MASSACHUSETTS WATER RESOURCES AUTHORITY
Deer Island
33 Tafts Avenue
Boston, MA 02128

Frederick A. Laskey
Executive Director

Telephone: (617) 242-6000
Fax: (617) 788-4899
TTY: (617) 788-4971

September 29, 2023

Todd Borci
EPA Region 1
5 Post Office Square, Suite 100
Mail Code ECAD4-4
Boston MA, 02109-3912

Catherine Coniaris
Department of Environmental Protection
1 Winter Street
Boston, MA 02108

RE: Massachusetts Water Resources Authority
Permit Number MA 0103284
Contingency Plan Threshold Exceedances: Stellwagen Basin DO concentration and percent saturation

Dear Mr. Borci and Ms. Coniaris:

The Massachusetts Water Resources Authority ("MWRA") monitors bottom water dissolved oxygen ("DO") concentration and percent saturation in the Stellwagen Basin[1] as part of its permit-attached Ambient Monitoring Plan[2] and Contingency Plan.[3] The Contingency Plan states that the bottom water DO concentration, during any survey while the water column is stratified (June through October), is expected to be at least 6.5 mg/L (caution level threshold) or at least 6.0 mg/L (warning level threshold), unless background conditions are lower. Background conditions are computed from monitoring during the baseline period 1992-2000, prior to when operation of the outfall in Massachusetts Bay began. When testing against the caution and warning level thresholds, if background conditions are lower than the thresholds, the measured values must be above the background conditions. Similarly, for DO percent saturation, during any survey from June through October, the caution level threshold is at least 80% and the warning level threshold is at least 75%, unless background conditions are lower.

On September 12, MWRA conducted a routine water column monitoring survey. After routine data quality checks, the results were compared to thresholds on September 27. **The threshold checks revealed that there was a caution level exceedance for the Stellwagen Basin bottom water DO concentration, and a warning level exceedance for Stellwagen Basin bottom water DO percent saturation.** The bottom water DO concentration for Stellwagen Basin was 6.08 mg/L. The Contingency Plan thresholds are 6.5 mg/L for the caution level and 6.0 mg/L for

[1] For an explanation of the DO measurements, see https://www.mwra.com/harbor/html/thresholds.htm#do.
[2] *Ambient Monitoring Plan for the Massachusetts Water Resources Authority Effluent Outfall (Revision 2.1, August 2021)*. Report 2021-08. https://www.mwra.com/harbor/enquad/pdf/2021-08.pdf.
[3] *Massachusetts Water Resources Authority Contingency Plan Revision 1*. 2001. Report 2001-ms-071. https://www.mwra.com/harbor/enquad/pdf/2001-ms-71.pdf. For sections in the Contingency Plan specifically relevant to DO, see pages 23-24 and 26.

the warning level, with the calculated background condition value being 6.23 mg/L. The bottom water DO percent saturation at Stellwagen Basin was 63.4%. The Contingency Plan caution and warning threshold levels are 80% and 75%, respectively, and the calculated background condition value is 67.17%. These results are similar to exceedances reported following the July routine survey. There were no exceedances on the August routine survey. As with exceedances reported in 2021 and 2022, MWRA believes that these exceedances are due to region-wide processes not related to the outfall.

These exceedances require regulatory and public notification, provided by this letter, in accordance with Part I.8.b (Contingency Plan) of the Deer Island Treatment Plant NPDES permit.

Background

Figure 1 shows MWRA monitoring locations in Massachusetts Bay. Stellwagen Basin is sampled at Station F22, in water 80.9 m (265 ft) deep, located 17.5 km (10.9 miles) away from the easternmost riser of the 30 m (100 ft) deep outfall diffuser.

