PLUME TRACKING MONITORING PLAN FOR THE POINT LOMA AND SOUTH BAY OCEAN OUTFALL REGIONS, SAN DIEGO, CALIFORNIA

Progress Report
March 2022

Report Period: January – December 2021

City of San Diego Point Loma Wastewater Treatment Plant
(NPDES CA0107409; Order No. R9-2017-0007)

City of San Diego South Bay Water Reclamation Plant
(NPDES CA0109045; Order No. R9-2021-0011)

U.S. IBWC South Bay International Wastewater Treatment Plant
(NPDES CA0108928; Order No. R9-2021-0001)

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Background

The Plume Tracking Monitoring Plan (PTMP) was designed to develop new and effective procedures for enhanced water quality monitoring and adaptive plume tracking in the San Diego region. These procedures included: (a) the deployment of real-time oceanographic mooring systems (RTOMS) located near the terminal diffuser wye structures of the Point Loma Ocean Outfall (PLOO) and the South Bay Ocean Outfall (SBOO); (b) deployment of static Acoustic Doppler Current Profiler (ADCP) and thermistor moorings; and (c) deployment and testing of a remotely operated towed vehicle (ROTV; i.e., ScanFish III). Although the requirement to develop the PTMP did not go into effect until October 1, 2017 for the PLOO region, and December 13, 2017 for the SBOO region, work began about two years earlier with the Scripps Institution of Oceanography (SIO), to design, build, and initiate field testing of the PLOO and SBOO real-time mooring systems.

Detailed here are significant activities that have been completed to date to achieve the objectives outlined in the PTMP (see Table 1 for updated PTMP timeline). As detailed in this report and last year's Progress Report, the deployment of both the SBOO and PLOO moorings have encountered challenges over the past two years, largely related to COVID-19 and supply chain disruptions, which have impacted the ability of the City of San Diego (City; CSD) to follow the original schedule outlined in the 2017 PTMP. Table 1 shows the current timeline of activities updated to reflect current and expected RTOMS deployment and recovery dates. Through the end of 2021, the PLOO RTOMS has completed a total of two deployments and the SBOO RTOMS has completed three deployments, with both moorings currently deployed for a third and fourth time, respectively. However, due to the COVID-19 pandemic, restrictions put in place in 2020 and 2021 are having an impact on progress and will likely continue to disrupt efforts in the future.

Timeline of Activities Completed (2015-2021)

2015

November

- Initial acquisition, training, and testing of the ROTV (ScanFish III).

2016

May

- ScanFish software/hardware training and field testing.

December

- First deployment of SBOO RTOMS.

2017

May

- ScanFish software/hardware training and field testing.

November

- ScanFish software/hardware training and field testing.

December

- First retrieval of SBOO RTOMS.

2018

March

- First deployment of PLOO RTOMS.

June

- ScanFish software/hardware training and field testing.

August

- Second deployment of SBOO RTOMS.

2019

March

- First retrieval of PLOO RTOMS.

May

- ScanFish software/hardware training and field testing.
- Consultation with SIO staff to strategize locations of the City's static moorings.

June

- 2018 PTMP Progress Report submitted.

September

- Second retrieval of SBOO RTOMS.

October

- Further consultation with SIO to develop a plan to transfer data storage and processing responsibilities of RTOMS data to the City of San Diego by the end of the current SIO contract in June 2022.
- Second deployment of PLOO RTOMS (see Figure 1).

December

- Work plan for ROTV/CTD (conductivity, temperature, depth) quarterly surveys completed (see Plume Tracking Pilot Study, submitted to Regional Board on March 3, 2020).
- Third deployment of SBOO RTOMS (see Figure 2).

2020

February

- PTMP Pilot Study - first quarter testing implemented in PLOO region. ScanFish towed at 60m, 80m, and 100m contours at PLOO water quality stations (see Figure 3).

March

- 2019 PTMP Progress Report submitted.

May

- Implemented quarterly ocean acidification (total alkalinity and dissolved inorganic carbon) and nitrate + nitrite water sample collection to supplement mooring data validation.
- Completed QA/QC review and assigned qualifiers for RTOMS data through 2019.
- Plume Tracking Pilot Study - second quarter testing implemented in PLOO region. ScanFish towed at 60m, 80m, and 100m contours at PLOO water quality stations (ScanFish controller issues prevented the implementation of testing in SBOO region this quarter) (see Figure 3).

June

- 2018-2019 Biennial Receiving Waters Monitoring & Assessment Report submitted, including initial results from both RTOMS.
- Consultation with SIO staff on ways to improve RTOMS data quality and instrument placement to better target plumes.

August

- PTMP Pilot Study - third quarter testing implemented in PLOO region. ScanFish towed at 60m, 80m, and 100m contours at PLOO stations (see Figure 3).
- PTMP Pilot Study - first quarter testing implemented in SBOO region. ScanFish towed at 10m, 20m, and 30m contours at SBOO stations (ScanFish became fouled on fishing gear and broke deflector wire, in addition to other technical issues, which reduced the testing period).

September

- Second retrieval of PLOO RTOMS – This retrieval was somewhat premature due to RTOMS breaking free from anchor cable on Sept 29th.

October

- Re-terminate ScanFish wire and connections to restore operational capabilities.

November

- PTMP Pilot Study - fourth quarter testing implemented in PLOO region. ScanFish towed at 60m, 80m, and 100m contours at PLOO stations (see Figure 3).
- PTMP Pilot Study - second quarter testing implemented in SBOO region. ScanFish became fouled on fishing gear and hit an obstacle/seabed, which resulted in the prevention of any further testing in SBOO this quarter.
- ScanFish was repaired and made ready for next quarter testing.

December

- Third retrieval of SBOO RTOMS.

2021

February

- ScanFish towed in PLOO region while second vessel conducted CTD sampling at the 100m stations (02/23/21). Early into the second day of side by side sampling, the ScanFish lost communication with deck unit. ScanFish conducting wire was causing the issue and section was replaced. (02/24/21)
- Static moorings serviced. (02/03/21)

March

- 2020 PTMP Progress Report submitted to the Regional Board.

