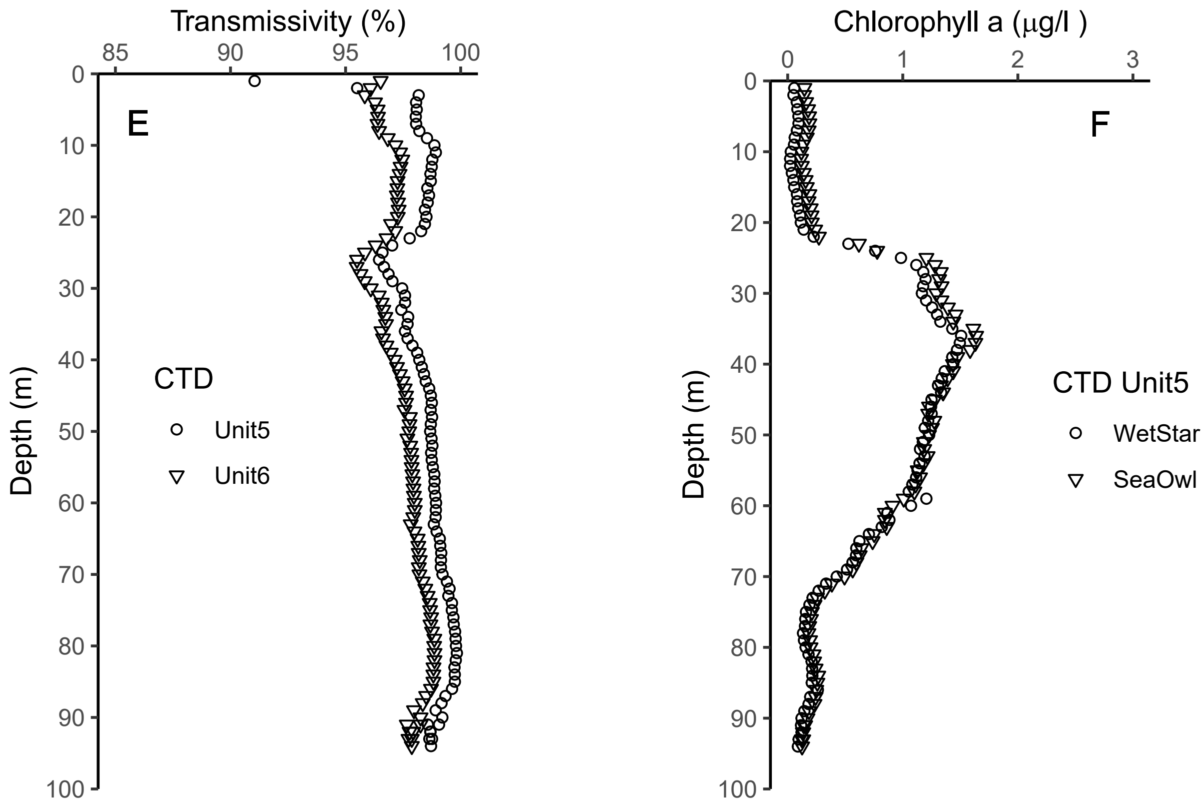

Figure 3 *continued*

Table 7

Results of routine dissolved oxygen sensor calibration for 2024.

Dissolved oxygen sensor calibration record, 2024		
Calibration Date	**Serial Number**	**O_2 (%)**
1/10/2024	43-0144	98.6
3/1/2024	43-0316	100.8
4/1/2024	43-0316	99.5
6/1/2024	43-0316	98.9
8/28/2024	43-1430	99.3
10/1/2024	43-1430	100.8
10/29/2024	43-1430	99.5
12/6/2024	43-1430	100.2
1/15/2025	43-2910	100.3

Table 8

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 2023).

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 bio-fouling)
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

Table 9

Summary of CTD (Sea-Bird 25Plus) and PLOO RTOMS temperature (Temp), salinity (Sal), and dissolved oxygen (DO) results from validation casts completed in 2024. NA = not available.