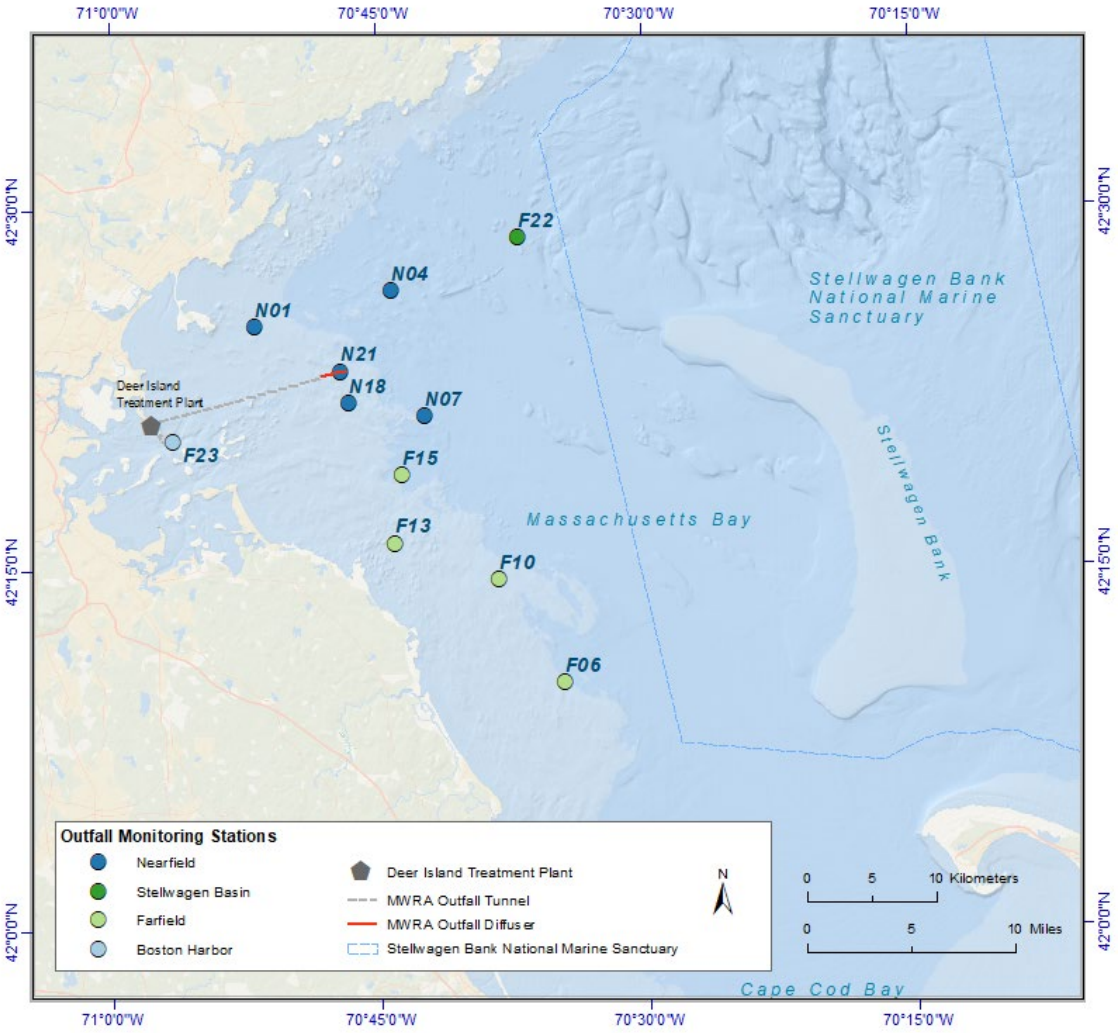

Figure 1. Map of outfall, nearfield, Stellwagen Basin, farfield, and harbor monitoring stations.

In past MWRA studies, regional factors have been identified as having a larger influence on DO levels in Massachusetts Bay than the outfall (emphasis added below):

> On a regional scale, circulation in the bays is often affected by the larger pattern of water flow in the Gulf of Maine. The western Maine coastal current usually flows southwestward along the coast of Maine and New Hampshire and depending on prevailing oceanographic and meteorological conditions may enter Massachusetts Bay south of Cape Ann (Geyer et al. 1992). Optimal conditions for inflow usually occur during the spring when winds out of the northeast bring significant freshwater inflow from the gulf into the bays and transport generally follows a counterclockwise path along the coast to Cape Cod Bay. Inflow from the gulf is the major source of nutrients to the bay. ***The inflow also helps to flush the bay, and gives the bay its water quality characteristics including dissolved oxygen levels*** and plankton communities (including nuisance blooms such as *Alexandrium*)…
>
> Furthermore, modeling and statistical analyses indicate that bottom water DO levels in Massachusetts Bay are highly correlated with conditions along the bay/Gulf of Maine boundary and that ***regional processes and advection are the primary factors governing bottom water DO concentrations in the bay*** (HydroQual 2001, Geyer et al. 2002, Jiang et al. 2007).[4]

For water column parameters other than nitrogen, such as chlorophyll or dissolved oxygen, MWRA monitoring has shown no outfall influence, even in the nearfield close to the outfall. For nitrogen the outfall influence extends as far as 20 km (12 miles) away on an infrequent basis, and persistently less than 10 km (6 miles) away.

Exceedances

Table 1 shows bottom water DO data from the September 12 survey and the Contingency Plan thresholds (caution, warning, and background). Results are shown for both the nearfield and Stellwagen Basin. At the Stellwagen Basin station, there was an exceedance of the caution level threshold for DO concentration and an exceedance of the warning level threshold for percent DO saturation.

