



# **TC25.1 OAE project Operations and Monitoring Report**

**Dosing Period  
2025-02-01 to 2025-06-30**

**August 2025**

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# 1 Summary

Table 1 - Summary for the current dosing period.

|                                                                               |                                                                                   |
|-------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| <b>Dosing period</b>                                                          | 1 February 2025 - 30 June 2025                                                    |
| <b>Project location</b>                                                       | Nova Scotia Power Tufts Cove Generating Station, 315 Windmill Rd, Halifax, Canada |
| <b>Feedstock material</b>                                                     | Magnesite calcination byproduct                                                   |
| <b>Total tonnes feedstock dosed</b>                                           | 1224.0                                                                            |
| <b>Maximum feedstock concentration in outfall [mg/L]<sup>(1)</sup></b>        | 164.3                                                                             |
| <b>Maximum feedstock concentration in ocean [mg/L]<sup>(2)</sup></b>          | 8.2                                                                               |
| <b>Ecotoxicology: Feedstock Lowest No-Observed Effect Concentration [g/L]</b> | 4                                                                                 |
| <b>Total outfall regulatory exceedances</b>                                   | 0                                                                                 |
| <b>Total ocean regulatory exceedances</b>                                     | 0                                                                                 |

(1) Outfall concentration (end-of-pipe) calculated from the gravimetric addition rate and nominal outfall flow rate of 190,000 L/min. (2) Ocean concentration calculated from the outfall concentration and a conservative dilution factor for the mixing zone of 20.

This report contains the operations and monitoring results from an Ocean Alkalinity Enhancement (OAE) field campaign conducted by Planetary, as summarized in Table 1. The campaign consisted of the controlled addition (dosing) of an alkaline material into an existing coastal outfall, and the concomitant analysis of the feedstock and monitoring of the activities' impact on water quality in the outfall and receiving marine waters.

No exceedances of any regulated marine or outfall water quality parameters were recorded during the dosing period. While Planetary's routine monitoring efforts detected several anomalous exceedances of federal marine water quality guidelines and/or provincial standards, none were ultimately attributed to Planetary's activities. Nonetheless, dosing was paused on 15 May as a precaution to investigate the anomalies. Dosing remained paused until the end of July for Nova Scotia Power's scheduled outfall maintenance (May/June), and for Planetary to install and test equipment upgrades (July; not included in the current report).

This report follows documentation from previous reporting periods, which is included on [Planetary's project page](#) on the Isometric credit registry.

## 2 Updates since last submission

Updates to Planetary's operations and monitoring program since the previous submission include the following:

- A new sampling station, located approximately 500 m SE of the discharge outfall, was added ("Narrows" in Fig. 3.1).
- Reduced ocean monitoring at the Sackville River location (Fig. 3.1), as this station was deemed to be uninformative in judging the impact of Planetary's dosing activity.

### 3 Project Overview

The project site is located in Halifax, Nova Scotia, Canada, at the Nova Scotia Power (NSP) Tufts Cove Power Generating Station. A cooling water loop, operated by NSP, continuously draws water from the surface of Halifax Harbour and discharges it at a nominal rate of ~190,000 L/min into the receiving waters of Tufts Cove (inset, Fig. 3.1). The discharge is at a tide-dependent depth of ~2-3 m below the surface.

On site, a high-solids slurry was created by mixing dry feedstock with ambient seawater drawn from the cooling loop outfall. The slurry was then dosed into the outfall via parallel metering pumps, which were controlled and monitored by Planetary's dosing system. The alkaline feedstock material, a byproduct of magnesite calcination consisting primarily of magnesium oxide, was imported in approximately 1.2 metric tonne bulk bags, and stored on-site in a dry, ventilated shelter. The bags were weighed by a calibrated scale at an intermediary warehouse in Dartmouth, NS before being transported to the dosing site. Samples were obtained from a representative subset of bulk bags prior to dosing in order to quantify feedstock metal content.

The impact of alkalinity addition on water quality in the outfall and ocean was monitored using sensor packages installed upstream (unalkalized water) and downstream (approx. 1 m beyond the discharge point) of the alkalinity dosing point, and via routine ocean sampling. During dosing, outfall sensor data were collected continuously, and discrete calibration, alkalinity and metals samples were obtained weekly. In the ocean, up to seven stations were routinely monitored (markers in Fig. 3.1) for a range of biogeochemical properties. Ocean monitoring took place at approximately 2-week intervals during dosing. A shore-tethered moored instrument package, installed approximately 10 m to the west and downstream of the ocean discharge point, provided ancillary biogeochemical sensor data, used primarily for research and development purposes.

Measurements from the outfall and ocean were assessed against a compilation of guidelines and standards from Federal (CCME), and Provincial (NSE/Atlantic RBCA) sources, and the Isometric OAE Protocol. A self-imposed stop trigger framework, consisting of criteria for pausing dosing, was followed.

A detailed description of Planetary's activities is contained in the Project Design Document (PDD) available on [Planetary's project page](#) on the Isometric credit registry.

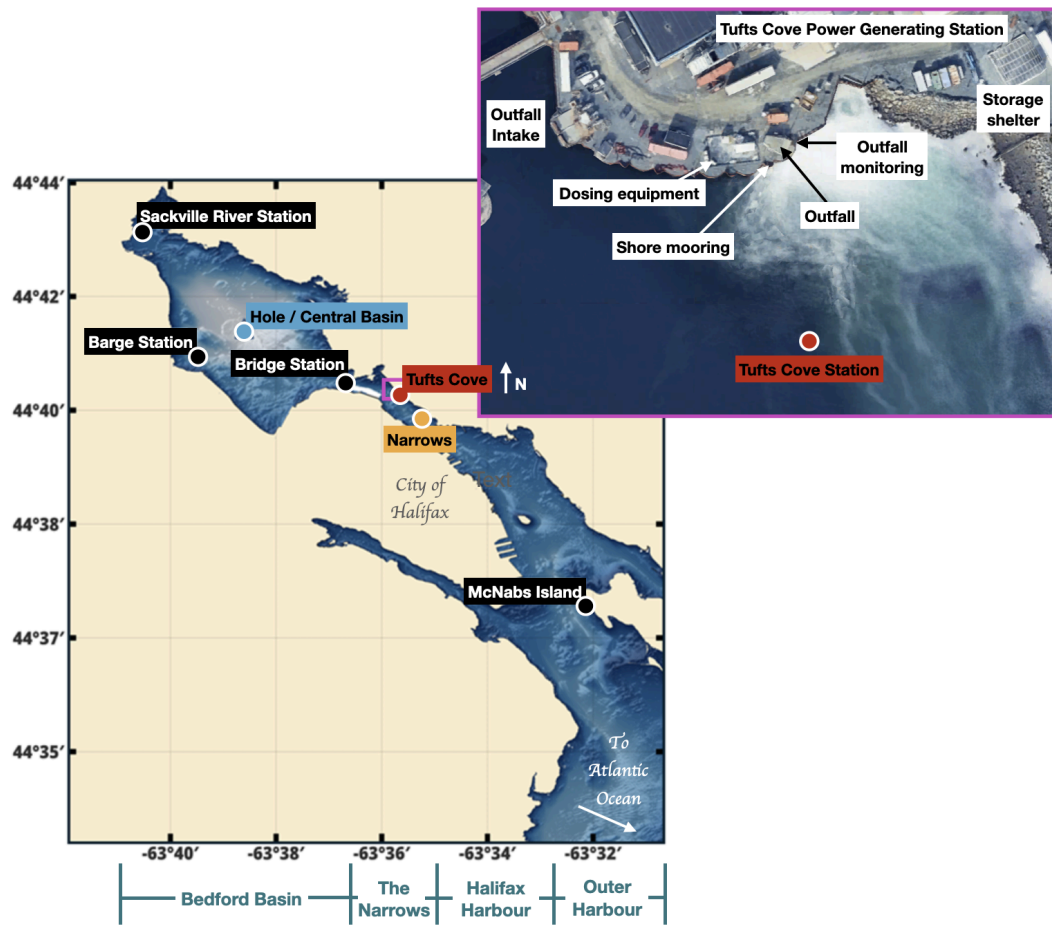


Figure 3.1 - Map of Bedford Basin and Halifax Harbour sampling stations.

## 4 Operations and Monitoring results

This section summarizes the results of the feedstock testing, and routine operations and monitoring conducted during the present dosing period. In all figures, vertical grey lines correspond with periods of active dosing. Refer to section 5 for an explanation of any data excursions, anomalies or gaps.

### 4.1 Feedstock analyses

Prior to all dosing activities, the feedstock underwent third-party testing to assess its potential environmental toxicity. Three independent tests were conducted, as summarized in Table 4.1. Additional details are provided in the [2024/2025 Operations report](#) (hereafter TC24).

**Across all tests, no statistically significant effects were observed at feedstock concentrations of 250 mg/L or below.** Moreover, an acute toxicity (LC50) concentration of 10 g/L was established for the feedstock, resulting in a classification of “**practically non-toxic**” (LC50 > 100 mg/L) according to the Global Harmonised System.

It is noteworthy that 250 mg/L was the highest concentration tested in the lobster larval effects testing (Table 4.1), so the no observed effect concentration (NOEC) may

be higher than this value; indeed, this is supported by the much higher NOEC value for the multitrophic effect study shown in Table 4.1. Nonetheless, **the 250 mg/L value is significantly higher than the maximum outfall concentration experienced during the current project period** (see [Table 4.3](#) below).