April

- Static moorings serviced. (04/07/21 & 04/12/21)

May

- ScanFish towed in PLOO region and plume observed (05/19/21)

June

- ScanFish towed in PLOO region at 80, 90, and 100 m depth contours. Observed plume heading in a southerly direction. (06/03/21)

July

- Oceanus suffered catastrophic engine failure and CSD is no longer capable of sampling

with the ScanFish while this vessel is out of service. (07/15/21)

September

- 4 days of static mooring servicing. (09/08, 09/09, 09/14, and 09/15/21)

November

- Third PLOO RTOMS and fourth SBOO RTOMS deployments (11/03/21)

Overview of Activities and Changes to Project Plan

The 2020 PTMP Progress Report, submitted in March 2021, detailed significant issues the City experienced with COVID-related supply chain disruptions and deployment challenges, which resulted in the delayed servicing of a number of essential oceanographic sensors, subsequently delaying the deployment of the RTOMS. Despite these delays, the City was confident that the moorings would be redeployed by the end of June 2021, as reported in the 2020 Progress Report. However, further COVID-related delays by collaborators at SIO pushed back the deployments to July 2021. Unfortunately, as preparations were beginning for the redeployment of the moorings in July, the City's primary ocean monitoring vessel (the *Oceanus*) experienced a catastrophic engine failure at sea. Subsequent investigation of the damage determined that the engines were not repairable and so the City has since been seeking new engines, which has been further hampered by COVID supply chain shortages. As of submitting this report, the vessel is still out of service (8 months later) as new parts cannot be obtained. As a result, the City has been operating the program with one vessel (the *Monitor III*), which is not equipped to handle the load requirements for the deployment of the RTOMS. Therefore, in August 2021, the City submitted a letter to the Regional Board informing them of the issue.

As a result, in collaboration with SIO staff, the City secured the services of an SIO vessel to redeploy the SBOO and PLOO moorings on November 03, 2021. This would have occurred earlier, but the City was still awaiting return of a number of essential sensors from SeaBird before the moorings could be redeployed to ensure a full suite of sensors were included. Currently, both the PLOO and SBOO RTOMS are deployed, with a full suite of sensors, and the anticipated retrieval date is the fall of 2022. Contract negotiations are currently underway with SIO to ensure continued support of this work beyond the current contract period through June 30, 2022.

Despite the moorings being out of service for much of 2021, the City continued to operate static moorings in both the PLOO and SBOO regions to act as data backups for the real-time moorings in their absence. These static moorings are more limited in their data collection, which includes continuous temperature and current data, but as they are much smaller and logistically less challenging to retrieve and deploy, they are much less likely to experience any notable challenges that would impact their continued operation. Additionally, these static moorings are serviceable from the City's smaller vessel, the Monitor III.

Sampling via the City's ROTV has proven to be quite challenging for a number of reasons similar to the technical issues and deployment challenges described above, which may also hinder the future usefulness of this technique for plume tracking purposes. Specifically, the occurrence of obstacles and abandoned fishing gear has caused significant damage to the ROTV, resulting in

many repairs at substantial cost to the City. On numerous occasions, the ROTV was almost completely lost due to entanglement and obstructions in the water column. Furthermore, technical challenges related to software and access to replacement parts have delayed operations, as there is no local support available. Finally, the loss of the City's primary monitoring vessel in mid-2021 resulted in all subsequent ROTV surveys being cancelled through the end of 2021. Therefore, only one quarterly survey took place in February 2021 in the PLOO region as the City began efforts towards implementing an adaptive plume tracking program. Nevertheless, preliminary results obtained in 2020, which are being prepared for the 2020-2021 Biennial Report and ROTV Piot Study report, are presented here (see Figure 3).

Despite the challenges, ROTV sampling during 2020 and 2021 was useful in capturing a range of ocean conditions (see Table 2). For example, during the February 2020 ROTV survey, ocean temperature and salinity conditions were weakly stratified and ocean currents remained consistent during the entire week, whereas data from the August survey showed strong thermal stratification and a pronounced near-surface halocline. Data collected by the ROTV were generally within the ranges of values observed with CTD instrumentation for the PLOO region for temperature, salinity, dissolved oxygen (DO), and colored dissolved organic matter (CDOM). The ROTV was the first instrument used by the City to collect tryptophan or optical brightener (OB) in the ocean, so there are no established ranges for these data in this region. The ROTV showed great potential for detecting plume signatures (see Figure 3), particularly in the PLOO region, however, it's full utility will be further assessed when final analysis and interpretations are completed for the upcoming 2020-2021 Biennial Report and ROTV Piot Study Report.

Historical Equipment Issues 2016-2021

(Previously reported, but updated and included here for reference)

RTOMS

PLOO-01

- Sea-Bird SeapHOx pH sensor @ 94 m (bottom): batteries died a few days into deployment, due to incorrect configuration during pool calibration testing.
- Turner Cyclops C7 Chlorophyll *a* and CDOM sensor @ 94 m (bottom): failed entire deployment.
- Chelsea UviLux BOD sensor @ 94 m (bottom): reset to factory default then failed one week after deployment.
- Sea-Bird SUNA nitrate sensor @ 94 m (bottom): fouled or otherwise failed ~five months after deployment, recorded large negative values.
- Sea-Bird SUNA nitrate sensor @ 1 m (surface): recorded negative values, possibly due to incorrect zero calibration and may be corrected post-processing.
- RDI ADCP batteries died shortly after 11 months deployed: was only predicted to last eight to nine months based on RDI software.
- AIS stopped working after deployment. New unit purchased.

SBOO-02

- Sea-Bird SeapHOx pH sensor @ 24 m (bottom): Failed after five months deployed.

- RDI ADCP batteries died shortly after 12 months deployed: was only predicted to last eight to nine months based on RDI software.
- Bottom controller @ 24 m: batteries died, as expected, after 12 months deployed, thus no bottom Satlantic SUNA nitrate, Wetlabs Eco-Triplet (CDOM, Chl-a, Backscatter), Chelsea UviLux (BOD), or Sea-Bird SeapHOx (pH) data after batteries died (Aug-Sept 2019).