[4] *Ambient Monitoring Plan for the Massachusetts Water Resources Authority Effluent Outfall (Revision 2.1, August 2021).* Report 2021-08. https://www.mwra.com/harbor/enquad/pdf/2021-08.pdf. See pages 24 and 40-41 for specific information on DO monitoring.

LOCATION	PARAMETER	TEST LEVEL	THRESHOLD VALUE	BACKGROUND VALUE	UNIT	TEST RESULT	EXCEEDANCE Y/N
Nearfield	bottom dissolved oxygen	CAUTION	6.5	6.05	mg/L	6.3	N
		WARNING	6				
Nearfield	bottom DO % saturation	CAUTION	80	65.28	%	68.5	N
		WARNING	75				
Stellwagen Basin	bottom dissolved oxygen	CAUTION	6.5	6.23	mg/L	**6.08**	**Y Caution**
		WARNING	6				
Stellwagen Basin	bottom DO % saturation	CAUTION	80	67.17	%	**63.4**	**Y Warning**
		WARNING	75				

Table 1. Bottom water DO results from the September 12 survey, with Contingency Plan thresholds

Figure 2 shows the vertical profiles for DO concentration and percent saturation results at station F22 (Stellwagen Basin) from the September 12 survey. The results from the downcast (as the instrument travels down through the water column) are in green, and the upcast results (as the instrument returns to the surface) are the yellow circles. The dark blue line is the mean of the results from the previous three years during the same time of year as the current results. The shaded blue and gray areas are, respectively: (a) the interquartile range of the results from 2000-2022 and (b) the minimum and maximum results from 2000-2022, respectively – both from the same time of the year as the survey results.