It should also be noted that these toxicity tests did not involve artificially dissolving the feedstock in the test vessels, thus exposure is limited to some degree by the feedstock's solubility. Where necessary, test solutions were prepared as elutriates or underwent leaching for up to 24 hours prior to conducting ecotoxicology tests. This approach – as opposed to using artificial solvents – was selected because it more closely mimics exposure in the natural environment, where dissolution is not limited by solubility due to rapid dilution across larger volumes of receiving water.

**Table 4.1 - Toxicity testing results.**

| Test                           | Organisms tested                                                       | Conducted by                                   | Feedstock test range | Outcome                                                                       |
|--------------------------------|------------------------------------------------------------------------|------------------------------------------------|----------------------|-------------------------------------------------------------------------------|
| Acute toxicity (LC50)          | Threespine stickleback ( <i>G. aculeatus</i> )                         | Harris Industrial Testing Services, NS, Canada | 625 - 10,000 mg/L    | LC50 > 10 g/L                                                                 |
| Multitrophic effects           | Phytoplankton, copepods, fish cell line; oyster and sea urchin embryos | Various labs in Canada and France <sup>1</sup> | 1.25 - 250 g/L       | NOEC = 4 g/L                                                                  |
| Lobster larvae chronic effects | American lobster ( <i>H. americanus</i> ) larvae                       | Huntsman Marine Science Centre, NB, Canada     | 5 - 250 mg/L         | No effect on larval survival, molting success and growth at or below 250 mg/L |

LC50 = Lethal Concentration 50; NOEC = No observed effect concentration

During dosing, the feedstock was routinely sampled for metal content analyses by a third party laboratory. The results were used to calculate the feedstock's equivalent hydroxide content (EQOH; a metric of the carbon dioxide removal efficacy) (Table 4.2). Sampling and analysis details are provided in the [TC24 report](#).

For the current dosing period, a **weighted-average EQOH value of 517.24 kg hydroxide per tonne feedstock** was derived.

Since the submission of the TC24 report, a new equation for EQOH, including terms for potassium and sodium carbonates, has been applied. By accounting for additional carbonates that lower EQOH, the new equation provides more comprehensive and conservative results. For the present feedstock, these species are present in such trace amounts that the final EQOH value is not notably impacted (avg. difference of 0.055 % between methods).

The sampling and weighting protocol was also updated for TC25.1. Whereas TC24 samples were composited by lot (unique production batch from the manufacturer), TC25.1 samples were sampled and composited by the week in which they were dosed. Each bag of feedstock was sub-sampled prior to being dosed, and combined with samples obtained from all other bags dosed during the same week.

<sup>1</sup> Faucher, G., and Kapsenberg, L. (2025): Assessing the effects and risks of ocean alkalinity enhancement on marine organisms through ecotoxicology tests [dataset]. PANGAEA, <https://doi.pangaea.de/10.1594/PANGAEA.977802>

After homogenization, a representative sample was then extracted for laboratory analysis. The weight-average EQOH value was calculated based on the EQOH values derived for each week's analysis and the proportion of material dosed during that week. This procedural change was enacted primarily to streamline on-site operations. During two weeks no EQOH samples were obtained; EQOH values for those weeks were calculated using lot-based analyses following procedures described in the TC24 report.

**Table 4.2 - Feedstock EQOH in kg/t.**

| Sample ID   | Analysis date    | Tonnes dosed | Weight | Lot EQOH | Weighted EQOH |
|-------------|------------------|--------------|--------|----------|---------------|
| 202502-1014 | <i>no sample</i> | 20.4         | 1.67%  | 509.66   | <b>517.24</b> |
| 202502-1921 | 2025-Feb-28      | 50.0         | 4.09%  | 525.06   |               |
| 202502-2528 | 2025-Feb-28      | 97.2         | 7.94%  | 525.38   |               |
| 202503-1014 | 2025-Apr-07      | 111.5        | 9.11%  | 553.06   |               |
| 202503-1720 | 2025-Apr-07      | 117.0        | 9.56%  | 536.55   |               |
| 202503-2428 | 2025-Apr-07      | 96.4         | 7.88%  | 523.33   |               |
| 202503-3104 | 2025-Apr-11      | 73.9         | 6.04%  | 502.94   |               |
| 202504-0711 | 2025-Apr-11      | 78.5         | 6.41%  | 496.44   |               |
| 202504-1417 | 2025-May-12      | 107.9        | 8.82%  | 471.02   |               |
| 202504-2125 | <i>no sample</i> | 104.9        | 8.57%  | 544.97   |               |
| 202504-2802 | 2025-May-12      | 148.7        | 12.15% | 500.22   |               |
| 202505-0509 | 2025-May-12      | 128.1        | 10.46% | 500.73   |               |
| 202505-1215 | 2025-May-16      | 89.4         | 7.31%  | 534.49   |               |

The sample ID identifies the dosing date range for a given sample: e.g., 202502-1921 = dosed between 19 and 21 Feb, 2025.

## 4.2 Dosing and site operations

During the current dosing period, dosing was paused on 15 May to investigate a data anomaly detected in the receiving waters (details below) and to undertake maintenance on the outfall (23 May - 30 June). Prior to 15 May, dosing was largely continuous from Mon-Fri (~24 hr/day).

Throughout the dosing period, approximately 1233 tonnes of dry material was transported to the site. After accounting for wastage due to minor spills and maintenance (Table A1.2), **a total of 1224 tonnes of dry alkalinity was dosed into the receiving waters of Tufts Cove.** The maximum rate of discharge was approximately 31 kg/min, corresponding to a maximum calculated outfall feedstock concentration of 164 mg/L. This value is significantly lower than the minimum toxicity levels for the feedstock identified through pre-trial testing. Feedstock concentrations in the immediate receiving waters are expected to be 20-fold (or more) lower, based on a conservative dilution factor derived, through independent studies, for Tufts Cove at a distance of ~20 m from the outfall (Yee et al. *manuscript in prep.*<sup>2</sup>).

<sup>2</sup> Yee, R., Musgrave, R., Atamanchuk, D. et al. (in prep.) Tracer release experiments in an intermittently stratified estuary to support ocean alkalinity enhancement research.

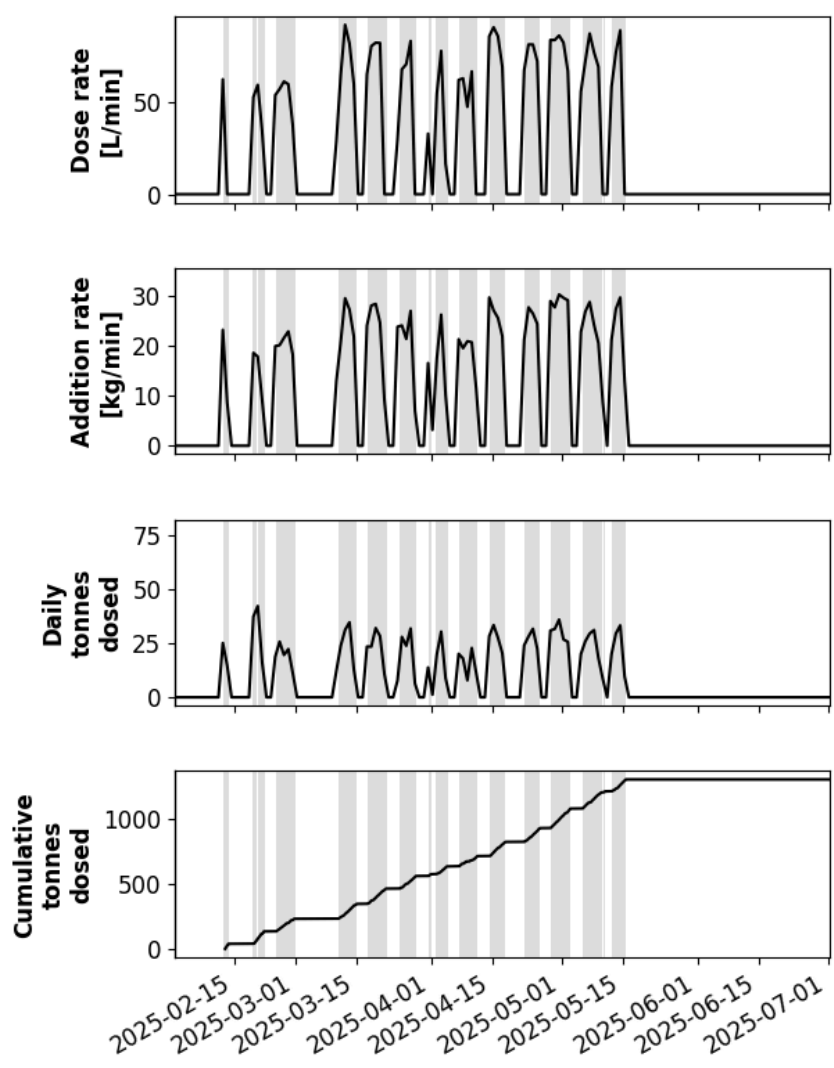


Figure 4.1 - Dosing time-series.