PLOO-02

- Pro-Oceanus pCO_2 sensor @ 1 m (surface): reading low values prior to deployment. Internal pump was replaced, which remedied the problem and worked for duration of deployment.
- Sea-Bird SUNA nitrate sensor @ 1 m (surface): recorded negative values at beginning of deployment and then continued to drift high throughout deployment. Initial values possibly due to incorrect zero calibration and may be possible to correct for drift during post-processing.
- Sea-Bird SUNA nitrate sensor @ 89 m (bottom): recorded very noisy suspect data after seven months deployed, then stabilized followed by step change and drift in data.
- Sea-Bird SeapHOx pH sensor @ 89 m (bottom): batteries for the SBE37-ODO part of the package ran out after three months deployed, and the problem fixed remotely by sending a command to switch power source to controller batteries.
- Sea-Bird SeapHOx pH sensor @ 30 m (middle): Failed after four months deployed.
- Sea-Bird ECO triplet chlorophyll, CDOM, and turbidity sensor and Chelsea UviLux BOD sensor @ 30 m (middle): Failed after nine months deployed, possibly related to problem with mid-water controller.
- Sea-Bird ECO triplet chlorophyll, CDOM, and turbidity sensor @ 1 m (surface): frequently reported noisy and negative values for much of the deployment and the sensor maxed out of programmed range for chlorophyll and turbidity.
- Cell phone communication lost on PLOO RTOM on February 14, 2020. Remote attempts to swap cell service were attempted without success. Cell phone modem on mooring was replaced on March 4, 2020 and communication resumed.
- Beacon that provides mooring position stopped working in March due to hardware problem and then communicated intermittently. New beacon installed on April 21, 2020 during favorable weather.
- On September 29, 2020, the mooring broke free from the anchor just below the 30 m instrument package and began drifting south towards Mexico. Staff were able to recover the top of the mooring and most of the remaining bottom portion later that evening.

SBOO-03

- Sea-Bird MicroCAT-ODO salinity, temperature, oxygen sensor @ 18 m (middle): Stopped reporting data after six months deployed. Upon recovery, it was noted that the connector on the mid water controller of the instrument had been sheared off.
- All sensors connected to bottom water controller (26 m) failed to report data consistently after eight months deployed. Impacted sensors include: Sea-Bird SeapHOx pH sensor, Sea-Bird ECO triplet chlorophyll, CDOM, and turbidity sensor, Sea-Bird SUNA nitrate sensor, and Chelsea UviLux BOD sensor.

- Sea-Bird SeapHOx pH sensor @ 1 m (surface): Failed to report data after nine months deployed.
- Sea-Bird SUNA nitrate sensor @ 26 m (bottom): recorded negative values throughout deployment. Suspect values possibly due to incorrect zero calibration and may be possible to correct for drift during post-processing.
- Sea-Bird ECO triplet chlorophyll, CDOM, and turbidity sensor @ 1 m (surface): intermittently reported noisy values and negative values for CDOM in particular during deployment and the sensor maxed out of programmed range for chlorophyll and turbidity on occasion.
- Sea-Bird SUNA nitrate sensor @ 1 m (surface): After nine months deployed, sensor showed significant step change in data and began reporting negative values.

ROTV

- ScanFish flap motors (both sides) were found to be leaking oil and in need of replacement. Received both new motor flaps from EIVA with a significant discount in pricing (40%). Repairs done before February survey. Cost of repairs $8000.
- ScanFish controller and altimeter returned to Denmark in May after displaying false altimeter readings that caused the ScanFish to be non-operable. Controller would not pass the pre-flight check with erroneous altimeter readings. EIVA recommended a firmware upgrade to the controller, which resulted in further firmware issues. Cost of repairs, backup cables, altimeter, and pressure sensor $16,000.
- ScanFish continued to display intermittent errors with altimeter even with a new unit, although much less frequently. Found a workaround by not bringing the ScanFish shallower than 10-15 meters.
- ScanFish hit an obstruction in the SBOO region, possibly derelict fishing gear. One deflector cable pulled through fitting. Both deflector cables were seriously damaged. Deflector cable attachment point slid along tow cable toward ScanFish. Found rope fibers on all 3 cables.
- While towing along the 30-m depth contour in the SBOO region, as we transitioned to the 20-m contour, the Flight software displayed: “System Error”, no communication between ScanFish and deck box. Recovered ScanFish main data cable; bulkhead failed causing a short (connection smoking). Operations cancelled for remaining two days. Cost of repairs $2500.
- ScanFish crashed in November and a large portion of the underside shell cracked off while surveying in SBOO region. Port cable clip found to be missing. Port cable had blue and orange fibers embedded in it. Appeared to have caught a trap on upcast and then crashed into bottom. Electronics still functioned but operated poorly afterwards. Cost of repairs $3500.

Equipment Issues from Current Reporting Period 2021

PLOO-03

- Sea-Bird Deep SeapHOx pH sensor @ 75 m (near bottom): failed prematurely and began reporting noisy and bad low pH values down to 3.7 pH after two weeks deployed. The SBE37-ODO continues to report good temperature, salinity, and dissolved oxygen data.
- Sea-Bird SeapHOx pH sensor @ 1 m (surface): batteries for the SBE37-ODO part of the package ran out prematurely after two months deployed, and the problem fixed remotely by sending a command to switch power source to controller batteries.
- Pro-Oceanus pCO_2 sensor @ 1 m (surface): began showing spikes in data every twelve hours during the internal blank zero calibration cycle after three weeks deployed and exhibiting suspect downward trend in pCO_2 values that does not appear to match other data (e.g. pH and DO).

SBOO-04

- Sea-Bird SeapHOx pH sensor @ 26 m (bottom): batteries for the SBE37-ODO part of the package ran out prematurely after two months deployed, and the problem fixed remotely by sending a command to switch power source to controller batteries.

ROTV

- February 24th - Communication issues between ROTV controller and deck unit

Planned Activities (2022)

2022

January

- Complete QA/QC review and assign qualifiers for RTOMS data through 2022.
- Assess future of Adaptive Plume Tracking for PLOO and SBOO – consult with SIO and Regional Board for direction. Develop work plan for future effort.

February

- Complete analysis of data from PLOO and SBOO RTOMS and ROTV adaptive sampling for inclusion in the City's 2020-2021 Biennial Receiving Waters Monitoring and Assessment Report.

March

- Submit 2021 PTMP Progress Report.
- Retrieval and redeployment of static ADCP and thermistor moorings in PLOO and SBOO regions.

June

- Submit 2020-2021 Biennial Receiving Waters Monitoring and Assessment Report, including results from RTOMs and ROTV.
- ROTV Pilot Study results will be submitted as a separate report.

August

- Third retrieval of PLOO RTOMS.
- Fourth deployment of PLOO RTOMS.