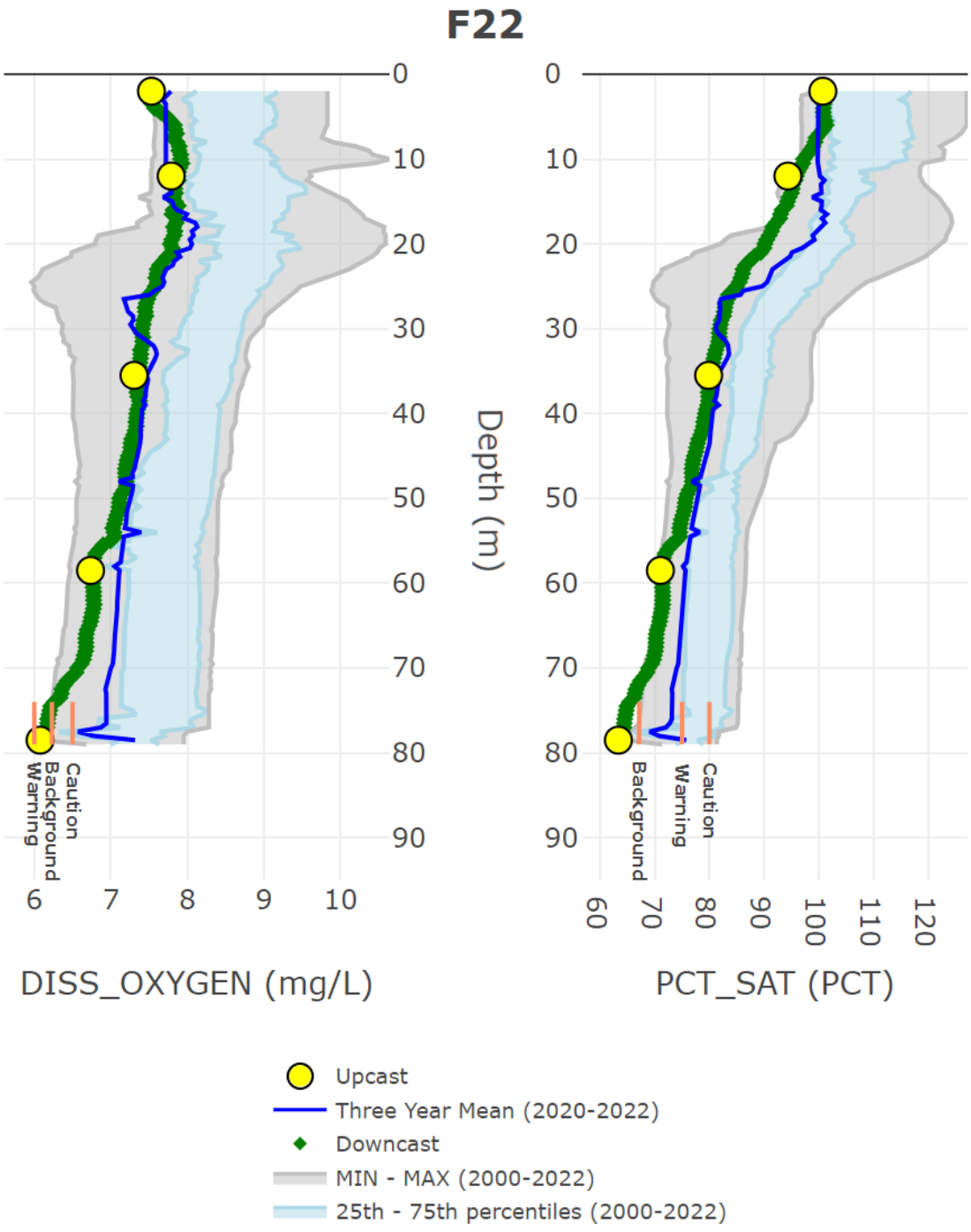

Figure 2. Vertical profiles of DO concentration (left) and percent saturation (right) measurements from Stellwagen Basin (F22) on the September 12 survey.

Discussion

This is the second Contingency Plan exceedance of 2023 following a previously reported exceedance[5] from the July survey. DO concentration and percent saturation were slightly higher on the August survey, resulting in no exceedances. Prior threshold exceedances of Stellwagen Basin DO concentration occurred in November 2021, which was a warning level exceedance, caution level exceedances occurred in September and October 2022.

Percent saturation exceedances at Stellwagen Basin occurred in October 2000 and warning level exceedances happened in September and November 2021, and August and September 2022. Excursions of percent saturation below the caution level were also not unusual in the pre-outfall phase of monitoring in both the nearfield and Stellwagen Basin – they occurred in seven of the eight years before the outfall went online.[6]

The nearfield DO concentration and percent saturation both met the Contingency Plan thresholds in September 2023, indicating that the outfall was not the cause of the lowered DO. Other farfield stations south of the outfall showed similar or lower bottom DO concentrations to the Stellwagen Basin F22 location, further indicating that DO concentrations in Massachusetts Bay are not adversely impacted by the outfall.

As with the previous DO threshold exceedances, MWRA believes this set of exceedances may be due to region-wide processes in the Gulf of Maine, and not related to the outfall.

[5] August 11, 2023 Contingency Plan Threshold Exceedance notification.
https://www.mwra.com/harbor/pdf/20230811_amx.pdf

[6] November 10, 2000 letter to DEP and EPA regarding Contingency Plan exceedances of DO.
https://www.mwra.com/harbor/pdf/ax111000.pdf