Table 4.3 - Operations and dosing summary statistics.

|                                                     |         |
|-----------------------------------------------------|---------|
| Total tonnes feedstock imported                     | 1233.3  |
| Tonnes of feedstock discarded as waste              | 9.35    |
| Total tonnes feedstock dosed                        | 1224.0  |
| Maximum volumetric dose rate [L/min]                | 91.4    |
| Maximum gravimetric addition rate [kg/min]          | 30.3    |
| Maximum outfall concentration [mg/L] <sup>(1)</sup> | 164.3   |
| Maximum daily additions [t/day]                     | 42.4    |
| Total site power consumed [kWh]                     | 16929.9 |
| Average power consumption [kWh/t netCDR]            | 14.9    |

(1) Outfall concentration (end-of-pipe) calculated from the gravimetric addition rate and nominal outfall flow rate of 190,000 L/min.

### 4.3 Outfall monitoring

Results from the outfall monitoring are summarized in Figures 4.2 - 4.3, and Table 4.5. All bottle data and details on the calibration samples and procedures are presented in Appendix 2.

Planetary's operational permit specifies limits on the pH and total suspended solids (TSS) content of water in the outfall, as summarized in Table 4.4. These properties were monitored closely through continuous measurements (TSS derived from a turbidity relationship; see Appendix A2.1), and dosing was adjusted accordingly if the limits were approached. **No exceedances of the pH or TSS limits occurred.**

Total alkalinity perturbations in the outfall, which were assessed as the difference between paired discrete samples obtained from the upstream and downstream sensor locations, showed **no TA increases in excess of the 1000  $\mu\text{mol/kg}$  limit** identified in the [Isometric OAE protocol](#) (Table 4.5).

**Table 4.4 - Summary of outfall monitoring.**

|                                                                             |                                         |
|-----------------------------------------------------------------------------|-----------------------------------------|
| <i>Outfall pH limit</i>                                                     | <i>6.5 &lt; pH &lt; 9 (end of pipe)</i> |
| <i>Outfall TSS limit (mg/L)</i>                                             | <i>40 (end of pipe)</i>                 |
| <i>Outfall TA limit (<math>\mu\text{mol/kg}</math>)</i>                     | <i><math>\Delta 1000</math></i>         |
| <b>Number of pH limit exceedances</b>                                       | 0                                       |
| <b>Number of TSS limit exceedances</b>                                      | 0                                       |
| <b>Maximum downstream pH</b>                                                | 8.90                                    |
| <b>Maximum downstream TSS (mg/L)</b>                                        | 38.4                                    |
| <b>Maximum <math>\Delta\text{TA}</math> (<math>\mu\text{mol/kg}</math>)</b> | 582.32                                  |

$\Delta$  = difference between downstream and upstream measurements.

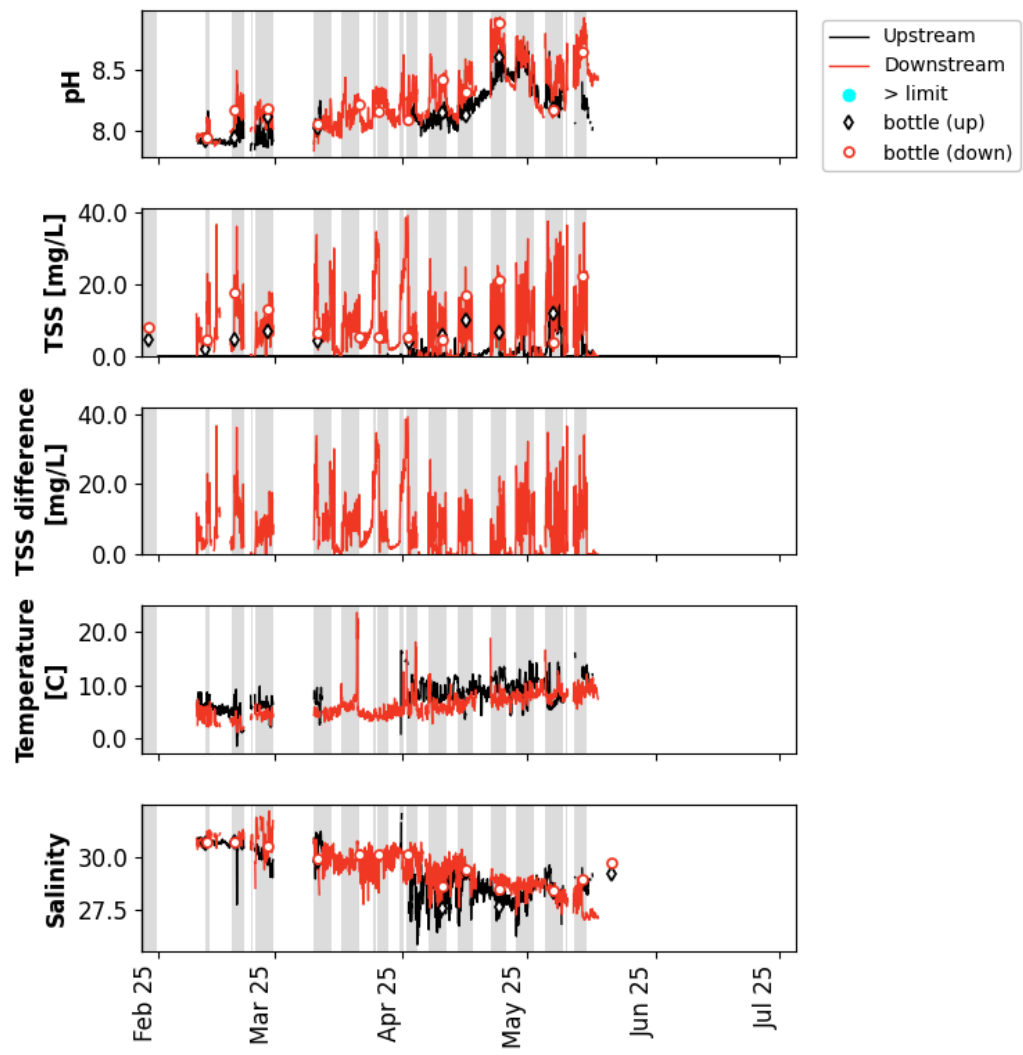


Figure 4.2 - Outfall monitoring time-series.

**Table 4.5 - Outfall TA measurements.**

| Sample date      | Dosing | Total alkalinity [ $\mu\text{mol/kg}$ ] |                |               |
|------------------|--------|-----------------------------------------|----------------|---------------|
|                  |        | Downstream                              | Upstream       | Difference    |
| 12-Feb-2025      | Yes    | 2146.62                                 | 2177.86        | -31.24        |
| 19-Feb-2025      | Yes    | 2247.15                                 | 2158.48        | 88.67         |
| 27-Feb-2025      | Yes    | 2242.75                                 | 2230.46        | 12.29         |
| 11-Mar-2025      | Yes    | 2119.91                                 | 2126.25        | -6.34         |
| 21-Mar-2025      | Yes    | 2183.36                                 | 2129.27        | 54.09         |
| 26-Mar-2025      | Yes    | 2154.94                                 | 2132.43        | 22.51         |
| 2-Apr-2025       | Yes    | 2151.43                                 | 2077.54        | 73.90         |
| 10-Apr-2025      | Yes    | 2165.10                                 | 1991.41        | 173.69        |
| 16-Apr-2025      | Yes    | 2156.13                                 | 2102.40        | 53.72         |
| 24-Apr-2025      | Yes    | 2687.32                                 | 2105.00        | 582.32        |
| 7-May-2025       | Yes    | 2137.14                                 | 2136.08        | 1.06          |
| 14-May-2025      | Yes    | 2459.00                                 |                |               |
| 21-May-2025      | No     | 2082.48                                 | 2077.65        | 4.83          |
| Dosing mean:     |        | <b>2237.57</b>                          | <b>2124.29</b> | <b>93.15</b>  |
| Dosing std. dev. |        | <b>168.60</b>                           | <b>60.20</b>   | <b>171.65</b> |