Sample Date	Actual Depth (m)	Temp_CTD (°C)	Temp_RTOMS (°C)	Sal_CTD (ppt)	Sal_RTOMS (PSU)	DO_CTD (mg/L)	DO_RTOMS (mg/L)
2-Jan-24	1	16.5	16.6	32.82	33.25	7.3	8.2
	10	16.6	16.6	33.24	33.25	8.1	NA
	20	16.6	16.6	33.24	33.24	8.1	NA
	30	16.5	16.6	33.24	33.24	8.1	8.1
	45	15.2	15.0	33.24	33.27	7.1	NA
	60	14.0	14.0	33.21	33.21	6.8	NA
	75	12.3	11.9	33.41	33.48	5.6	5.0
	87	11.6	11.6	33.56	33.53	4.8	NA
	89	11.6	11.6	33.58	33.53	4.7	4.7
13-Feb-24	1	15.0	15.0	32.56	33.08	6.8	8.4
	10	15.0	15.0	33.07	33.08	8.1	NA
	20	14.9	14.9	33.08	33.08	8.1	NA
	30	14.9	14.9	33.09	33.09	7.9	8.2
	45	13.6	13.7	33.25	33.26	6.6	NA
	60	12.3	12.3	33.43	33.44	5.3	NA
	75	11.4	11.5	33.51	33.52	4.5	4.7
	87	11.2	11.2	33.63	33.18	4.3	NA
	89	11.1	11.1	33.68	33.38	4.2	4.1
14-May-24	1	17.2	17.6	33.24	33.43	7.5	8.5
	10	12.3	12.6	33.45	33.41	5.8	NA
	20	11.0	10.8	33.57	33.24	4.7	NA
	30	10.6	10.7	33.66	33.64	4.5	NA
	45	10.5	10.5	33.76	33.76	3.4	NA
	60	10.1	10.2	33.85	33.55	3.5	NA
	75	9.9	9.9	33.90	33.62	2.9	2.6
	87	9.9	9.9	33.94	33.77	3.0	NA
	89	9.9	9.9	33.95	33.78	3.0	3.0
13-Aug-24	1	22.4	22.9	32.75	33.48	5.7	8.1
	10	18.0	17.9	33.45	33.37	11.5	NA
	20	13.8	12.7	33.40	32.55	8.6	NA
	30	11.8	11.8	33.33	33.33	6.5	NA
	45	11.2	11.3	33.45	33.12	5.6	NA
	60	10.7	10.7	33.59	33.05	4.3	NA
	75	10.7	10.7	33.64	33.15	4.2	3.6
	87	10.7	10.7	33.68	33.43	4.1	NA
	89	10.7	10.7	33.69	33.22	4.0	4.0

Table 9 *continued*

Sample Date	Actual Depth (m)	Temp_CTD (°C)	Temp_RTOMS (°C)	Sal_CTD (ppt)	Sal_RTOMS (PSU)	DO_CTD (mg/L)	DO_RTOMS (mg/L)
19-Nov-24	1	15.6	15.6	33.36	33.32	8.2	8.2
	10	15.4	15.4	33.35	33.23	8.2	NA
	20	13.7	12.9	33.24	27.92	7.5	NA
	30	12.4	12.4	33.25	33.16	6.7	6.9
	45	11.5	11.5	33.38	33.36	5.5	NA
	60	10.6	10.6	33.56	33.20	4.4	NA
	75	10.3	10.3	33.62	33.58	4.0	3.6
	87	10.3	10.3	33.67	33.36	3.9	NA
	89	10.3	10.3	33.68	33.50	3.9	3.5

Table 10

Summary of CTD (Sea-Bird 25Plus) and SBOO RTOMS temperature (Temp), salinity (Sal), and dissolved oxygen (DO) results from validation casts completed in 2024. NA = not available.