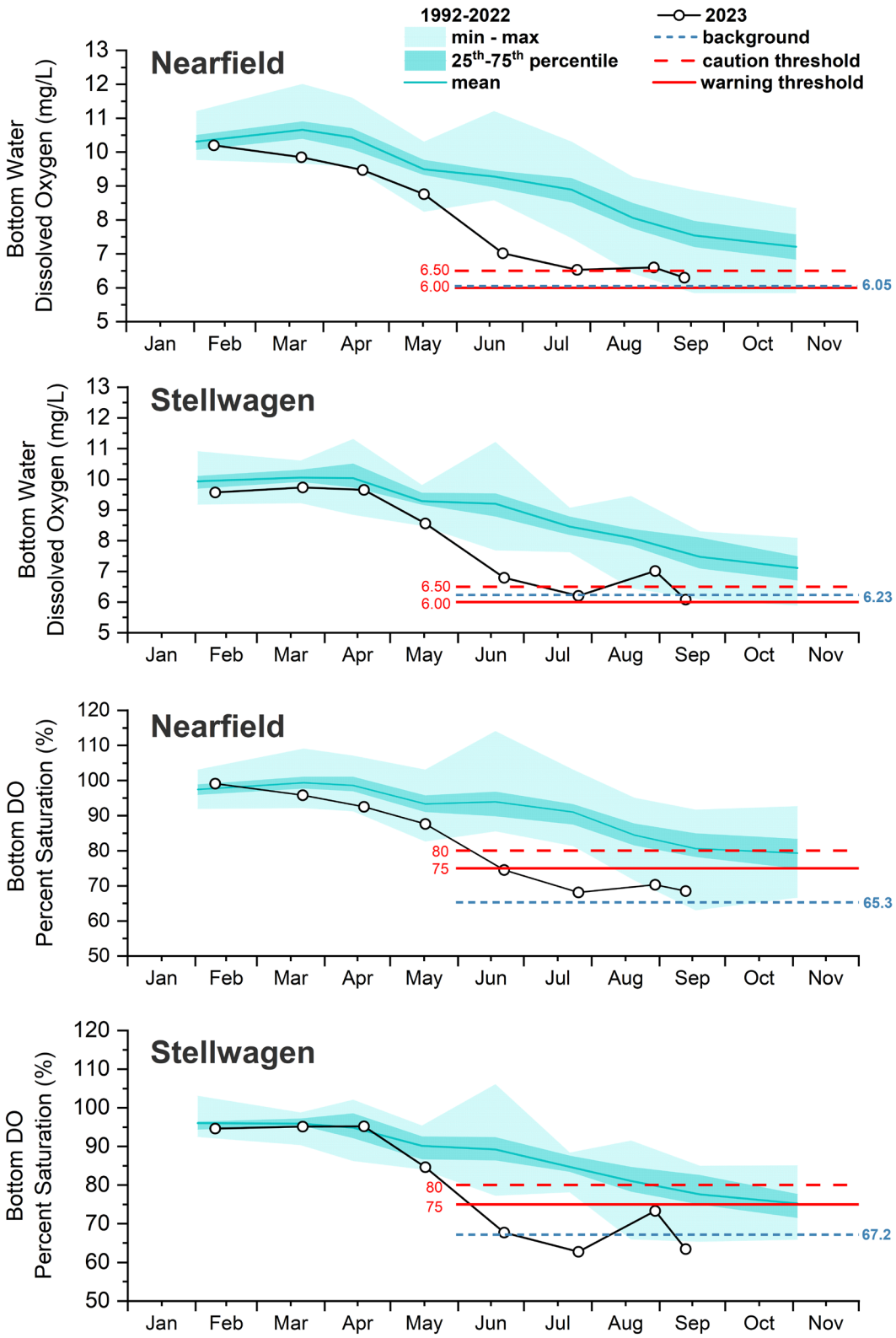

Figure 3. 2023 DO concentration seasonal progression results compared to 1992-2022 historical results in Stellwagen Basin and the nearfield. Contingency Plan thresholds and background levels used to determine exceedances are shown.

It should be noted that under stratified water column conditions – as existed for this survey – it is normal for DO concentrations and percent saturation to decrease in bottom waters over time (see historical data in Figure 3). As a result of the stratification, in the absence of strong storms, there is no physical mechanism for the water below the thermocline to be reaerated through exchange with the atmosphere, and natural biological consumption processes cause DO in the bottom water to decline. Stratification naturally breaks down with the onset of stormier weather in the fall. Once that occurs, the water column mixes and surface and bottom DO measurements equalize. Figure 3 above shows the slightly increased bottom dissolved oxygen on the August survey. Preliminary review of the data indicate some mixing may have occurred between the July and August surveys, possibly driven by storms on August 8 and 25.

