



# MASSACHUSETTS WATER RESOURCES AUTHORITY

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November 3, 2023

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Boston MA, 02109-3912

Catherine Coniaris  
Department of Environmental Protection  
1 Winter Street  
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RE: Massachusetts Water Resources Authority  
Permit Number MA 0103284  
Contingency Plan Threshold Exceedances: Nearfield DO Concentration and Stellwagen  
Basin DO Concentration

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<sup>1</sup> as part of its permit-attached Ambient Monitoring Plan<sup>2</sup> and Contingency Plan.<sup>3</sup> 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.

On October 18, MWRA conducted a routine water column monitoring survey. After routine data quality checks, the results were compared to thresholds on October 30. **The threshold checks for bottom water DO concentration revealed that there was a warning level exceedance for the nearfield and a caution level exceedance for the Stellwagen Basin station.** The warning level exceedance occurred for the nearfield because the measured value of 5.96 is lower than the 6.0 mg/L warning threshold (the 6.05 background concentration is higher than the warning threshold). The caution level exceedance occurred at the Stellwagen Basin station because the measured value of 6.22 mg/L, although higher than the 6.0 mg/L warning threshold, is lower

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<sup>1</sup> For an explanation of the DO measurements, see <https://www.mwra.com/harbor/html/thresholds.htm#do>.

<sup>2</sup> *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>.

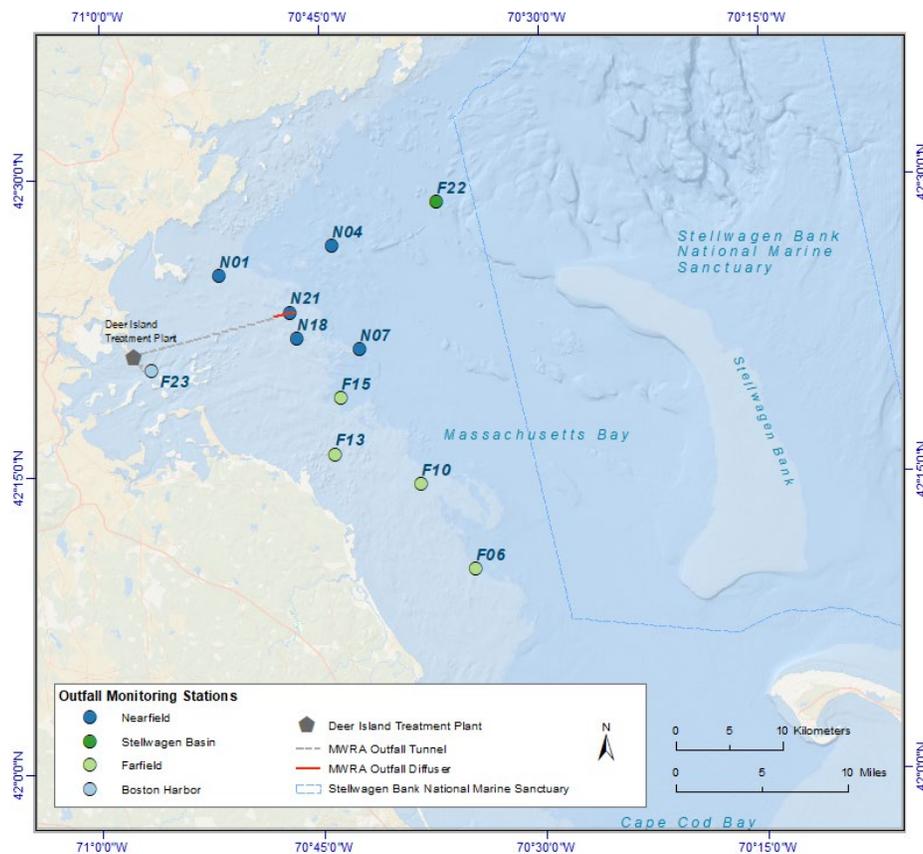
<sup>3</sup> *Massachusetts Water Resources Authority Contingency Plan Revision 1*. 2001. Report 2001-ms-071. <https://www.mwra.com/harbor/enquad/pdf/2001-ms-71.pdf>. For sections in the Contingency Plan specifically relevant to DO, see pages 23-24 and 26.