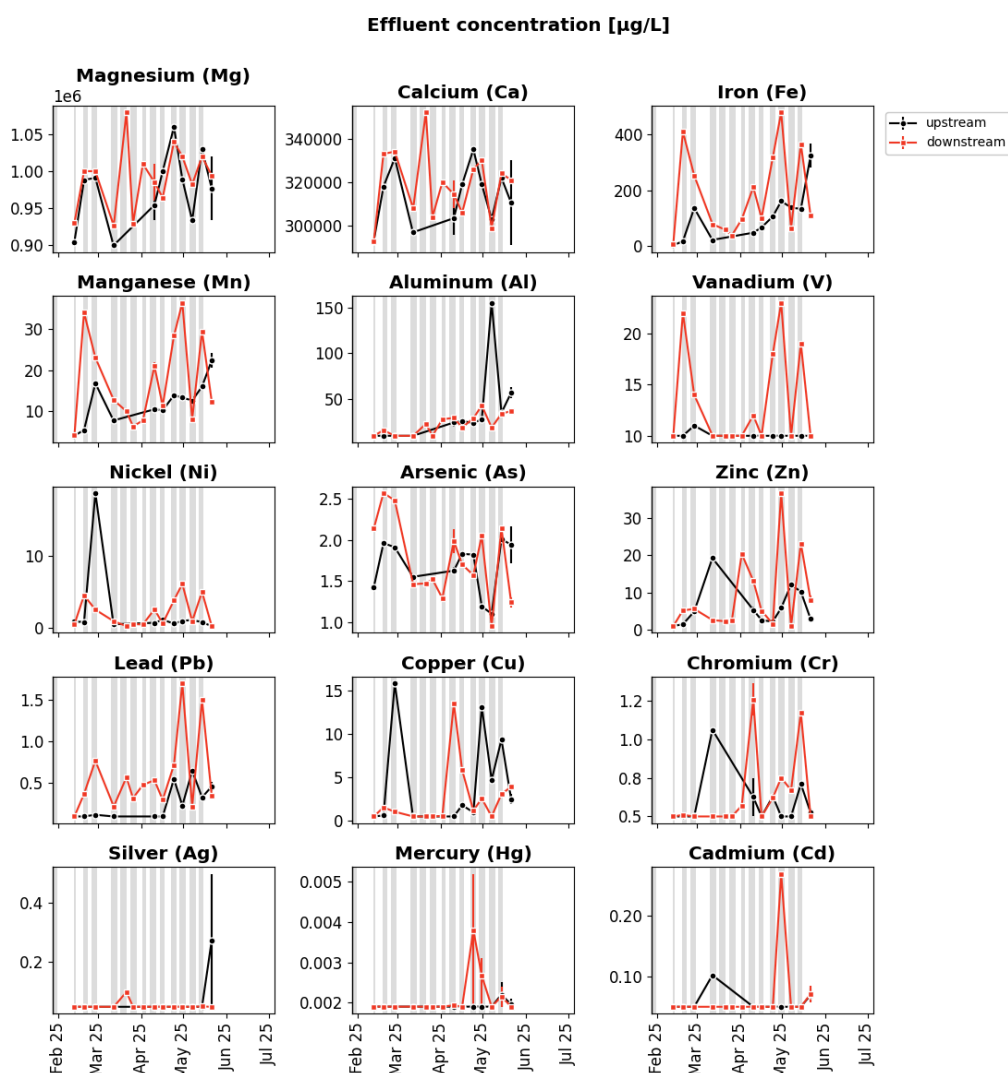


**Figure 4.3 - Outfall metal measurements.** A subset of tested metals, selected based on their proportional abundance in the feedstock or environmental significance, is shown here. Among the subset, results are arranged here from greatest (Mg) to lowest (Cd) concentration in the feedstock. Error bars represent the range of replicate samples. Note that results below detection were set to their detection limit.

#### 4.4 Receiving waters monitoring

The ocean monitoring results are presented in the figures below, with additional sampling details in [Appendix 2](#). In the figures below “Other Stns.” refers to the average of all other stations not shown in the figure.

On several occasions, water column and sediment metals were observed to be in excess of their federal or provincial EQS (water) or stop-trigger (sediment) thresholds. In all cases, Planetary’s stop trigger framework was followed to ascertain the cause of the overages. Despite Planetary recording these incidences, each instance was ultimately found to be either an anomalous result, or not attributable to Planetary’s dosing activities. More details on these results are provided in Section 5. Except for increases in Mg and Ca (the two most abundant metals in the feedstock) in the sediment at the Tufts Cove station, **there is no evidence of apparent**

**accumulation or increase of any other metals' concentrations** over time during Planetary's dosing. These results support the conclusion that the anomalous overages were not linked to Planetary's dosing. See section 5 for further details.

Notwithstanding the anomalous (false-positive) exceedances noted above and in Section 5, **no federal or provincial marine surface water guideline or quality standards were known to be exceeded** for the current period. The majority of observations remained within the range of background variability, or showed no significant changes over time:

- Average water column biogeochemistry remained within background levels for all measured variables (Fig. 4.4). Note that the shading in this figure represents the range of observations during the current dosing period.
- Sediment metals remained within the background, or pre-dosing ranges (Fig. 4.5). Except for Mg and Ca, no metals showed indication of accumulation or increasing concentrations over time. Any detected exceedances were not attributed to dosing (see section 5).
- Water column (surface and bottom) metals remained below their EQS thresholds (Fig. 4.6-4.7); some anomalous overages were detected, but were not attributed to dosing (see section 5). No metals showed indication of accumulation or increasing concentrations over time.
- TSS remained below the CCME guideline of <25 mg/L above ambient levels (Fig. 4.8). Note that the mooring TSS data (Fig. A2.2 in Appendix 2) are noisy due to the significant presence of bubbles that interfere with the optical turbidity measurements.
- TA perturbations were below the Isometric limit of 1000  $\mu\text{mol/kg}$  (Fig. 4.9)

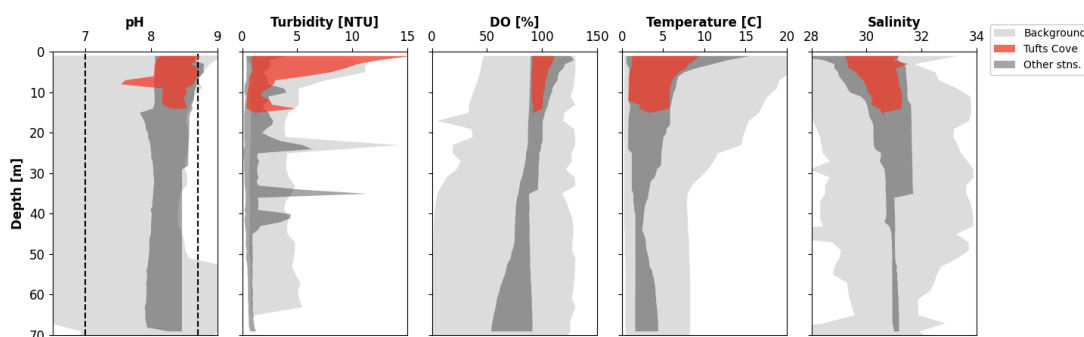


**Figure 4.4 - Summary of water column observations.**

Note that in Figs. 4.5-4.7, below, a subset of tested metals is shown. The subset was selected based on their proportional abundance in the feedstock or environmental significance, as informed by the availability of respective EQS standards and guidelines. Among the subset, results are arranged here from greatest (Mg) to lowest (Cd) concentration in the feedstock. Results below detection were set to their detection limit. Dashed lines are the stop-trigger limits (sediment metals) or the Tier 1 EQS thresholds (water metals). Markers represent the average measured concentration, and error bars are the range of observations from replicate samples.

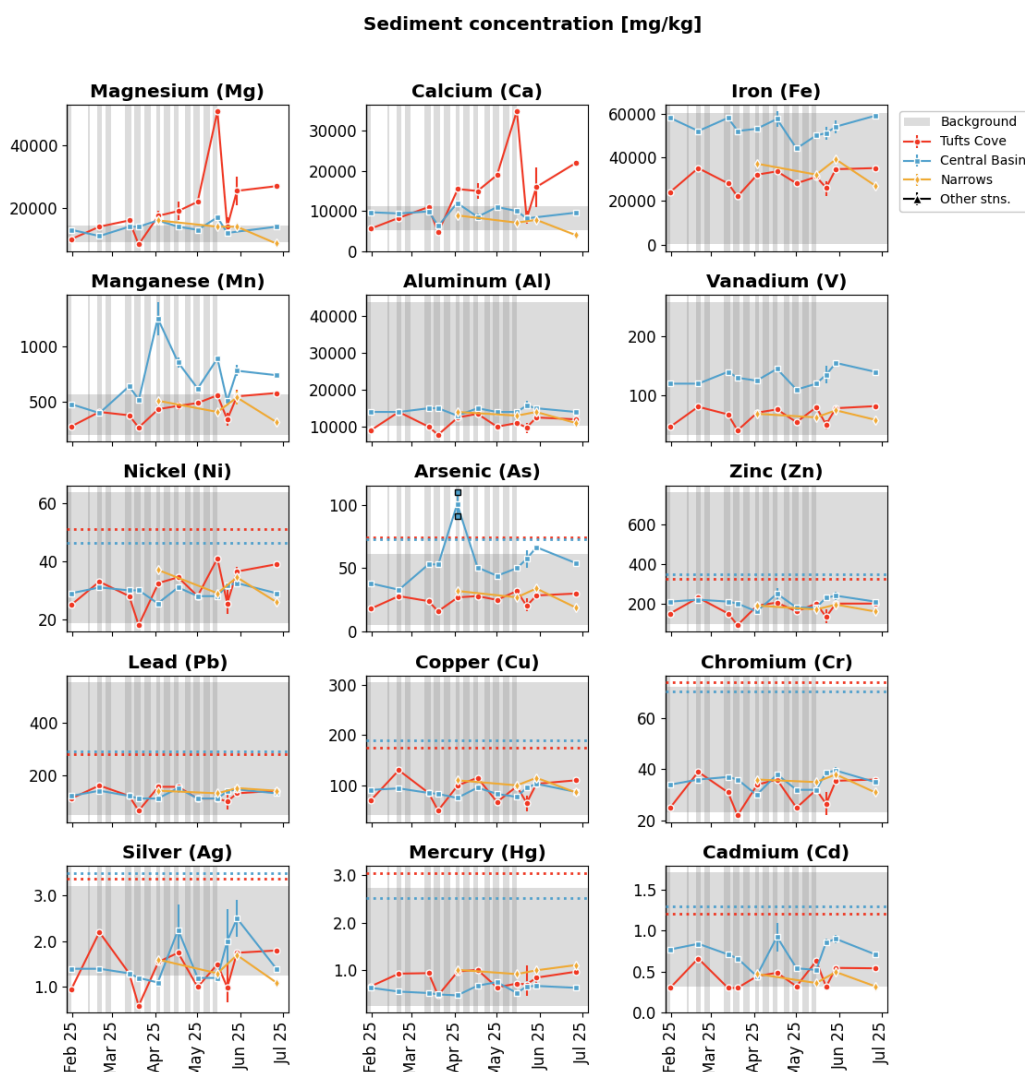


**Figure 4.5 - Sediment metal measurements. The apparent As overage (outlined marker) was unrelated to Planetary's dosing (Table 5.1).**