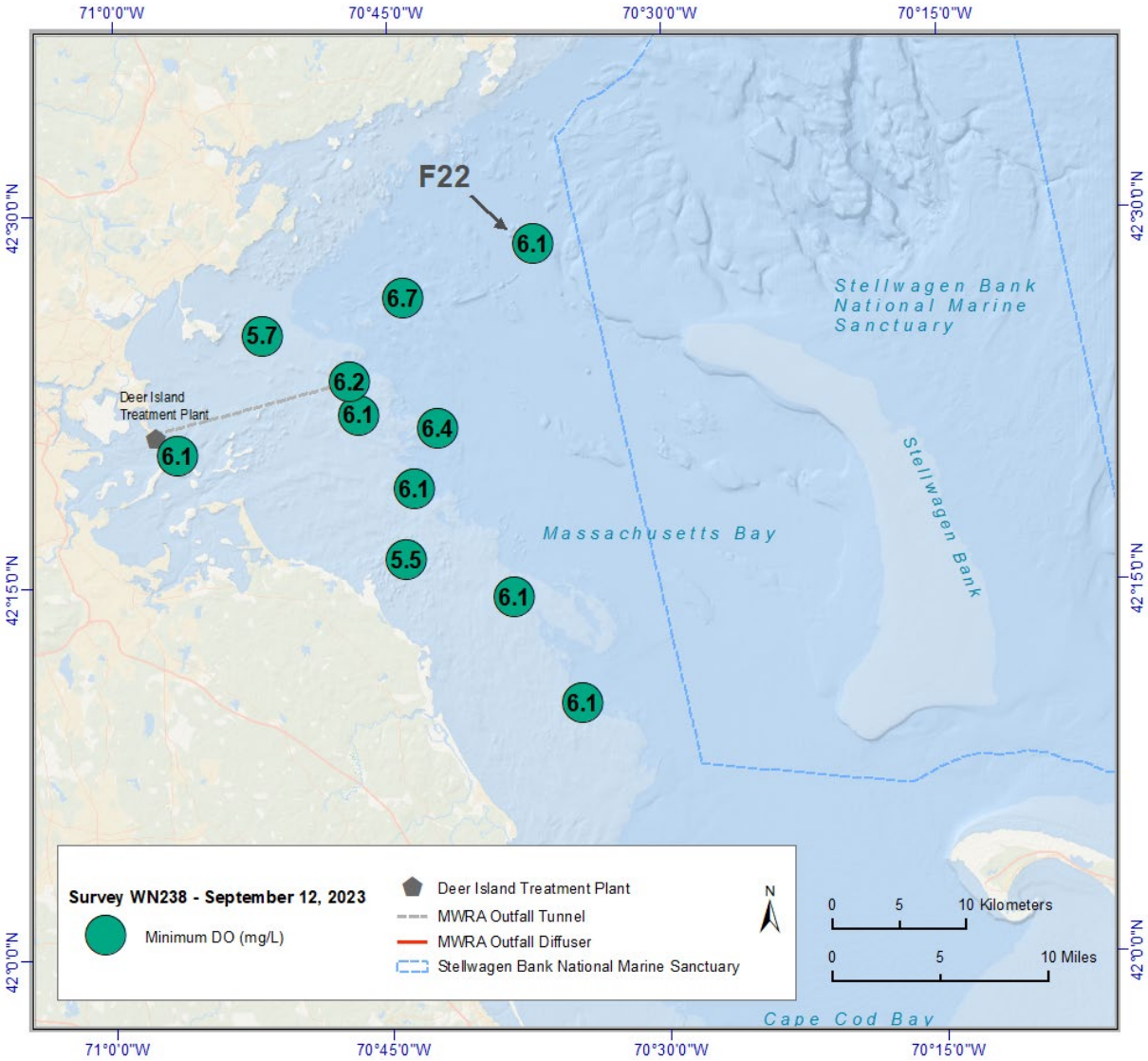

Figure 4. Minimum Dissolved Oxygen concentration (mg/L) at each station monitored on survey WN238. Contingency Plan exceedance reported here only for station F22.

Preliminary examination of the qualitative phytoplankton measurements collected by MWRA to date in 2023 show there was an extended bloom of the dinoflagellate *Tripos muelleri* (formerly known as *Ceratium tripos*) that dominated the Gulf of Maine from April through July. As with any algae bloom, as organisms begin to die off and sink to the bottom, oxygen is consumed in the bottom waters. This *Tripos* bloom extended from Martha's Vineyard, MA to Penobscot Bay, ME, so it was not exclusive to Massachusetts Bay.[7] During the *Tripos* die off, historically low DO concentrations were observed in June and July at both nearfield and Stellwagen locations (Figure 3). While DO recovered slightly before the August survey, this low starting point coupled with the typical seasonal decline in DO through late summer contributed to September DO concentrations at the low end of historic ranges throughout Massachusetts Bay.

Deer Island Treatment Plant Effluent Results

There is also no evidence these exceedances are related to the Deer Island Treatment Plant outfall discharge. The NPDES permit specifies two limits for effluent carbonaceous biochemical oxygen demand (cBOD), a measure of its oxygen depletion potential: a monthly average of 25 mg/L and a weekly average of 40 mg/L. cBOD limits are met consistently at DITP. During the period between the September 12 survey and the previous survey on August 29, the average of the effluent cBOD samples was 4.1 mg/L, well below the monthly permit limit. The average effluent cBOD the week preceding the September 12 survey (September 5-12) was 4.2 mg/L, also well below the weekly permit limit. No Deer Island Treatment Plant operational issues were reported between the August and September surveys.

Long-Term Trends in Dissolved Oxygen

As with the previous DO threshold exceedances, MWRA believes these exceedances may be due to long-term, region-wide changes not related to the outfall. Figure 5 shows observed trends at Station F22 since 1992. There are statistically meaningful trends (represented by the orange lines) in temperature (increasing) and DO concentration (decreasing) for vertically averaged observations (five depths spanning the water column) and for surface and bottom measurements independently. There is no significant difference between rates of change at the surface or bottom.

Although Figure 5 presents data only from Station F22, similar temperature and DO patterns are seen at all MWRA stations. At most MWRA stations temperature increases have been 0.4-0.6 degrees Celsius per decade, and oxygen declines have been 0.12-0.25 mg/L DO per decade. Researchers have seen similar results both regionally, nationally, and globally. Higher water temperatures are a factor that contributes to lower DO concentrations.