than both the 6.5 mg/L caution level threshold and the 6.23 mg/L background concentration. There were no exceedances for DO percent saturation. 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. The outfall nearfield is a group of five stations (N01, N04, N07, N18, and N21) covering a 10 by 12 kilometer (km; 6 by 7.5 mile) area centered on the outfall diffuser. The stations are located at distances between 60 meters (m; N21) and 7.1 km (N04) from the 30 m (100 ft) deep outfall diffuser. Station depths range from 26.6 m (N18) to 50.2 m (N07). For the calculation of the nearfield DO values to compare to the Contingency Plan thresholds, the deepest measurements from each of the five stations are averaged together. Stellwagen Basin is sampled at Station F22, in water 81 m (266 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.

The farfield stations (F06, F10, F13, and F15) south of the nearfield are farther from the outfall and not part of Contingency Plan thresholds. However, they often can provide useful context for nearfield and Stellwagen Basin conditions. Farfield stations range from 9 km (F15) to 29 km (F06) from the outfall, with depths ranging from 25.2 m (F13) to 38.3 m (F15). Station F23 at the mouth of Boston Harbor, 25.4 m deep and 12 km from the outfall, also gives useful context.

Past MWRA studies have identified regional factors 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).<sup>4</sup>

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 October 18 survey and the Contingency Plan thresholds (caution, warning, and background). Results are shown for both the nearfield and Stellwagen Basin. At nearfield stations, there was an exceedance of the warning level threshold for DO concentration. At the Stellwagen Basin station, there was an exceedance of the caution level threshold for DO concentration.