Sample Date	Actual Depth (m)	Temp_CTD (°C)	Temp_RTOMS (°C)	Sal_CTD (ppt)	Sal_RTOMS (PSU)	DO_CTD (mg/L)	DO_RTOMS (mg/L)
22-Feb-24	1	15.6	15.7	32.80	32.85	8.0	8.2
	10	15.1	15.3	32.97	32.88	8.1	NA
	18	14.5	14.6	33.08	33.03	7.8	8.0
	26	13.8	13.8	33.16	32.46	7.1	7.2
8-May-24	1	17.2	17.2	33.18	33.38	7.6	8.5
	10	13.9	13.7	33.44	33.38	8.1	NA
	18	11.3	11.3	33.57	33.53	4.7	4.7
	26	10.9	10.9	33.68	33.02	4.1	3.6
7-Aug-24	1	21.0	20.9	33.17	33.46	7.1	7.6
	10	15.1	16.1	33.40	33.37	8.8	NA
	18	12.1	12.4	33.44	33.46	6.9	7.8
	26	11.6	11.5	33.53	33.54	5.1	4.8
6-Nov-24	1	16.1	16.1	33.18	33.27	8.1	8.5
	10	14.6	12.9	33.27	33.34	7.7	NA
	18	12.3	12.0	33.27	33.31	6.2	6.4
	26	11.7	11.7	33.35	33.34	5.6	5.4