The Gulf of Maine Research Institute has also seen similar patterns in temperature in the wider Gulf of Maine. The Institute declared March-May 2023 as the "second hottest spring" since 1982. The Institute's most recent web page on Gulf of Maine warming has a wealth of information on this regional warming trend.[8]

---

[7] Cameron Thompson, Northeastern Regional Association of Coastal Ocean Observing Systems, personal communication. August 7, 2023.

[8] Gulf of Maine Research Institute. "Gulf of Maine Warming Update: Spring 2023". Available at: https://gmri.org/stories/gulf-of-maine-warming-update-spring-

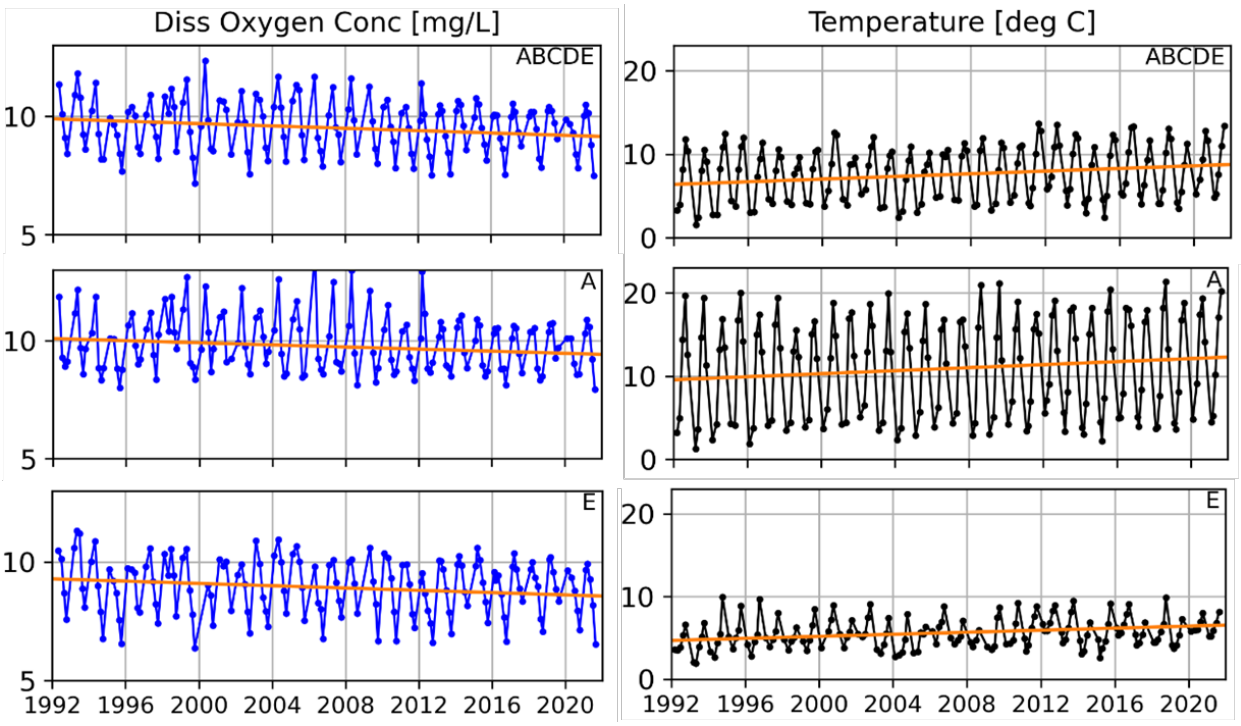

Figure 5. Trends in DO concentration and temperature at Station F22 since 1992. The top panels are averages of readings at all five depths monitored ("ABCDE"). The middle panels are at the surface ("A"), and the bottom panel is the bottom water ("E").

Relationship to Water Quality Standards

Although bottom water DO concentrations at Stellwagen Basin were threshold exceedances per the Contingency Plan (CP), aquatic life was not necessarily endangered. CP thresholds were intended to enable detection of changed conditions compared to the 1990s baseline period, not necessarily to indicate harmful or degraded conditions. The Stellwagen Basin DO concentration – 6.08 mg/L – was a caution level exceedance but still above Massachusetts state water quality standards (6.0 mg/L).[9] Marine DO concentration standards in other New England states and New York range from 4.8-5 mg/L, in contrast to that of Massachusetts.[10]

The origin of the lower DO standard used in other northeastern states can be found in EPA's January 2000 document, *Draft Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras*. That document stated that "If the DO exceeds the chronic protective value for growth (4.8 mg/L), the site meets objectives for protection." This same phrase appeared in the final version of the criteria issued in November 2000.[11] In fact, as early as December 1997, the Outfall Monitoring Task Force (the predecessor to OMSAP,

---

2023/#:~:text=Marine%20Heatwave%20Conditions&text=Applying%20this%20broadly%20accepted%20definition,the%20threshold%20of%20a%20MHW.