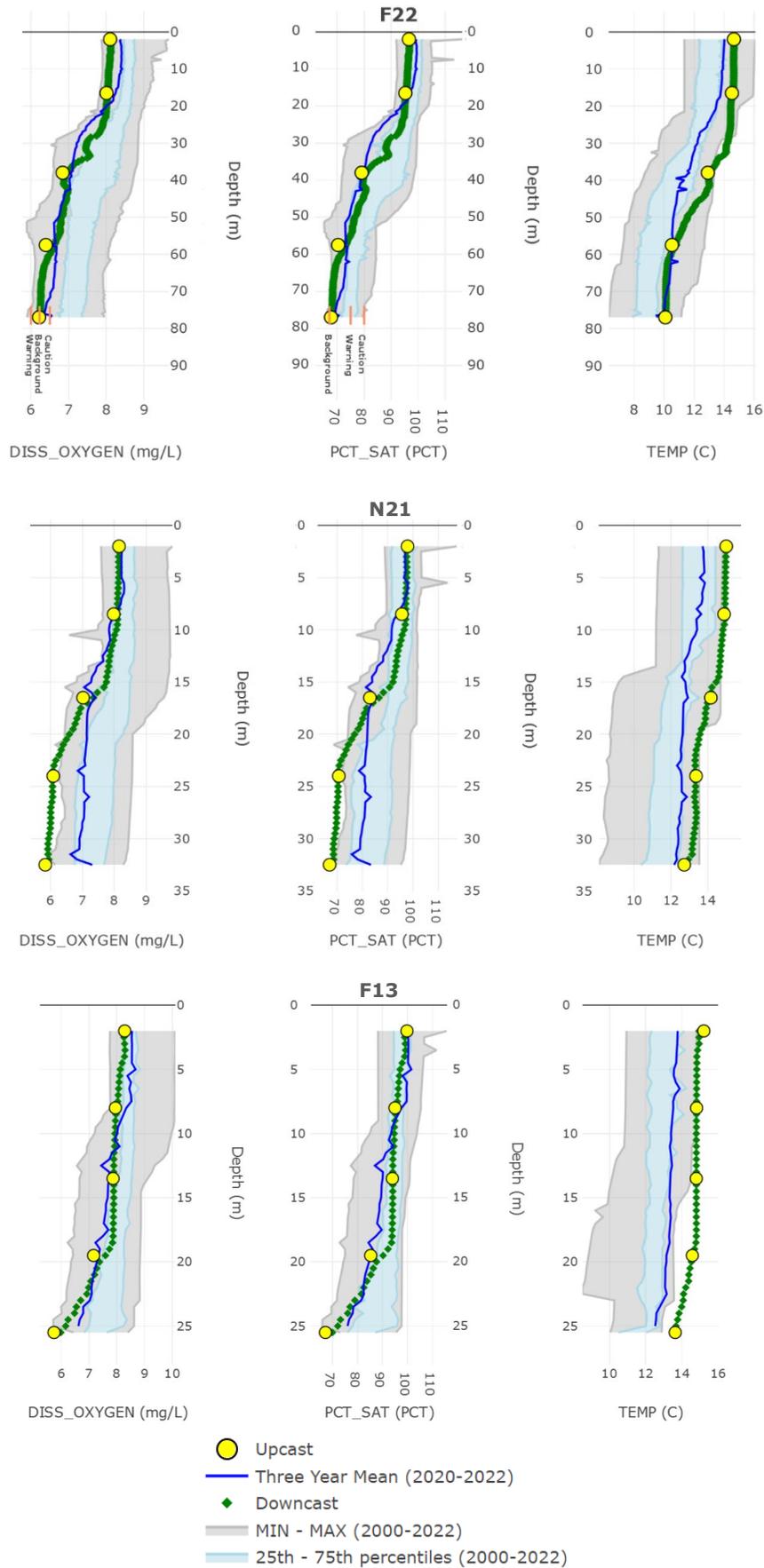
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<sup>4</sup> *Ambient Monitoring Plan for the Massachusetts Water Resources Authority Effluent Outfall (Revision 2.1, August 2021)*. Report 2021-08. <https://www.mwra.com/harbor/enquad/pdf/2021-08.pdf>. See pages 24 and 40-41 for specific information 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	5.96	Y Warning
		WARNING	6				
Nearfield	bottom DO % saturation	CAUTION	80	65.28	%	68	N
		WARNING	75				
Stellwagen Basin	bottom dissolved oxygen	CAUTION	6.5	6.23	mg/L	6.22	Y Caution
		WARNING	6				
Stellwagen Basin	bottom DO % saturation	CAUTION	80	67.17	%	67.7	N
		WARNING	75				

**Table 1.** Bottom water DO results from the October 18 survey, with Contingency Plan thresholds

Figure 2 shows the vertical profiles for DO concentration, DO percent saturation, and temperature results at three stations on the October 18 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), percent saturation (middle), and temperature (right) measurements from selected stations in Stellwagen Basin (F22), Nearfield (N21), and Farfield (F13) on the October 18 survey. Thresholds are not shown for N21 because the thresholds are an average across the five nearfield stations.

## **Discussion**

This is the third Contingency Plan exceedance of 2023 following previously reported exceedances<sup>5</sup> from the July and September surveys. DO concentration and percent saturation were slightly higher on the August survey, resulting in no exceedances.

Recent threshold exceedances of bottom water dissolved oxygen are summarized in Table 2 below. 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.<sup>6</sup>

Farfield stations south of the outfall showed similar or lower bottom DO concentrations to both the nearfield and Stellwagen Basin stations, further indicating that DO concentrations in Massachusetts Bay are not adversely impacted by the outfall (Figure 3).