September

- Retrieval and redeployment of static ADCP and thermistor moorings in PLOO and SBOO regions.

October

- Fourth retrieval of SBOO RTOMS.

December

- Fifth deployment of SBOO RTOMS.

Tables and Figures

Plume Tracking Monitoring Plan

Progress Report

March 2022

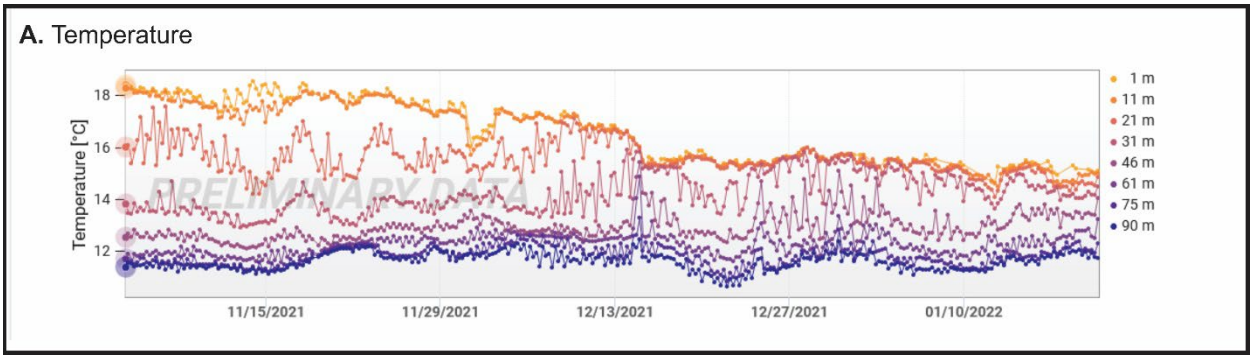
TABLE 1. Updated Plume Tracking Monitoring Plan timeline/progress. Current reporting year highlighted.

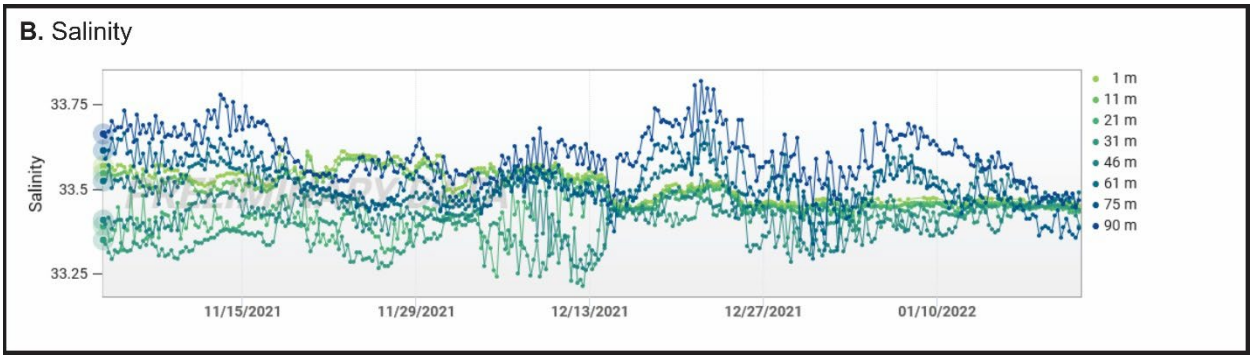
		Real-time Ocean Mooring Systems						Adaptive Plume Tracking				
		PLOO		SBOO								
Year	Quarter	Deploy (D) / Recover (R)	Acquire Data	Deploy (D) / Recover (R)	Acquire Data	Data Management	Static ADCP / Thermistor Moorings*	ROTV Training & Testing	Develop Pilot Study	Conduct Pilot Study	Implement Adaptive Plume Tracking	Progress
2016	Qtr 1						PL, SB					●
	Qtr 2						PL, SB	X				●
	Qtr 3						PL, SB					●
	Qtr 4			D1	X	X	PL, SB					●
2017	Qtr 1				X	X	PL, SB					●
	Qtr 2				X	X	PL, SB	X				●
	Qtr 3				X	X	PL, SB					●
	Qtr 4			R1	X	X	PL, SB	X				●
2018	Qtr 1	D1	X			X	PL, SB					●
	Qtr 2		X			X	PL, SB	X				●
	Qtr 3		X	D2	X	X	PL, SB		X			●
	Qtr 4		X		X	X	PL, SB		X			●
2019	Qtr 1	R1	X		X	X	PL, SB		X			●
	Qtr 2				X	X	PL, SB	X	X			●
	Qtr 3	D2	X	R2	X	X	PL, SB		X			●
	Qtr 4		X	D3	X	X	SB		X			●
2020	Qtr 1		X		X	X	PL, SB			X		●
	Qtr 2		X		X	X	PL, SB			X		●
	Qtr 3	R2	X		X	X	PL, SB			X		●
	Qtr 4			R3	X	X	PL, SB			X		●
2021	Qtr 1					X	PL, SB			X		●
	Qtr 2					X	PL, SB			X		●
	Qtr 3					X	PL, SB					●
	Qtr 4	D3	X	D4	X	X	PL, SB					●
2022	Qtr 1		X		X	X	PL, SB				X	
	Qtr 2		X		X	X	A/N				X	
	Qtr 3	R3	X	R4	X	X	A/N				X	
	Qtr 4	D3	X	D4	X	X	A/N				X	

TABLE 2. Summary of parameters recorded by the ScanFish during 2020. Data include minimum, maximum, mean and sample size (n), separated by quarter. Sample sizes differed due to variations in sampling interval and data quality. These data have only partially been reviewed for quality. OB = optical brightener, TRYP = tryptophan. *2021 data are not yet prepared and will be presented in the upcoming 2020-2021 Biennial Report and ROTV Piot Study report.*