[9] Massachusetts Surface Water Quality Standards, 314 CMR 4.05(4)(a)(1). https://www.mass.gov/doc/314-cmr-400-surface-water-quality-standards/download

[10] New England Interstate Water Pollution Control Commission matrix of state water quality standards. Available at: https://neiwpcc.org/our-programs/pollution-control/water-quality-standards/wqs-matrix/

[11] https://www.epa.gov/sites/default/files/2018-10/documents/ambient-al-wqc-dissolved-oxygen-cape-code.pdf

the Outfall Monitoring Science Advisory Panel) had already noted that "the DO thresholds appear to be overly sensitive." In February 2000, after the publication of the draft criteria, MWRA proposed changing the warning level threshold from 6.0 mg/L to 4.8 mg/L. OMSAP agreed to review the issue once the final criteria were issued.[12] However, while the DO thresholds in the Contingency Plan were modified to add the "unless background conditions are lower" clause, the 6.0 mg/L warning level threshold remained. Given that the measured levels of DO are higher than the marine DO standards for other northeast states, it seems unlikely at this time that the low DO concentrations in the bottom waters at the Stellwagen Basin site are adversely affecting aquatic life.

On March 27, 2023, Judy Pederson, Chair of OMSAP, sent a memo[13] to EPA and MA DEP recommending that the DO caution and warning level thresholds be set to 6.0 mg/L and 5.0 mg/L, respectively. The rationale for this change was based on the 2000 EPA report cited above, as well as research done at Dalhousie University (Halifax, Nova Scotia) on DO tolerances of important species in the Gulf of St. Lawrence and Scotian Shelf region.[14]

It is also worth noting that DO percent saturation is not in the current state water quality standards. Percent saturation was removed from EPA's National Recommended Water Quality Criteria in 2002, and from the MA DEP Water Quality Standards in 2006. The CP thresholds applied to MWRA's monitoring program were established in 2000.

The March 27, 2023 OMSAP memo also recommended that percent saturation be dropped as a Contingency Plan threshold since "this metric was not deemed ecologically relevant as a standard for caution and warning levels."[15]

---

[12] Attachment C of the November 10, 2000 letter to DEP and EPA regarding Contingency Plan exceedances of DO. https://www.mwra.com/harbor/pdf/ax111000.pdf

[13] Judy Pederson, email to Alexa Sterling (EPA) and Cathy Conairis (MA DEP), "DO Recommendations for the MWRA contingency plan." March 31, 2023.

[14] Brennan CE, Blanchard H, Fennel K. 2016. Putting Temperature and Oxygen Thresholds of Marine Animals in Context of Environmental Change: A Regional Perspective for the Scotian Shelf and Gulf of St. Lawrence. *PLoS ONE* 11(12): e0167411. doi:10.1371/journal.pone.0167411.

[15] Judy Pederson email, March 31, 2023.

Conclusion

The conclusion of our initial evaluation, based on the information presented here, is that the exceedance is not related to the outfall. It may be related to widely recognized regional long-term trends of warming temperatures and declining oxygen concentrations, which are clear from analysis of many independent datasets including MWRA monitoring data. Additionally, the waning bloom of the dinoflagellate *Tripos muelleri*, which at its peak extended from Martha's Vineyard, MA to Penobscot Bay, ME, along with other physical factors this summer, may have contributed to low DO levels.

MWRA will provide raw monitoring data upon request. If you have any questions regarding this matter, please email Betsy Reilley at betsy.reilley@mwra.com.

Sincerely,

Rebecca Weidman
Deputy Chief Operating Officer

cc:

Environmental Protection Agency, Region I
Steve Wolf
Alexa Sterling

National Marine Fisheries Service
Christine Vaccaro

Stellwagen Bank National Marine Sanctuary
Peter DeCola

US Food and Drug Administration
David Lamoureux

MA Executive Office of Energy and Environmental Affairs
Vandana M. Rao

MA Division of Marine Fisheries
Christine Petitpas
Terry O'Neil

MA Dept of Public Health
Michael Moore

Cape Cod Commission
Timothy Pasakarnis

Outfall Monitoring Science Advisory Panel
Robert Beardsley
Peter Burn
Virginia Edgcomb
Loretta Fernandez
Robert Kenney
Mark Patterson
Judith Pederson
Jeffrey Rosen
Juliet Simpson
Juanita Urban-Rich

Public Interest Advisory Committee
Bruce Berman

Hyannis Library
Antonia Stephens

MWRA Library
Karen Graham