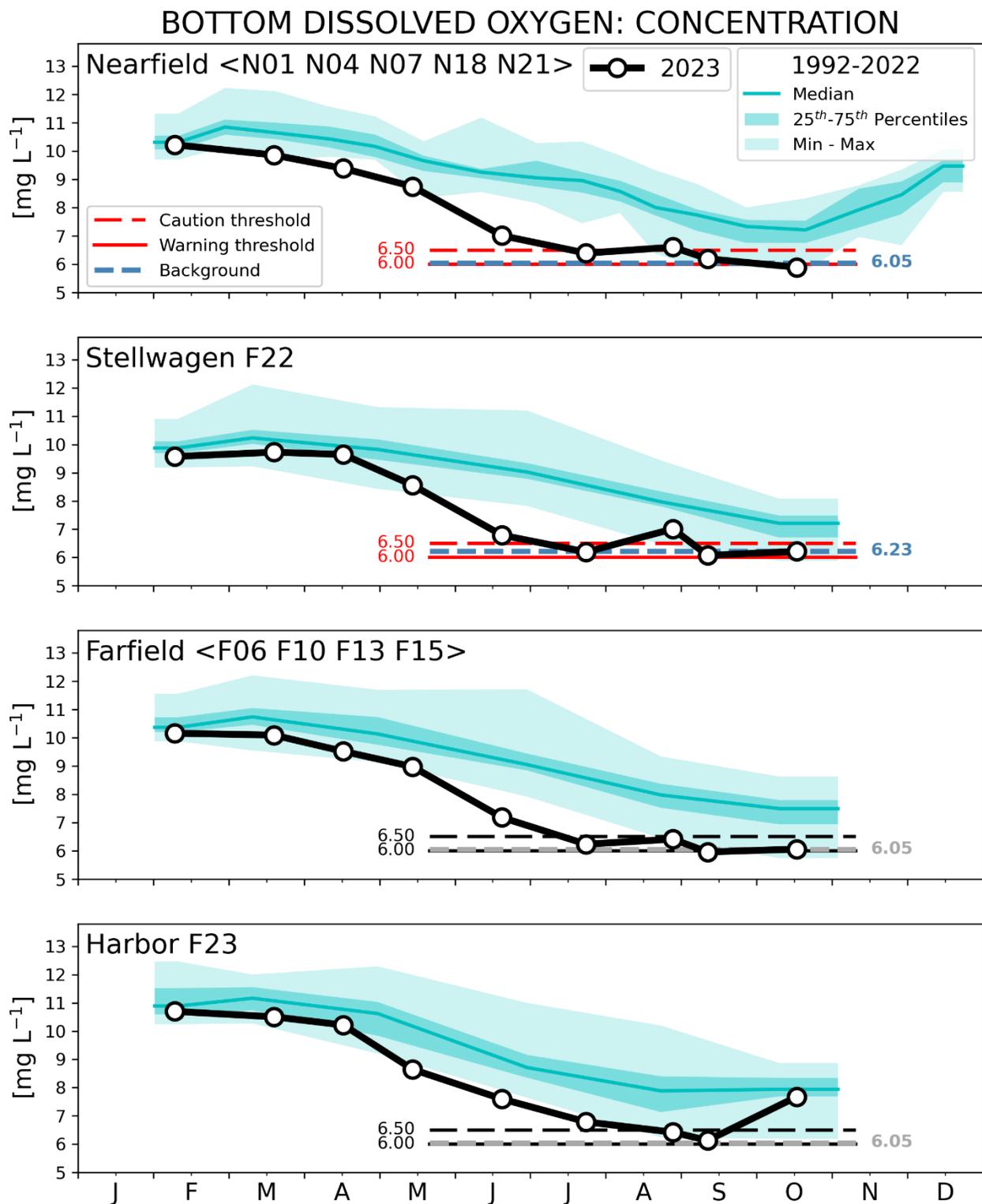
As with the previous DO threshold exceedances, MWRA believes this set of exceedances may be due to region-wide processes in the Gulf of Maine, and not related to the outfall.