		Parameter					
Quarter	Statistic	CDOM	DO	Temp	Salinity	OB	TRYP
Winter	min	0.04	4.29	11.47	33.33	9.65	1.74
	max	2.67	8.73	15.88	33.73	66.19	2.04
	mean	0.64	7.39	13.87	33.51	20.22	1.85
	n	38,390	38,462	38,483	38,483	36,248	36,220
Spring	min	0.04	3.19	9.77	33.12	1.48	1.76
	max	2.95	9.09	18.64	34.63	65.71	2.62
	mean	0.89	4.45	11.07	33.80	25.17	1.85
	n	16,614	16,614	16,614	16,614	16,609	16,614
Summer	min	0.19	3.81	10.47	32.91	2.06	1.72
	max	1.79	9.36	22.82	34.27	50.26	1.93
	mean	0.71	6.62	12.63	33.52	21.11	1.80
	n	46,927	46,927	46,927	46,927	46,927	46,927
Fall	min	0.04	4.32	11.19	33.06	5.58	1.68
	max	3.13	7.84	17.56	34.95	52.16	3.86
	mean	0.82	5.95	13.17	33.59	22.89	1.77
	n	33,311	33,311	33,311	33,311	33,310	33,311

FIGURE 1. Preliminary data from the third deployment of the PLOO real-time oceanographic mooring system from 11/03/2021 to present, shown as daily averages. These raw real-time data have not been reviewed for quality and may include errors. Parameters include, **A**: Temperature; **B**: Salinity; **C**: Carbon Dioxide; **D**: pH; **E**: Oxygen; **F**: Nitrate; **G**: Chlorophyll; **H**: CDOM; **I**: Turbidity; and **J**: BOD. For real time preliminary data from the PLOO mooring, see http://mooring.ucsd.edu/dev/ploo/





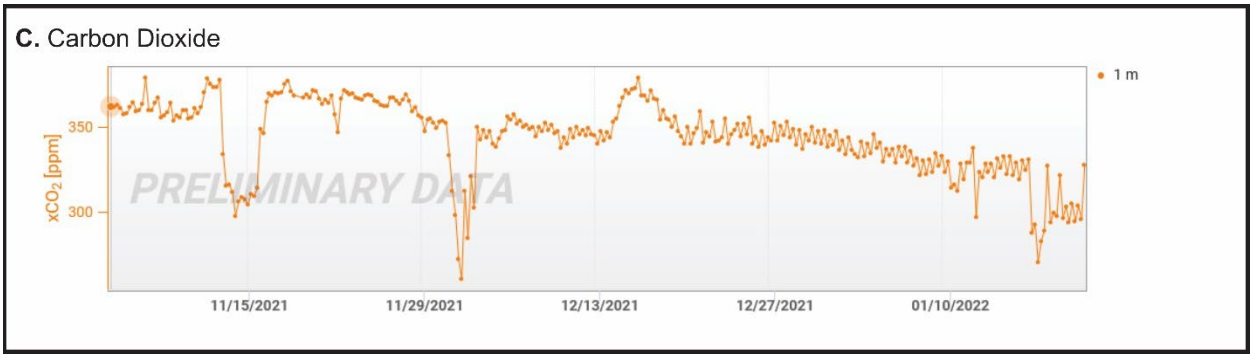
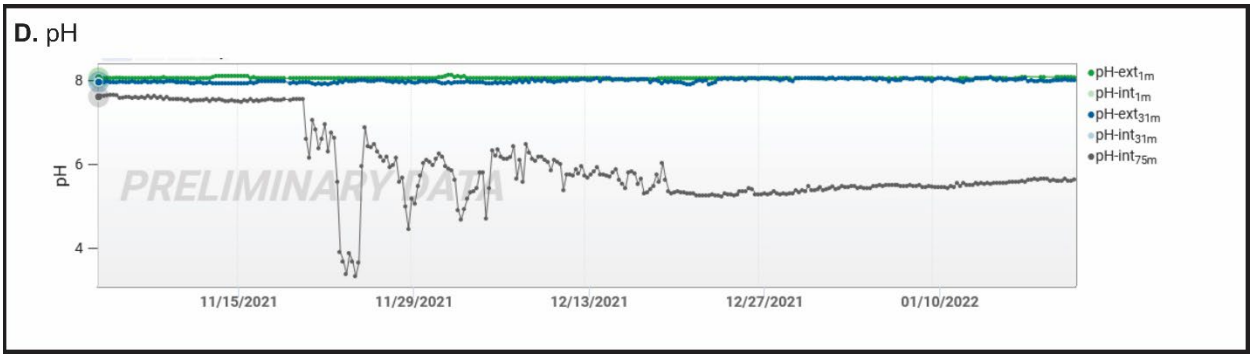
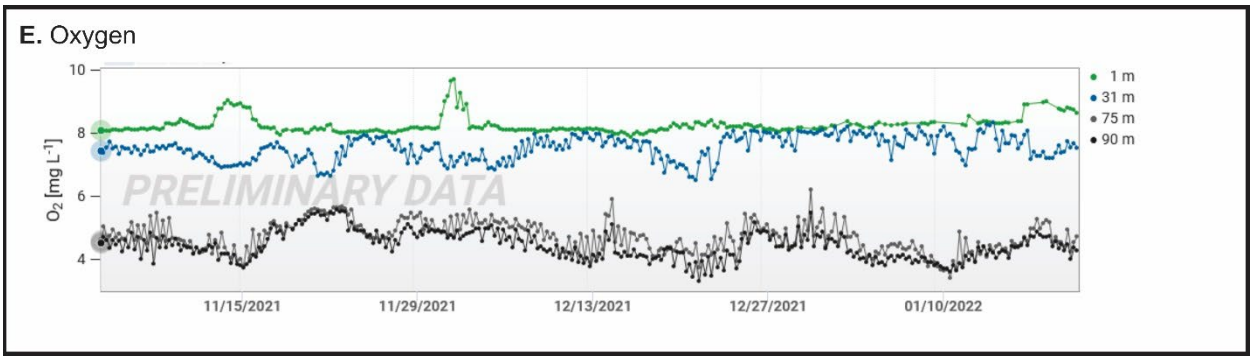
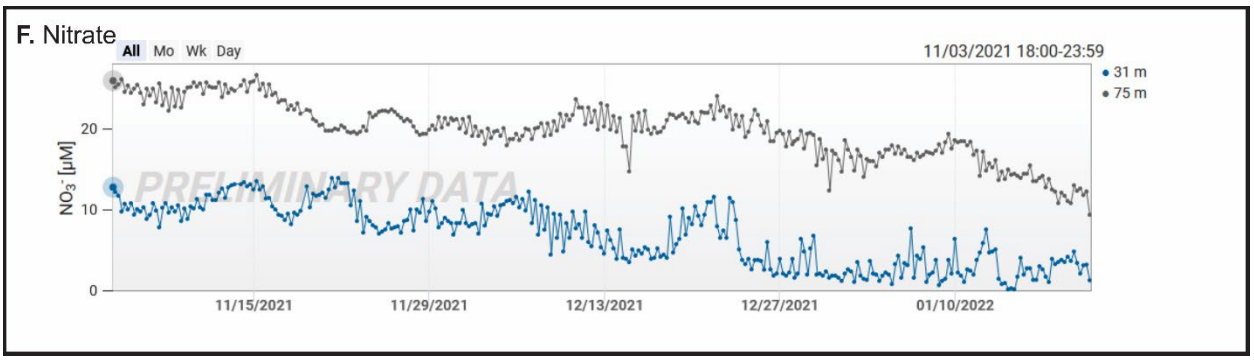
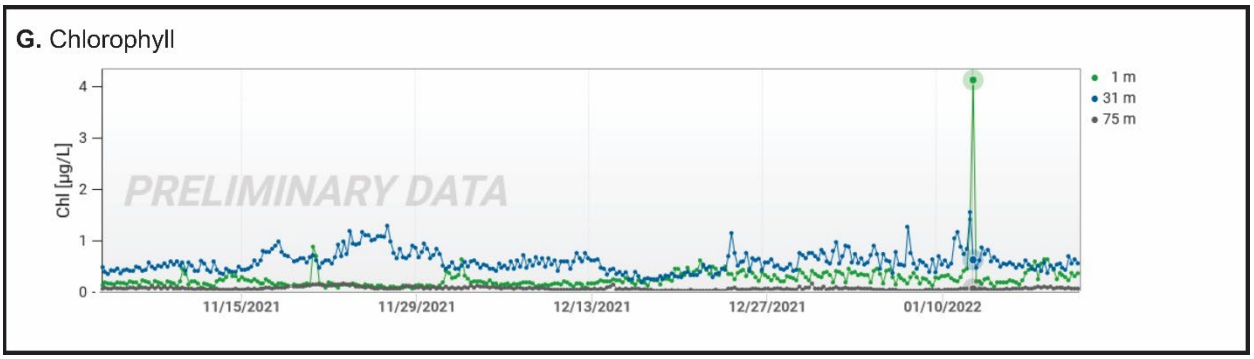