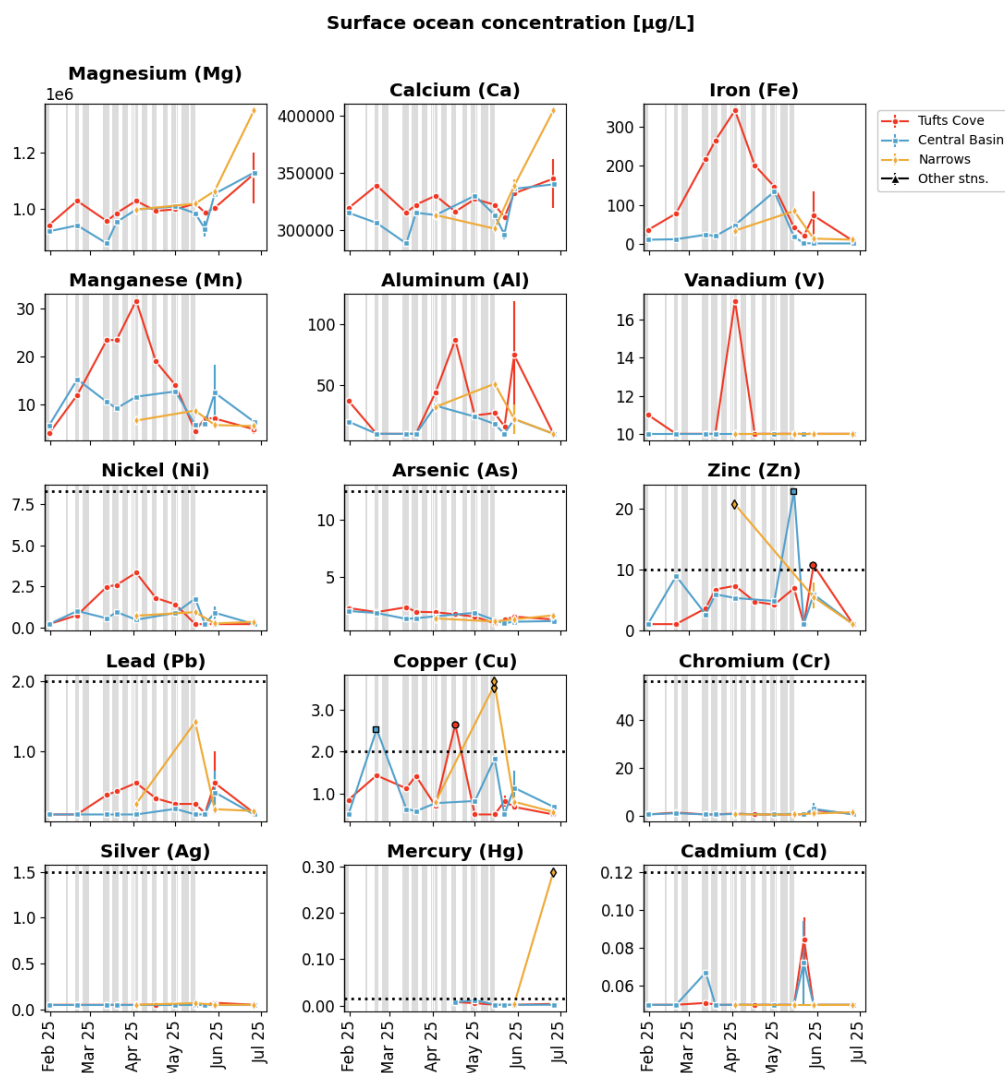


Figure 4.6 - Surface water total metals concentrations. See Table 5.1 for an explanation of the apparent overages (outlined markers) - none were linked to Planetary's dosing.

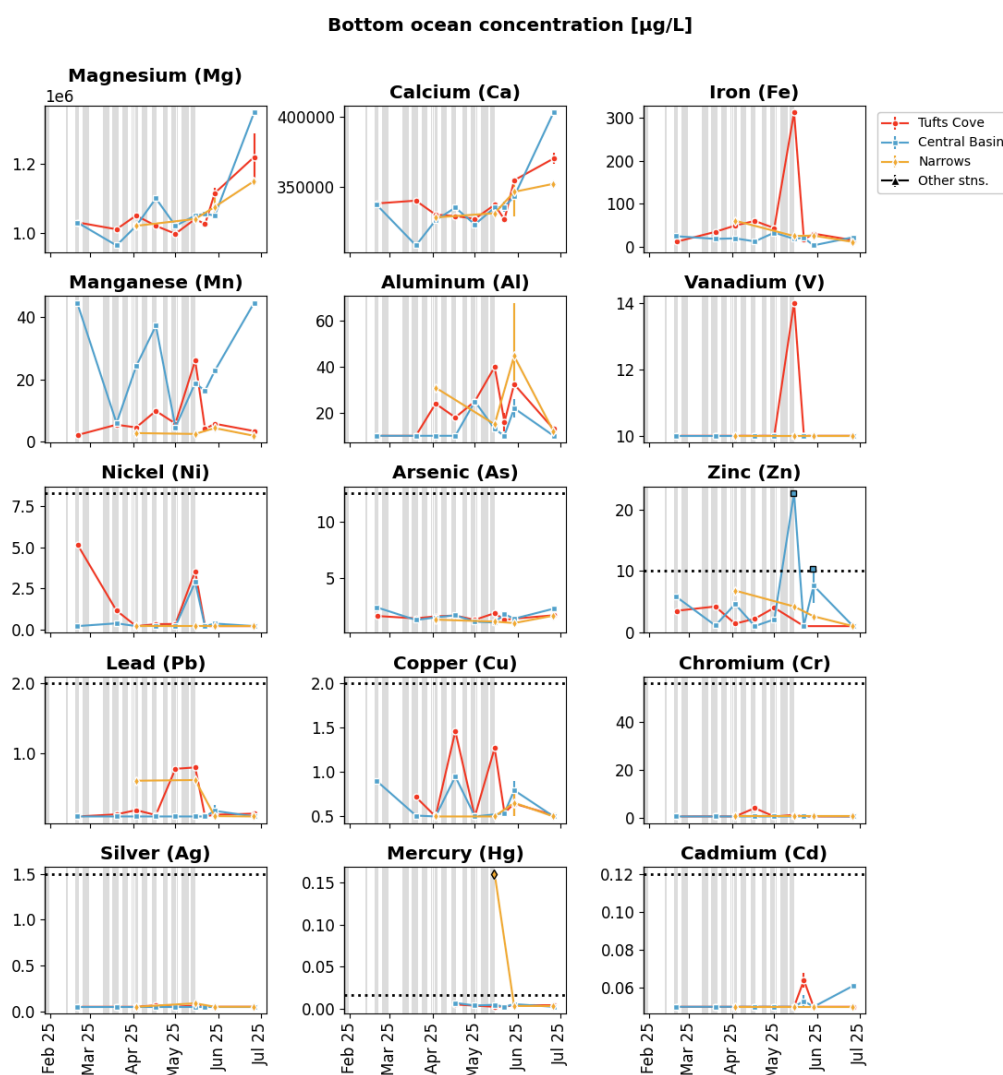


Figure 4.7 - Bottom water total metals concentrations. See Table 5.1 for an explanation of the apparent overages (outlined markers) - none were linked to Planetary's dosing.

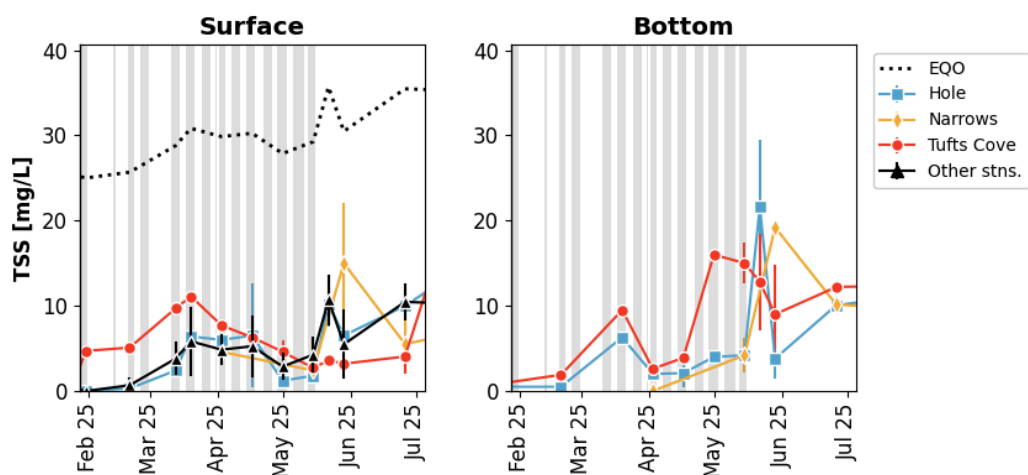


Figure 4.8 - TSS in the receiving waters. The dashed line is the EQS limit, defined as 25 mg/L above out-of-plume conditions. Markers and errorbars are the average and standard deviation of measurements, respectively.