	<b>Nearfield</b>				<b>Stellwagen Basin</b>			
	<i>Concentration</i>		<i>Percent saturation</i>		<i>Concentration</i>		<i>Percent Saturation</i>	
	Caution	Warning	Caution	Warning	Caution	Warning	Caution	Warning
Sep 2021								X
Nov 2021						X		X
Aug 2022								X
Sep 2022		X			X			X
Oct 2022		X			X			
July 2023					X			X
Sep 2023					X			X
Oct 2023		X				X		

**Table 2.** Surveys with bottom oxygen exceedances in the past three years.

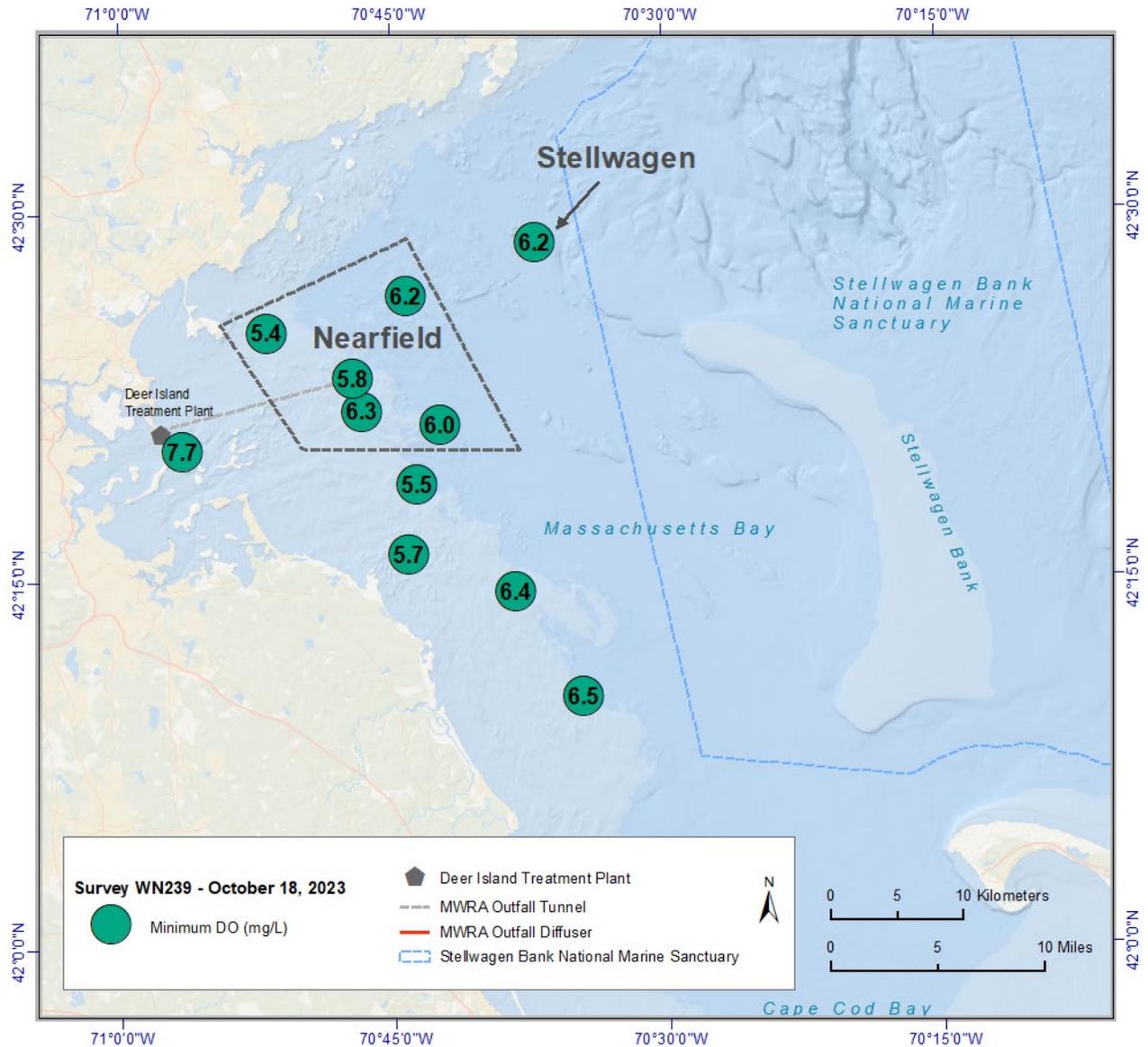
<sup>5</sup> Contingency Plan Threshold Exceedances Webpage. <https://www.mwra.com/harbor/html/archive.htm#cpexceed>