FIGURE 1. Continued…









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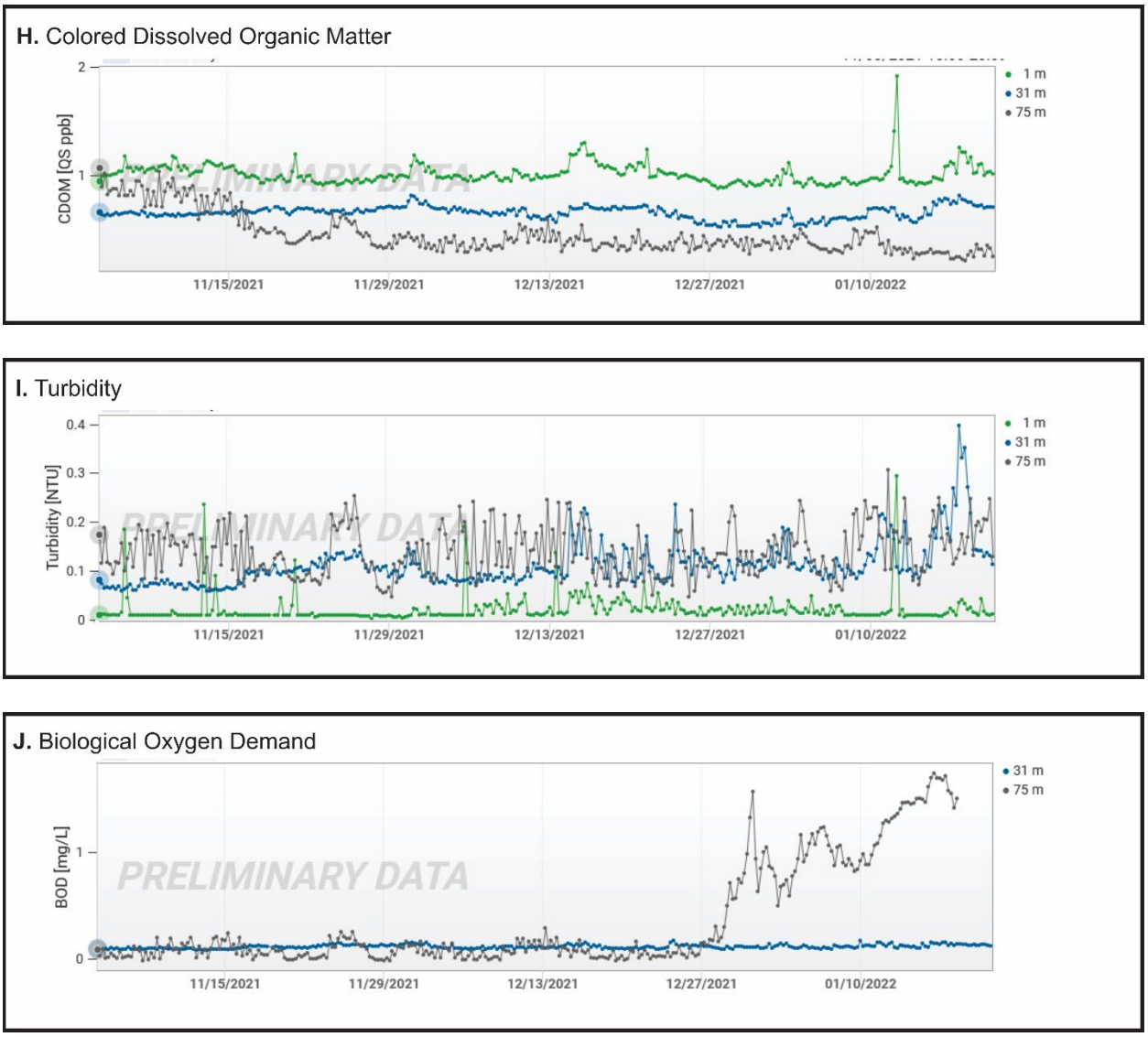