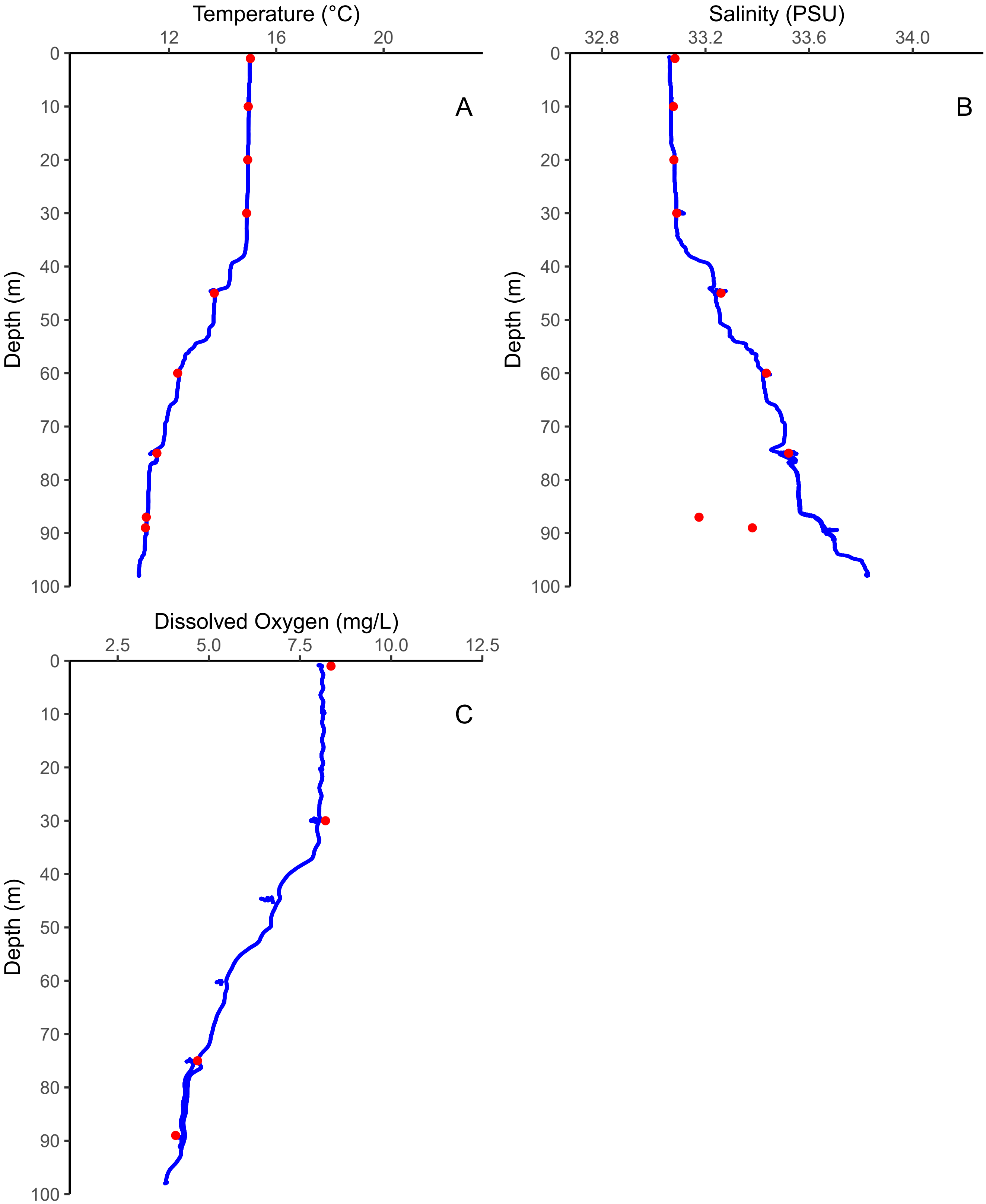

Figure 4

Comparison of results from the Sea-Bird 25Plus CTD profiles (blue line) and the PLOO RTOMS sensors (red dots) during the February 2024 CTD validation cast. Data include (A) temperature, (B) salinity, and (C) dissolved oxygen.