<sup>6</sup> 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 the nearfield, Stellwagen Basin, the farfield, and the mouth of Boston Harbor. Contingency Plan thresholds and background levels used to determine exceedances are shown in color on the panels for nearfield and Stellwagen stations where they apply; they are repeated in black and gray in the other two panels for reference.

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. While the Boston Harbor station F23 was well mixed and reaerated before the October 18 survey, mixing had not yet occurred at stations in Massachusetts Bay (Figure 4).



**Figure 4.** Minimum bottom water dissolved oxygen concentration (mg/L) at each station monitored on survey WN239. Contingency Plan exceedance reported here for nearfield and Stellwagen Basin.

DO concentrations on the October 18 survey were relatively low at nearfield stations, farfield stations, and the Stellwagen Basin station. Only at the Boston Harbor station where the water column was well mixed were bottom water concentrations above 7 mg/L. Notably, DO percent saturation was not below thresholds in October. As shown in the right column of Figure 2, temperature measurements were well above historic averages. Since warmer water holds less dissolved oxygen, the relative percent saturation was slightly above Contingency Plan thresholds, despite concentrations slightly below.

Preliminary examination of the qualitative phytoplankton measurements collected by MWRA to date in 2023 show there was an extended bloom of the dinoflagellate *Tripes 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 *Tripes* bloom extended from Martha's Vineyard, MA to Penobscot Bay, ME, so it was not exclusive to Massachusetts Bay.<sup>7</sup> During the *Tripes* die off, historically low DO concentrations were observed in June and July at nearfield, farfield, 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 and October 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 October 18 survey and the previous survey on September 12, the average of the effluent cBOD samples was 3.97 mg/L, well below the monthly permit limit. The average effluent cBOD the week preceding the October 18 survey (October 11-18) was 4.80 mg/L, also well below the weekly permit limit. No Deer Island Treatment Plant operational issues have been reported in 2023.