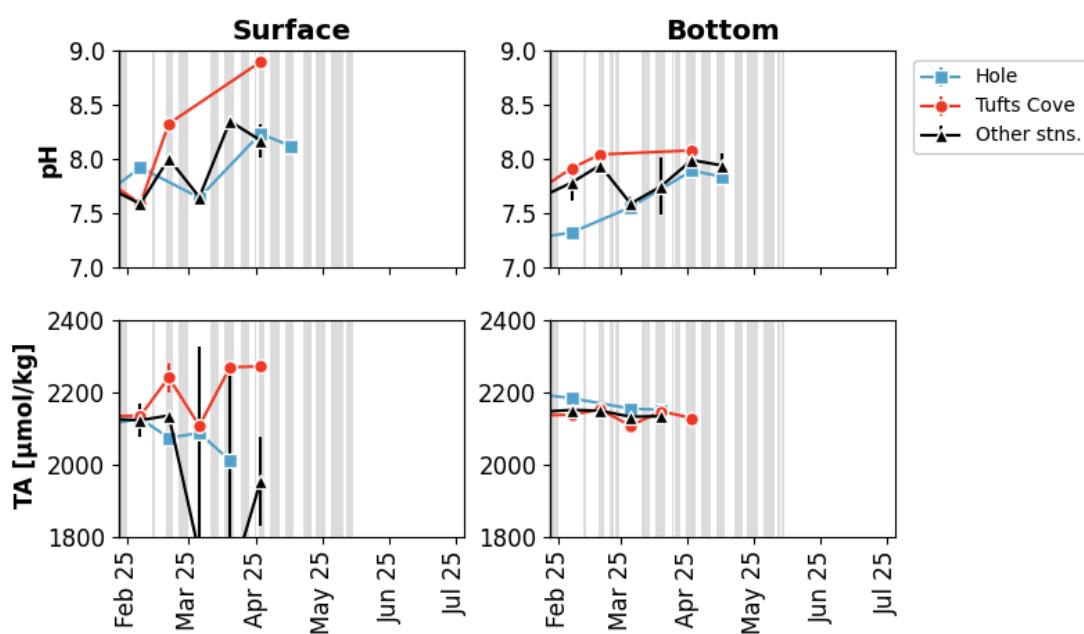


Figure 4.9 - Ocean carbonate system bottle samples. Some data are missing due to a backlog from the third party laboratory; those data will be filled in the subsequent report. Markers and errorbars are the average and standard deviation of measurements, respectively.

## 5 Data anomalies and gaps

Planetary's routine monitoring program detected several apparent overages of various stop-trigger or EQS thresholds (Table 5.1). The most notable overages occurred throughout May, where several water column (surface and bottom water) metals measurements were observed to be in excess of their respective EQS thresholds. An initial Hg exceedance was detected on 15 May (sample obtained on 1 May; results received on 15 May), and dosing was paused as a precaution while the source of the anomaly was investigated. Additional samples obtained on and after 15 May (i.e., after dosing had been paused) revealed several other apparent exceedances (in Cu, Hg and Zn). The in-depth internal investigation, which was submitted to the relevant provincial and federal regulators, concluded that the anomalies were **not related to Planetary's dosing activities**.

Overall, the exceedances detected during the current dosing period were attributed to one or more of the following:

1. External sources, such as storm and wastewater discharge. Several storm drains and industrial and municipal discharge sites exist near Planetary's dosing site. Following significant weather events, additional inputs of trace metals via these conduits are common.
2. Legacy metals in Halifax Harbour. As an industrial harbour, legacy metals loading (especially of copper, silver, lead and mercury) and accumulation in sediments is well documented in Halifax (e.g., Tay et al., 1992<sup>3</sup>; Buckley, Smith & Winters 1995<sup>4</sup>; Williams, 2010<sup>5</sup>).
3. Sediment resuspension. In some cases, the sampling equipment makes contact with the sediment during water sample collection. These occurrences, which are sometimes unavoidable due to challenging sampling conditions, are evidenced by elevated near-bottom turbidity readings. The resulting samples are invalidated by the introduction of particulate sediment metals into the water samples.

A rigorous quality control procedure is applied to the data, with only robust results being accepted. Only anomalies due to external sources or legacy metal content are shown and included in the final monitoring dataset. Therefore, gaps in the datasets represent samples that did not pass Planetary's quality control measures.

Overall, throughout the dosing period and since the beginning of metals sample collection in spring 2024 (see the [TC24 report](#)), **Planetary has observed no evidence of persistently increasing metals concentrations** (water or sediment, excluding Mg and Ca in sediments) at any of the sampling locations. These results do not support a link between the apparent exceedances and Planetary's dosing.

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<sup>3</sup> Tay K-L, Doe KG, Wade SJ, Vaughan DA, Berrigan RE, Moore MJ. 1992. Sediment bioassessment in Halifax harbour. *Environ Toxicol Chem* 11: 1567-1581.

<sup>4</sup> Buckley, D.E, Smith, J.N and Winters, G.V. Accumulation of contaminant metals in marine sediments of Halifax Harbour, Nova Scotia: Environmental factors and historical trends: *Applied Geochemistry*, vol. 10, no. 2, pp. 175-195, 1995.

<sup>5</sup> Williams, G., Parsons, M.B., Hellou, J. and Scott, D.B. (2010). Evaluating the effects of wastewater treatment on marine sediment chemistry in Halifax Harbour, Nova Scotia. *Atlantic Geology*, 46 (1).

**Table 5.1 - Summary of data anomalies and gaps**

| Data type                 | Date(s)                      | Event                                 | Dosing on or off | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------------------|------------------------------|---------------------------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Gaps                      |                              |                                       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| General                   | 28 Feb - 10 March            | Missing dosing and outfall data       | Off              | All dosing and monitoring paused for a company-wide event.                                                                                                                                                                                                                                                                                                                                                                                                |
|                           | 15 May - 30 June             | Missing dosing and outfall data       | Off              | Dosing stopped due to stop-trigger investigation and routine site maintenance. Outfall measurements stopped.                                                                                                                                                                                                                                                                                                                                              |
| Outfall                   | 12 March - 28 March          | Missing upstream outfall data         | On               | Sensor issues requiring service to the upstream sensor array. Only TA bottle samples obtained. Upstream TSS assumed 0 mg/L in calculating outfall TSS difference for regulatory permit, otherwise upstream data not required for regulatory or crediting purposes.                                                                                                                                                                                        |
| Ocean                     | 24 April - 30 June           | Some missing bottle pH, TA and S data | On until 15 May  | Data currently unavailable from Dalhousie U.                                                                                                                                                                                                                                                                                                                                                                                                              |
|                           | 20 February, 13 March, 1 May | pH                                    | On               | Issues with pH sensor.                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Mooring                   | 1 June - 30 June             | Turbidity and TSS data gap            | Off              | Data omitted due to evidence of extreme bio-fouling impacting turbidity readings                                                                                                                                                                                                                                                                                                                                                                          |
|                           | throughout                   | pCO <sub>2</sub> and TA gaps          | On/Off           | Sensor issues requiring service.                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Anomalies and Exceedances |                              |                                       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Ocean                     | 20 February                  | Cu > EQS (Hole, surface)              | On               | Determined to be linked to external sources or legacy metal content in the Harbour. Dosing not paused. The subsequent set of samples revealed all results to be below the EQS values. The lack of a corresponding spike in other major feedstock metals does not support a link to dosing.                                                                                                                                                                |
|                           | 3 April                      | Zn > EQS (Narrows, surface)           | On               |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                           | 17 April                     | Cu > EQS (Tufts Cove, surface)        | On               |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                           | 1 May                        | Hg > EQS (Tufts Cove, bottom)         | On               | <p><b>Data was received on 15 May, and dosing was stopped on the same date to conduct an investigation into the source.</b> The investigation revealed that the source was an anomaly due to sediment resuspension, evidenced by elevated bottom water TSS. No corresponding spike in other major feedstock metals implies no link to dosing.</p> <p>The anomaly is not shown in the present dataset as sediment resuspension invalidated the result.</p> |

**Table 5.1 - Continued.**

| <b>Data type</b> | <b>Date(s)</b> | <b>Event</b>                                                                                      | <b>Dosing on or off</b> | <b>Explanation</b>                                                                                                                                                                                                                                                                                                                                                                            |
|------------------|----------------|---------------------------------------------------------------------------------------------------|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ocean            | 15 May         | Several surface and bottom water exceedances of Cu, Hg, Zn Narrows and Hole (surface and bottom). | On                      | In response to the 1 May Hg exceedance, dosing was paused on 15 May. Parallel exceedances at locations distant from the outfall lead to the conclusion that these anomalies were due to external sources, legacy metal content in the Harbour, and storm runoff. The lack of a corresponding spike in other major feedstock metals at any sampling station does not support a link to dosing. |
|                  | 29 May         | Zn > EQS (Tufts Cove, surface; Hole bottom)                                                       | Off                     | Not dosing, so link to Planetary activity not established. Likely due to external sources or legacy metal content. No other metals show signs of elevated concentrations.                                                                                                                                                                                                                     |
|                  | 26 June        | Hg > EQS (Narrows, surface).                                                                      | Off                     | Not dosing, so link to Planetary's dosing not established. Likely external source or analytical error. No other metals show signs of elevated concentrations.                                                                                                                                                                                                                                 |
| Sediment         | 3 April        | As > stop-trigger limit (Hole)                                                                    | On                      | Likely legacy metals content in Halifax Harbour sediments. Dosing not paused. The follow-up sample was below the EQS limit and did not confirm the initial exceedance.                                                                                                                                                                                                                        |

## 6 Research and Development

### 6.1 Evidence of dissolution

As part of on-going research and development efforts, Planetary is investigating various lines of evidence to demonstrate feedstock dissolution in the receiving waters. Below summarizes the state of work, to-date; a subsequent monitoring report will provide updated testing results.