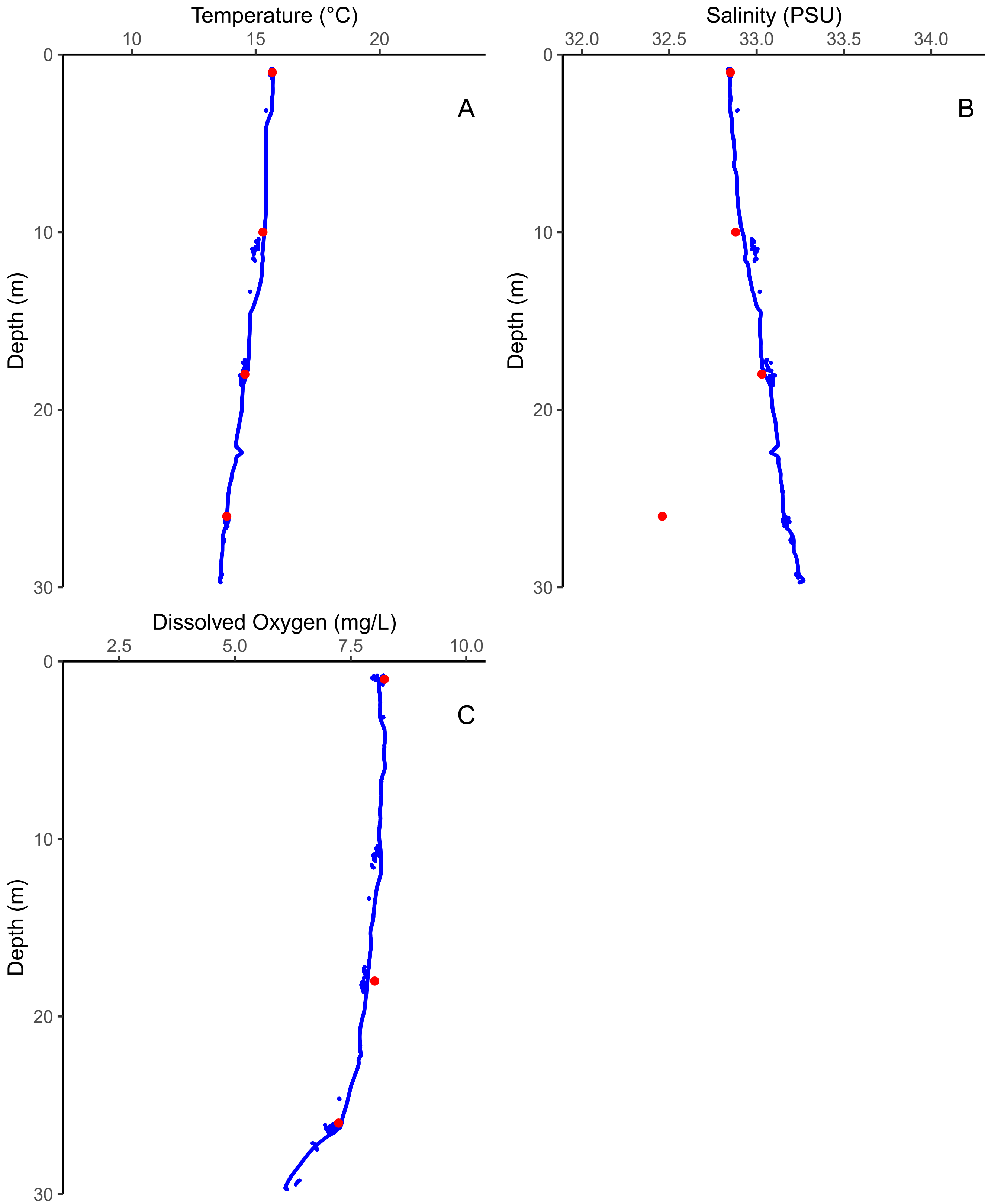

Figure 5
Comparison of results from the Sea-Bird 25Plus CTD profiles (blue line) and the SBOO RTOMS sensors (red dots) during the February 2024 CTD validation cast. Data include (A) temperature, (B) salinity, and (C) dissolved oxygen.

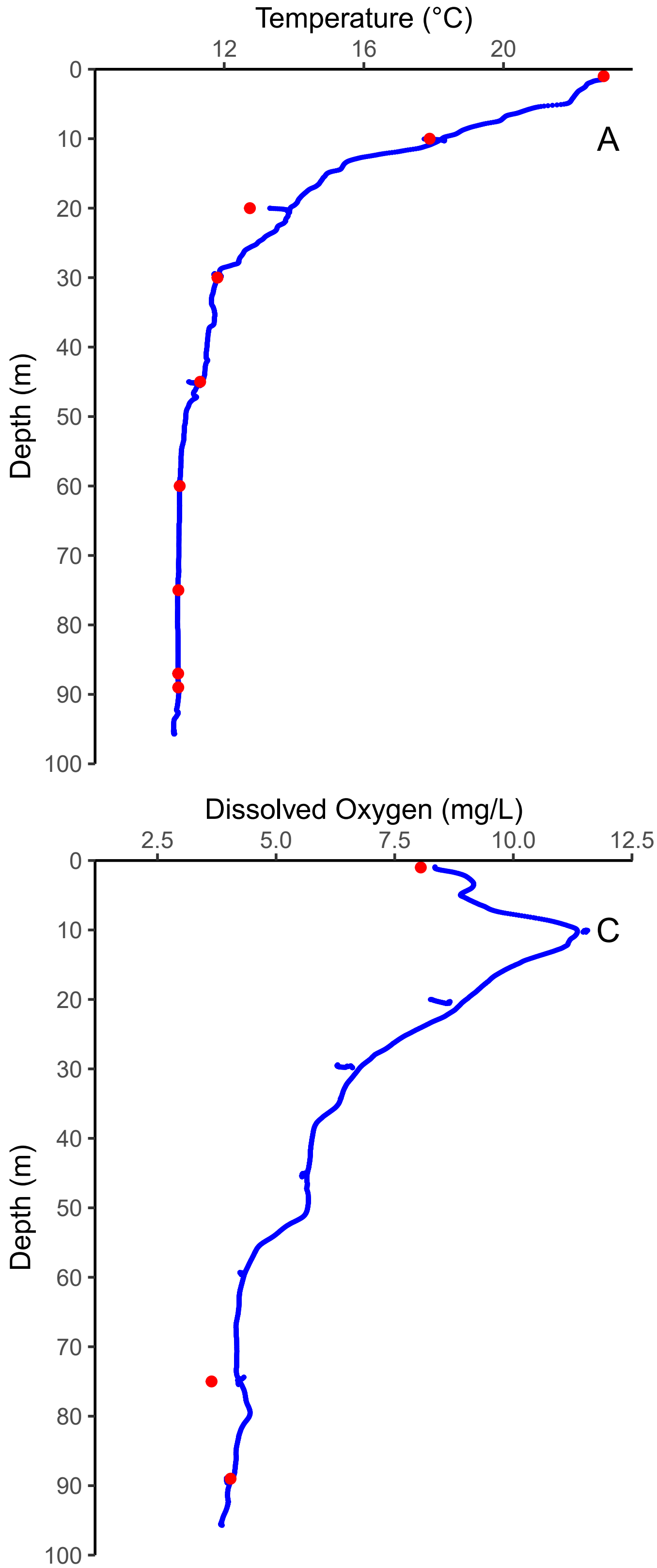

Figure 6

Comparison of results from the Sea-Bird 25Plus CTD profiles (blue line) and the PLOO RTOMS sensors (red dots) during the August 2024 CTD validation cast. Data include (A) temperature, (B) salinity, and (C) dissolved oxygen.