FIGURE 2. Preliminary data from the fourth deployment of the SBOO real-time oceanographic mooring system from 11/03/2021 to present, shown as daily averages. These raw real-time data have not been reviewed for quality and may include errors. Parameters include, **A**: Temperature; **B**: Salinity; **C**: Carbon Dioxide; **D**: pH; **E**: Oxygen; **F**: Nitrate; **G**: Chlorophyll; **H**: CDOM; **I**: Turbidity; and **J**: BOD. For real time preliminary data from the SBOO mooring, see http://mooring.ucsd.edu/dev/sboo/

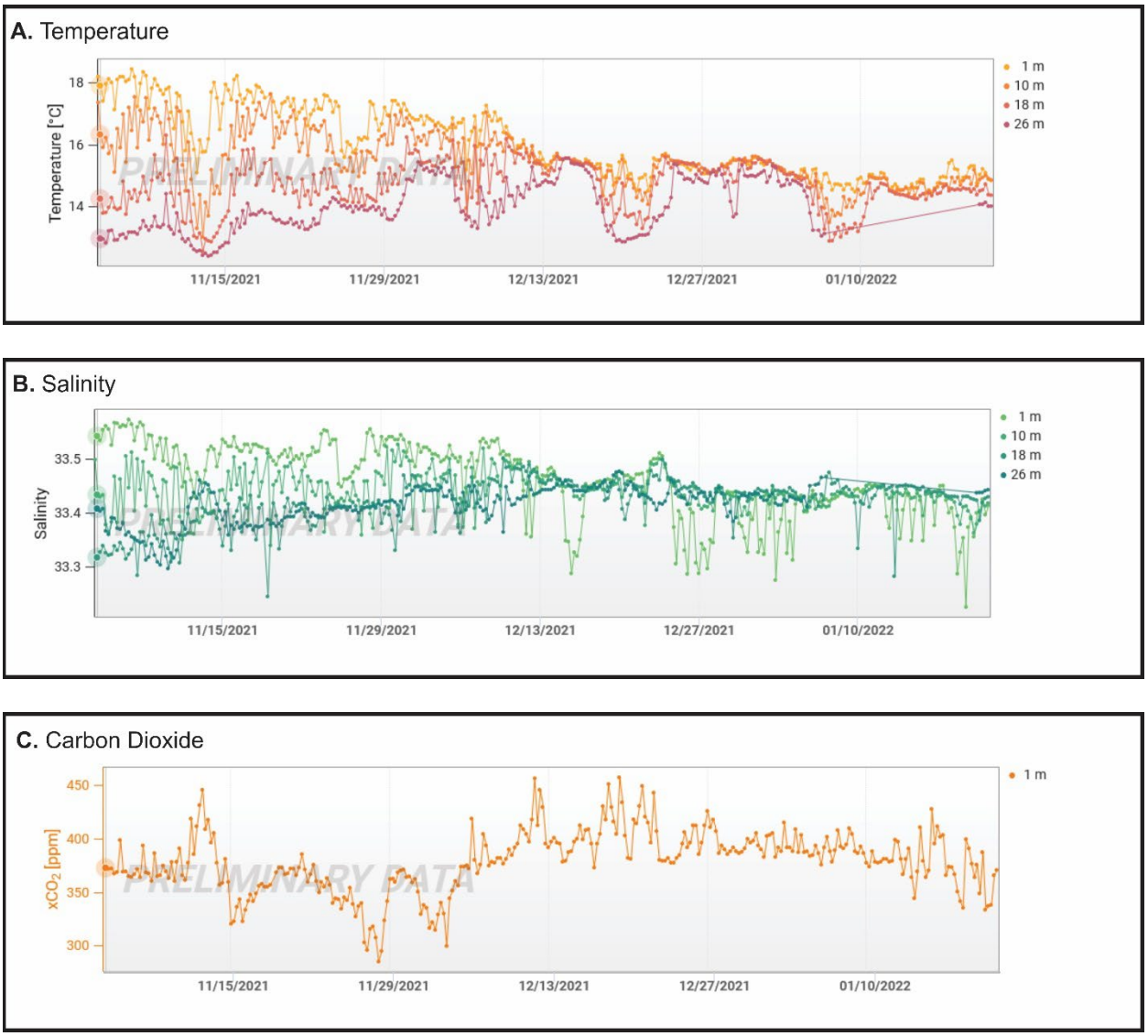

FIGURE 2. Continued…

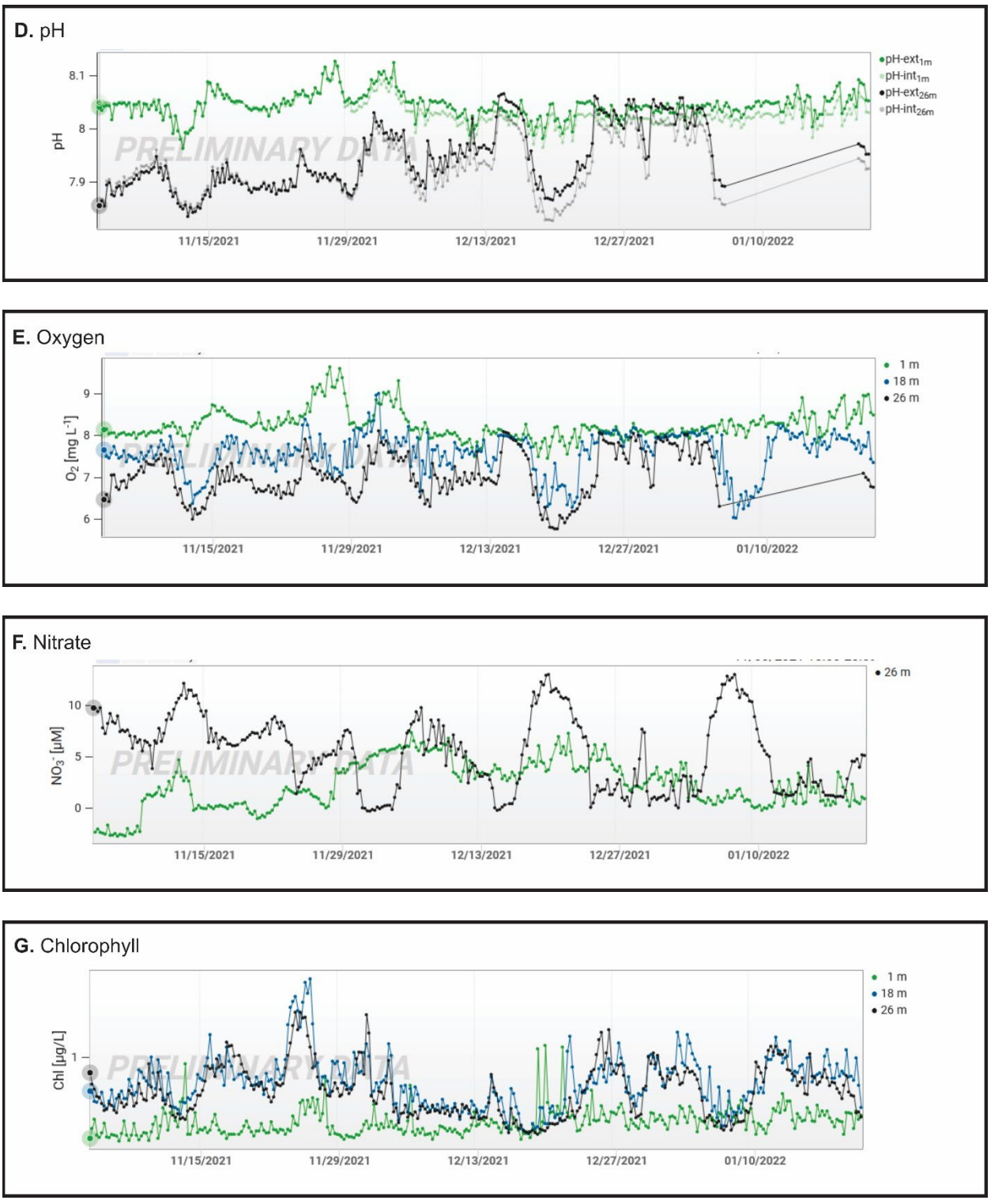

FIGURE 2. Continued…