Feedstock dissolution was characterized in the laboratory prior to dosing, with experiments yielding dissolution rates on the order of  $1 \times 10^{-5}$  mol/m<sup>2</sup>/s (details in the [TC24 report](#) and the PDD available on [Planetary's project page](#)). These rates are approximately 10x lower than published values for MgO dissolution (Mejias et al., 1999<sup>6</sup>), possibly due to rapid saturation of seawater in the closed-system experiments, and thus may underestimate realized dissolution rates in the ocean. Nevertheless, the experimental rate corresponds to >95% of the feedstock dissolving in less than 24 hours, providing a high-degree of confidence that dissolution in Halifax Harbour would occur rapidly.

This hypothesis has been tested through regular and targeted ocean sampling efforts. As described in the [TC24 report](#), paired filtered and unfiltered TA samples showed a decline in particulate alkalinity at stations leading away from the outfall at Tufts Cove, while vertical water column turbidity measurements also showed high turbidity (a proxy for high particle content) near to the outfall, and diminishing values leading away from it. The routine outfall and ocean TSS sampling also provide evidence of feedstock dissolution or dissipation: TSS at the Tufts Cove offshore station (60 m from the outfall) was typically 5-10-fold lower in concentration than the end-of-pipe measurements.

Additional dissolved and total TA samples have been collected routinely in the receiving water since August, 2024, and a targeted study was conducted in August 2025 to map particle dissolution away from the alkalinity discharge point. Preliminary results show TA above baseline (non-OAE) conditions near to the outfall, with a high fraction of it being dissolved, and decreasing concentrations of particulate TA moving away from the outfall. An in-depth analysis from this sampling will be presented in the subsequent report.

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<sup>6</sup> Mejias, J. A., Berry, A. J., Refson, K., and Fraser, D. G. (1999). The kinetics and mechanism of MgO dissolution. Chemical Physics Letters. [https://doi.org/10.1016/S0009-2614\(99\)00909-4](https://doi.org/10.1016/S0009-2614(99)00909-4)

## Appendix 1 Additional tables and figures

**Table A1.1 - Summary of on-site events**

|                                 |                                                                                                                          |
|---------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| <b>28 Feb. - 10 March, 2025</b> | Dosing paused for site shut-down - company-wide break                                                                    |
| <b>10 March, 2025</b>           | Dalhousie-led Dye tracer experiment conducted (dosing paused to facilitate experiment) to assess dilution and dispersion |
| <b>May 15, 2025</b>             | Stop-trigger investigation initiated. Dosing paused during investigation and upgrades.                                   |
| <b>May 23 - 30 June 2025</b>    | Outfall shutdown for maintenance and upgrades. Dosing and outfall monitoring paused.                                     |

**Table A1.2 - Summary of undosed, waste feedstock**

| <b>Service Date</b>                    | <b>Mass [kg]</b> | <b>Description</b>               |
|----------------------------------------|------------------|----------------------------------|
| 24/02/2025                             | 300              | Tank cleaning                    |
| 27/03/2025                             | 1,300            | Waste mixture of magnesium oxide |
| 12/05/2025                             | 2,250            | Waste mixture of magnesium oxide |
| 23/05/2025                             | 5,500            | Split bags removed from site     |
| <b>Total Waste</b>                     | <b>9,350</b>     |                                  |
| <b>Subtract non-dosed bags removed</b> | <b>0</b>         |                                  |
| <b>Net waste removed</b>               | <b>9,350</b>     |                                  |

## Appendix 2 Monitoring data

Samples for pH, salinity, TSS, total alkalinity (TA) and dissolved trace metal content were obtained from both outfall sensor locations, the shore-tethered mooring, and from boat surveys. Sediment samples were also collected from the boat surveys using a sediment grabber. Shore samples were obtained on an approximately weekly basis while boat samples were generally taken 1-2 times per month. Exceptions include additional sampling around a stop-trigger event, or ad-hoc R/D endeavours, and reduced sampling during dosing outages (see section 5 and Table A2.1).

Details on the sample collection and analyses are provided in the [TC24 report](#). Briefly, pH, TA and metals samples were analyzed by third-party laboratories, while TSS analyses were conducted in-house following standardized methods. Total suspended solids analyses were conducted in-house to minimize potential under-biasing caused by particle dissolution during the time between sample collection and analysis. A standard curve relationship between discrete TSS and the corresponding sensor turbidity measurements was derived to calculate a continuous TSS record; see below.

The sensor data (outfall, mooring and water column vertical profile) were calibrated using the discrete bottle data by calculating the offset between paired sensor and bottle measurements, and applying the time-varying bias to the sensor dataset.

The monitoring data were assessed against a set of limits identified for most measured variables. Details on the stop-trigger framework are contained in PDD available on [Planetary's project page](#) on the Isometric credit registry. Briefly, the limits were assembled from federal and provincial regulations for marine waters, and, in the absence of regulations, calculated based on historical data records for the region. For sediment metals, stop-triggers are only defined for 9 sediment metals (Ag, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn), shown as dashed lines in Fig. 4.5. Various water metals, pH, TSS, temperature, salinity, and oxygen are regulated for marine waters under the Canadian Council of Ministers of the Environment (CCME), while outfall TA and pH and TSS limits were defined under the Isometric OAE Protocol and by the Nova Scotia Department of Environment and Climate Change, respectively.

**Table A2.1 - Sampling and servicing events**

| Date        | Event | Data collected                                                     |
|-------------|-------|--------------------------------------------------------------------|
| 12-Feb-2025 | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 19-Feb-2025 | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 20-Feb-2025 | BS    | CTD; Sediment grab (metals); Water metals; Bottles: TSS, pH, TA, S |
| 27-Feb-2025 | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 11-Mar-2025 | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 13-Mar-2025 | BS    | CTD; Sediment grab (metals); Water metals; Bottles: TSS, pH, TA, S |
| 20-Mar-2025 | BS    | CTD; Sediment grab (metals); Water metals; Bottles: TSS, pH, TA, S |
| 21-Mar-2025 | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 26-Mar-2025 | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 2-Apr-2025  | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 3-Apr-2025  | BS    | CTD; Sediment grab (metals); Water metals; Bottles: TSS, pH, TA, S |
| 9-Apr-2025  | OS/S  | Water metals                                                       |
| 10-Apr-2025 | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 16-Apr-2025 | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 17-Apr-2025 | BS    | CTD; Sediment grab (metals); Water metals; Bottles: TSS, pH, TA, S |
| 24-Apr-2025 | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 30-Apr-2025 | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 1-May-2025  | BS    | CTD; Sediment grab (metals); Water metals; Bottles: TSS, pH, TA, S |
| 7-May-2025  | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 14-May-2025 | OS/S  | TSS, pH, TA, S, Water metals                                       |
| 15-May-2025 | BS    | CTD; Sediment grab (metals); Water metals; Bottles: TSS, pH, TA, S |
| 21-May-2025 | OS/S  | pH, TA, S, Water metals                                            |
| 22-May-2025 | BS    | CTD; Sediment grab (metals); Water metals; Bottles: TSS, pH, TA, S |
| 29-May-2025 | BS    | CTD; Sediment grab (metals); Water metals; Bottles: TSS, pH, TA, S |
| 26-Jun-2025 | BS    | CTD; Sediment grab (metals); Water metals; Bottles: TSS, pH, TA, S |