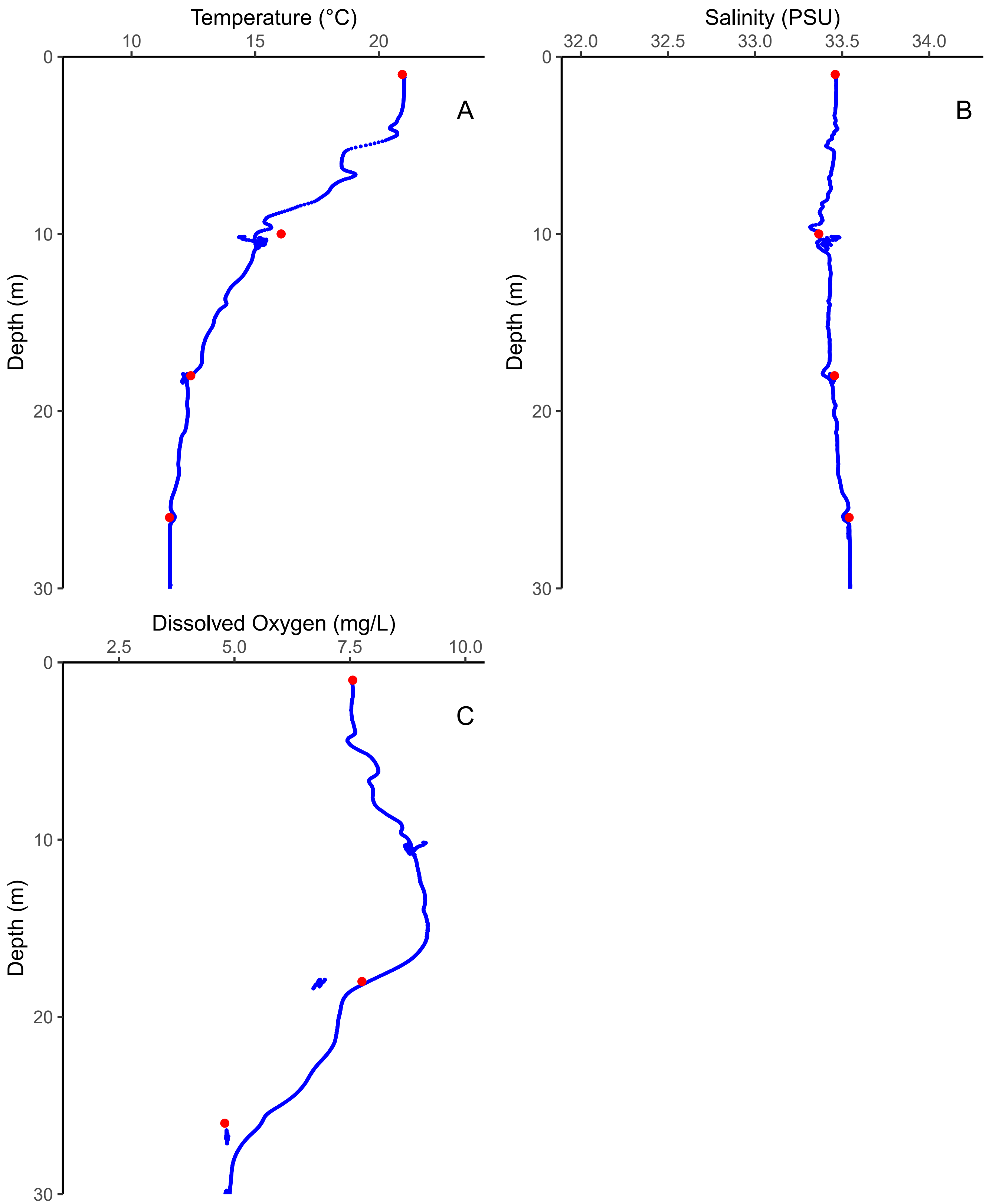

Figure 7

Comparison of results from the Sea-Bird 25Plus CTD profiles (blue line) and the SBOO RTOMS sensors (red dots) during the August 2024 CTD validation cast. Data include (A) temperature, (B) salinity, and (C) dissolved oxygen.