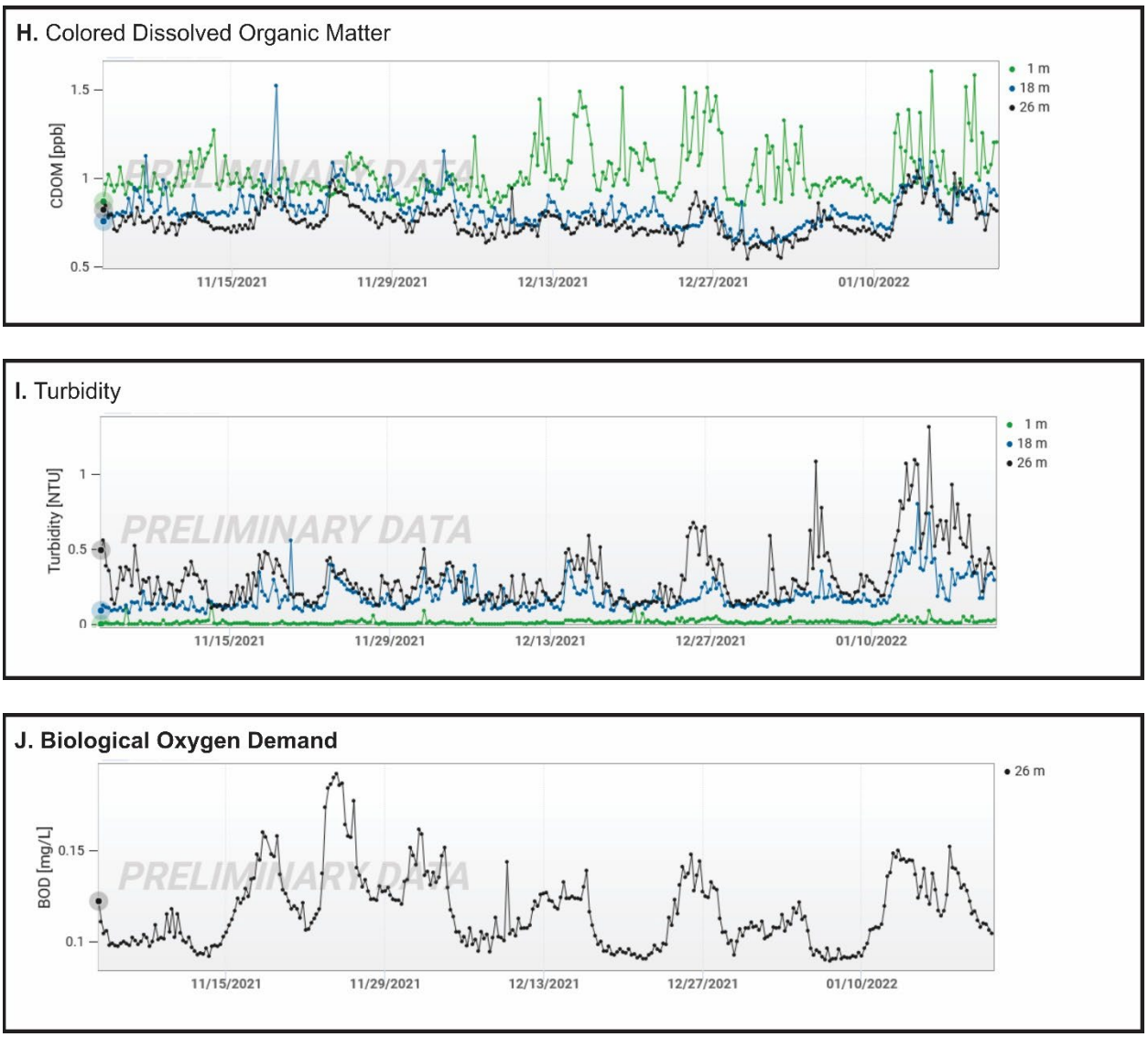

FIGURE 3. Select oceanographic parameters recorded during February and August 2020 ROTV tows. Transects are separated according to depth contour (determined by the nearest water quality station) and were collected over 1-3 days during each quarter in conjunction with regular quarterly water quality sampling. Data are interpolated using the LoESS (Locally Estimated Scatterplot Smoothing) method. Black marks show the location (depth and latitude) of the ROTV. *These data are preliminary, and 2021 data are not yet prepared and will be presented in the upcoming 2020-2021 Biennial Report and ROTV Piot Study report.*