#### *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.

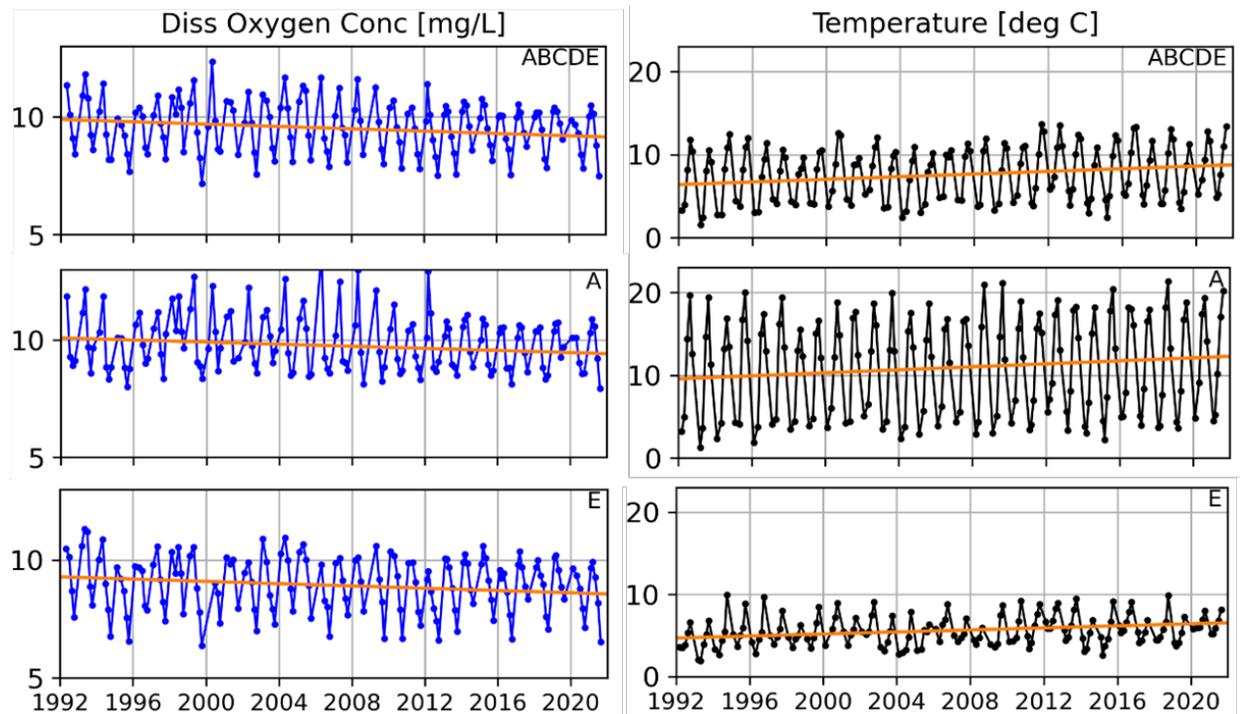
Although Figure 5 presents data only from Station F22, similar temperature and DO patterns are seen at all MWRA stations. At most MWRA stations temperature increases have been 0.4-0.6 degrees Celsius per decade, and oxygen declines have been 0.12-0.25 mg/L DO per decade.

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<sup>7</sup> Cameron Thompson, Northeastern Regional Association of Coastal Ocean Observing Systems, personal communication. August 7, 2023.

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 spring 2023 (March – May) the second hottest since 1982, which preceded the eighth hottest summer (June – August). The Institute’s most recent web page on Gulf of Maine warming has a wealth of information on this regional warming trend.<sup>8</sup>



**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

<sup>8</sup> Gulf of Maine Research Institute. “Gulf of Maine Warming Update: Summer 2023”. Available at: <https://gmri.org/stories/gulf-of-maine-warming-update-summer-2023/>

standards (6.0 mg/L).<sup>9</sup> 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.<sup>10</sup>

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.<sup>11</sup> In fact, as early as December 1997, the Outfall Monitoring Task Force (the predecessor to OMSAP, 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.<sup>12</sup> 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, Dr. Judith Pederson, Chair of OMSAP, sent a memo<sup>13</sup> 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.<sup>14</sup>

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<sup>9</sup> 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>

<sup>10</sup> New England Interstate Water Pollution Control Commission matrix of state water quality standards. Available at: <https://neiwppcc.org/our-programs/pollution-control/water-quality-standards/wqs-matrix/>

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

<sup>12</sup> 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>

<sup>13</sup> Dr. Judith Pederson, email to Alexa Sterling (EPA) and Cathy Conairis (MA DEP), "DO Recommendations for the MWRA contingency plan." March 31, 2023.

<sup>14</sup> 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.

## **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. The October survey was the final survey in 2023. Contingency plan exceedances of dissolved oxygen reported in 2023 will continue to be investigated as all data are reviewed and synthesized.

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](mailto:betsy.reilley@mwra.com).

Sincerely,

Rebecca Weidman  
Deputy Chief Operating Officer

**cc:**

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