BS = Boat survey; OS/S = outfall sampling & service

**Table A2.2 - Discrete outfall sample data**

| Sample Date and Time [UTC] | Sample Location | pH   | Total Alkalinity [μmol/kg] | DIC [μmol/kg] | Salinity | TSS [mg/L] |
|----------------------------|-----------------|------|----------------------------|---------------|----------|------------|
| 12/02/2025 16:54           | Upstream        | 7.92 | 2177.86                    | 2087.25       | 30.66    | 1.9        |
| 12/02/2025 19:03           | Downstream      | 7.94 | 2146.62                    | 2081.42       | 30.71    | 4.4        |
| 19/02/2025 15:42           | Upstream        | 7.94 | 2158.48                    | 2068.56       | 30.72    | 4.6        |
| 19/02/2025 15:10           | Downstream      | 8.16 | 2247.14                    | 2102.3        | 30.72    | 17.5       |
| 27/02/2025 16:54           | Upstream        | 8.11 | 2230.46                    | 2072.72       |          | 7          |
| 27/02/2025 16:33           | Downstream      | 8.18 | 2242.74                    | 2080.17       | 30.51    | 13.2       |
| 11/03/2025 14:31           | Upstream        | 8.02 | 2126.25                    | 2001.19       | 29.76    | 4.3        |
| 11/03/2025 16:19           | Downstream      | 8.06 | 2119.91                    | 2003.58       | 29.89    | 6.4        |
| 21/03/2025 18:41           | Upstream        |      | 2129.27                    |               |          |            |
| 21/03/2025 19:06           | Downstream      | 8.21 | 2183.36                    | 1980.79       | 30.13    | 5.3        |
| 26/03/2025 11:47           | Upstream        |      | 2132.43                    |               |          |            |
| 26/03/2025 12:24           | Downstream      | 8.16 | 2154.94                    | 1990.05       | 30.14    | 5.2        |
| 02/04/2025 12:27           | Downstream      | 8.09 | 2151.43                    | 2005.62       | 30.08    | 5.2        |
| 02/04/2025 13:52           | Downstream      |      |                            |               |          | 8.7        |
| 02/04/2025 14:09           | Downstream      |      |                            |               |          | 13.5       |
| 02/04/2025 14:25           | Upstream        |      | 2077.54                    |               |          | 3.9        |
| 10/04/2025 17:24           | Upstream        | 8.14 | 1991.41                    | 1844.15       | 27.52    | 5.6        |
| 10/04/2025 18:03           | Downstream      | 8.43 | 2165.1                     | 1859.66       | 28.57    | 4.6        |
| 16/04/2025 13:45           | Upstream        | 8.13 | 2102.4                     | 1943.02       | 29.26    | 9.8        |
| 16/04/2025 13:09           | Downstream      | 8.31 | 2156.12                    | 1924.15       | 29.37    | 17         |
| 24/04/2025 15:25           | Upstream        | 8.61 | 2105                       | 1641.05       | 27.59    | 6.6        |
| 24/04/2025 15:25           | Upstream        |      |                            |               |          | 11         |
| 24/04/2025 15:25           | Upstream        |      |                            |               |          | 8.4        |
| 24/04/2025 14:44           | Downstream      | 8.89 | 2687.32                    | 1926.14       | 28.45    | 21         |
| 24/04/2025 14:44           | Downstream      |      |                            |               |          | 17.4       |
| 30/04/2025 14:58           | Upstream        | 8.61 |                            | 1737.51       | 28.17    | 10.8       |
| 30/04/2025 14:58           | Upstream        |      |                            |               |          | 9.4        |
| 30/04/2025 14:23           | Downstream      | 8.66 |                            | 1706.78       | 28.87    | 19         |
| 30/04/2025 14:23           | Downstream      |      |                            |               |          | 26         |
| 07/05/2025 13:04           | Upstream        | 8.18 | 2136.08                    | 1978.21       | 28.35    | 11.8       |
| 07/05/2025 13:04           | Upstream        |      |                            |               |          | 10.2       |
| 07/05/2025 12:33           | Downstream      | 8.16 | 2137.14                    | 1962.37       | 28.38    | 3.6        |
| 07/05/2025 12:33           | Downstream      |      |                            |               |          | 4.4        |
| 14/05/2025 11:30           | Downstream      | 8.65 | 2459                       | 1953.21       | 28.95    | 22.2       |
| 14/05/2025 11:30           | Downstream      |      |                            |               |          | 7.2        |
| 21/05/2025 12:48           | Upstream        |      | 2077.65                    |               | 29.18    |            |
| 21/05/2025 12:41           | Downstream      |      | 2082.48                    |               | 29.69    |            |

### A2.1 Turbidity vs TSS relationship

Figure A2.1 below shows the standard curve relationship derived between sensor turbidity and bottle TSS. The blue line shows the applied equation and the corresponding 95% confidence bounds. The black and red markers represent all data collected since July, 2024, and data collected during the winter (November 2024 - February 2025), respectively. The data collected prior to November and after February show significantly more noise at the lower range of observations, likely representing biological particles, which may confound the turbidity-vs-TSS relationship. For this reason, and because regression through all data points (not shown) tends to under-estimate TSS at the higher range of observations ( $R^2 = 0.40$ ), we elected to use the post-November regression line ( $TSS = 1.01 * Turb$ ;  $R^2 = 0.83$ ) as the best-fit predictor of TSS at Tufts Cove for the present operational period. This equation was applied to the continuous turbidity measurements to derive TSS in real-time.

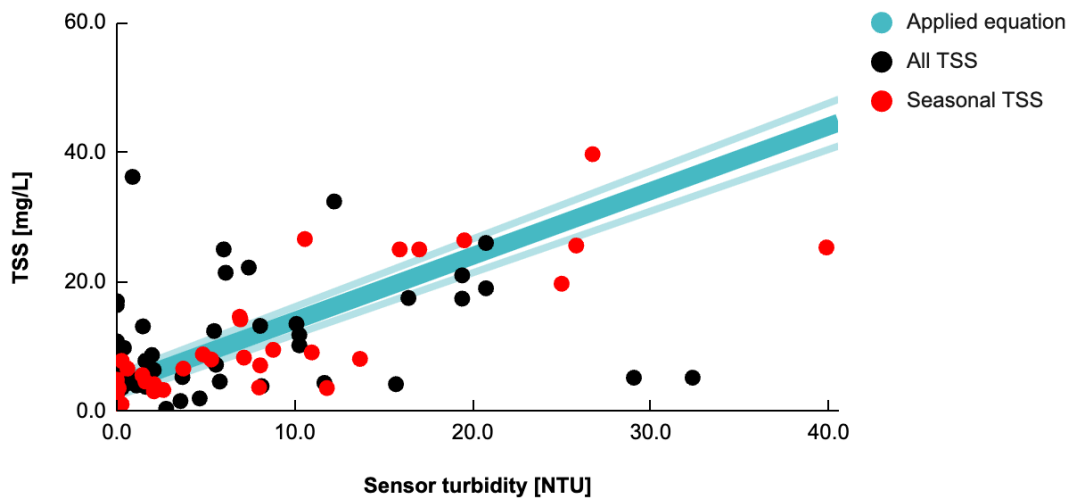


Figure A2.1 - Turbidity vs TSS relationship

## A2.2 Mooring data

The shore tethered mooring at Tufts Cove is used primarily for R/D purposes. Sever interruptions to the datasets resulted from instrument malfunctions and bio-fouling. Note that the turbidity (and derived TSS) data are noisy due to the presence of bubbles.

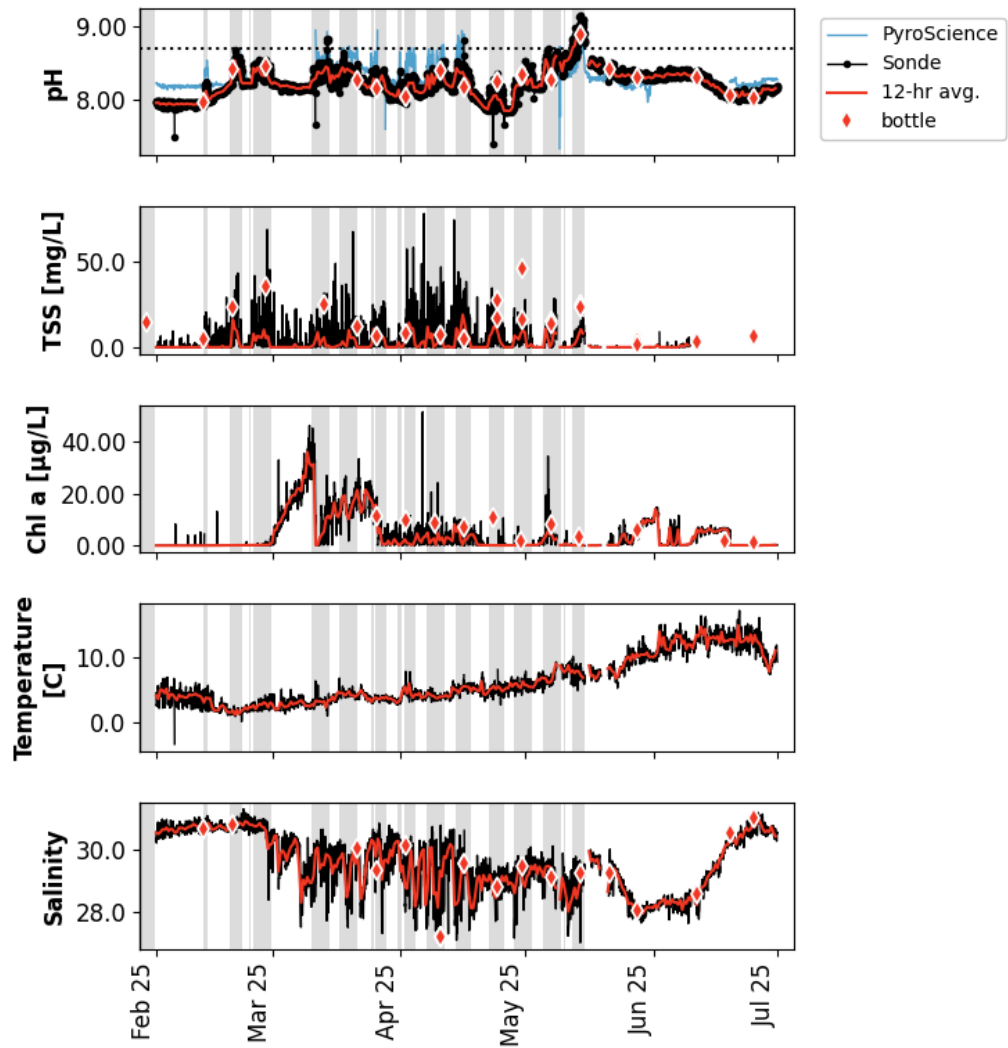


Figure A2.2 - Mooring observations