Table 11

Summary of water samples (lab) and RTOMS SUNA sensor nitrate + nitrite results from samples collected during 2024. Negative SUNA data indicate downward sensor drift that requires correction. MDL = Method Detection Limit; ND = non-detect (<1.3 μM for lab water samples); NA = not available.

Mooring	Sample Date	Target Depth (m)	Niskin Depth (m)	Lab Nitrate + Nitrite (μM)	SUNA Nitrate + Nitrite (μM)	Comments
PLOO	2-Jan-24	30	30.1	1.4	-3.3	Applied drift correction. Offset correction = +3.35 μM and slope correction = -0.01156 μM/day
		89	89.8	18.2	22.1	Applied drift correction. Offset correction = -3.87 μM
		89	89.8	18.9	22.1	"
	13-Feb-24	30	30.0	<MDL	5.5	"
		89	89.6	18.9	23.2	"
		89	0.2	19.1	23.2	"
	14-May-24	30	29.6	21.4	28.6	"
		89	90.0	25.1	18.2	SUNA values showed inconsistent drift and step changes; not possible to apply correction
		89	90.0	27.2	18.2	"
	13-Aug-24	30	30.7	12.6	17.7	"
		89	89.5	23.7	14.2	"
		89	89.3	22.1	14.2	"
	19-Nov-24	30	29.9	11.3	18.8	"
		89	90.0	22.3	19.6	"
		89	89.4	22.2	19.6	"
SBOO	22-Feb-24	1	1.0	<MDL	-9.7	SUNA values showed inconsistent drift and step changes; not possible to apply correction
		26	26.4	5.9	NA	Bottom controller failure; no SUNA data collected
		26	26.3	4.6	NA	"
	8-May-24	1	0.9	4.1	-11.9	"
		26	25.9	20.3	NA	"
		26	25.9	21.0	NA	"
	7-Aug-24	1	0.7	<MDL	0.1	Applied drift correction based on consistent min SUNA values. Offset correction = +1.15 μM
		26	26.6	33.8	21.3	Problem with discrepancy in lab duplicates; not possible to verify SUNA values
		26	26.7	14.7	21.3	"
	6-Nov-24	1	0.9	<MDL	-0.7	"
		26	26.1	13.3	-1	SUNA sensor malfunction; not possible to apply correction
		26	26.1	13.1	-1	"

Table 12

Summary of bacteriological QA analyses conducted during 2024 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	217	103	-0.75	1.96	Fail to Reject
	Fecal Coliform	194	102	0.72	1.96	Fail to Reject
	Enterococcus	209	98	-0.90	1.96	Fail to Reject
Field Duplicate	Total Coliform	45	24	0.45	1.96	Fail to Reject
	Fecal Coliform	60	25	-1.29	1.96	Fail to Reject
	Enterococcus	57	25	-0.93	1.96	Fail to Reject

Table 13

Results of benthic macrofauna sample re-sort analyses conducted during 2024 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-24	B12	0.0%	**Jan-24**	I3	0.0%	**Jul-24**	9408	0.0%
	E19	0.2%		I6	0.0%		9409	0.0%
	E25	0.0%		I15	0.0%		9434	0.5%
				I18	0.0%		9419	1.0%
							9445	0.0%
Jul-24	B10	0.0%	**Jul-24**	I4	0.0%		9410	0.0%
	E5	0.0%		I8	0.5%		9440	0.0%
	E15	0.0%		I22	0.0%			
	E23	0.0%		I27	0.0%			
				I31	0.0%			
				I35	0.0%			