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November 19, 2021

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Catherine Vakalopoulos
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 Dissolved Oxygen
Concentration and Percent Saturation

Dear Mr. Borci and Ms. Vakalopoulos:

The Massachusetts Water Resources Authority (“MWRA”) monitors concentration and percent saturation of bottom water dissolved oxygen (“DO”)¹ in the Stellwagen Basin as part of its permit-attached Ambient Monitoring Plan² and Contingency Plan.³ The Contingency Plan states that the DO concentration, during any survey while the water column is stratified (roughly May 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. For DO percent saturation, during any survey while the water column is stratified, the caution level threshold is at least 80%, or for the warning level threshold at least 75%, unless background conditions are lower. Background conditions are computed from monitoring that was done during the baseline period, 1992-2000, prior to when operation of the Deer Island Treatment Plant outfall in Massachusetts Bay began. When testing against the caution and warning level thresholds, if background conditions are lower than the thresholds, the DO concentration and percent saturation must be above the background conditions.

On November 2, 2021, MWRA conducted a routine water column monitoring survey. This survey, the last of the year, was delayed from October 27, 2021 due to a storm event. After routine data quality checks, the results were compared to thresholds on November 15, 2021. The threshold checks revealed that the warning level was exceeded for both bottom water DO concentration and percent saturation at the Stellwagen Basin site (“station F22”) where the

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>. See pages 24 and 40-41 for specific information on DO monitoring.

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.

measurements were 5.89 mg/L and 65.9%, respectively. As noted above, the Contingency Plan warning threshold level concentration is 6.0 mg/L and percent saturation is 75%. The calculated background condition values for concentration and percent saturation are 6.23 mg/L and 67.17%, respectively. This exceedance for Stellwagen Basin DO concentration and percent saturation requires this regulatory and public notification in accordance with Part I.8.b (Contingency Plan) of the Deer Island Treatment Plant NPDES permit.

Background

Station F22 where the exceedance occurred is in water 79.7 meters (m; 261.5 feet) deep, and is located 17.5 kilometers (km; 10.9 miles) away from the easternmost riser of the 30 m (100 feet) deep outfall (Figure 1).

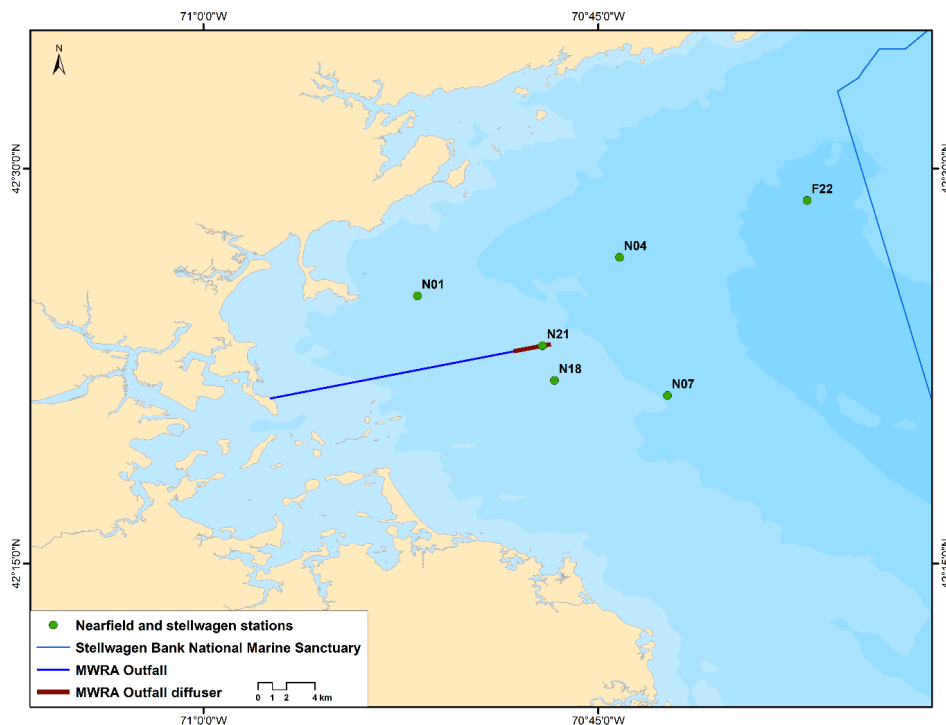


Figure 1. Map of Stellwagen Basin station (F22), nearfield, and the outfall.

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).⁴

For water column parameters other than nitrogen, such as chlorophyll or dissolved oxygen, MWRA monitoring has shown no outfall influence. For nitrogen, the outfall influence extends as far as 20 km (12 miles) away on an intermittent basis, and persistently less than 10 km (6 miles) away. Despite this effluent influence on nitrogen local to the outfall, the best available budgets for nitrogen in the Massachusetts and Cape Cod Bays system indicate that more than 90% originates from the Gulf of Maine offshore.^{5,6} There is no evidence that dissolved oxygen conditions at station F22 are influenced by the outfall.

Exceedance

Table 1 shows bottom water DO data from the November 2 survey and the Contingency Plan thresholds (caution, warning, and background). Results are shown for both the Stellwagen Basin station and the “nearfield,” a spatial average across five stations located within a 10 x 12 km area centered on the outfall.

LOCATION	PARAMETER	TEST LEVEL	THRESHOLD VALUE	BACKGROUND VALUE	UNIT	TEST RESULT	STDEV	N	EXCEEDANCE Y/N
Nearfield	bottom dissolved oxygen	CAUTION	6.5	6.05	mg/L	7.02	0.48	5	N
	bottom dissolved oxygen	WARNING	6						
Nearfield	bottom DO % saturation	CAUTION	80	65.28	%	81.8	6.3	5	N
	bottom DO % saturation	WARNING	75						
Stellwagen Basin	bottom dissolved oxygen	CAUTION	6.5	6.23	mg/L	5.89	0	1	Y
	bottom dissolved oxygen	WARNING	6						
Stellwagen Basin	bottom DO % saturation	CAUTION	80	67.17	%	65.9	0	1	Y
	bottom DO % saturation	WARNING	75						

Table 1. Bottom water DO results from the November 2 survey, with Contingency Plan thresholds.

Figure 2 shows the DO concentration results for station F22 from the November 2 survey. The results from the downcast (as the instrument travels down through the water column) are in green, and results from the upcast (as the instrument returns to the surface) are the yellow triangles. The dark blue line is the mean of the results from the previous three years during the same time period, late October or very early November, as the current downcast and upcast

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>

⁵ Deltares. 2021. *Demonstration of the updated Bays Eutrophication Model*. Boston: Massachusetts Water Resources Authority. Report 2021-02. Available at <http://www.mwra.com/harbor/enquad/pdf/2021-02.pdf>

⁶ HydroQual. 2000. *Bays Eutrophication Model (BEM): modeling analysis for the period 1992-1994*. Boston: Massachusetts Water Resources Authority. Report 2000-02. Available at <http://www.mwra.com/harbor/enquad/pdf/2000-02.pdf>

results. The shaded blue area is the interquartile range of the results from 2000-2020, and the shaded gray area spans the minimum and maximum results from 2000-2020 from the same time period.

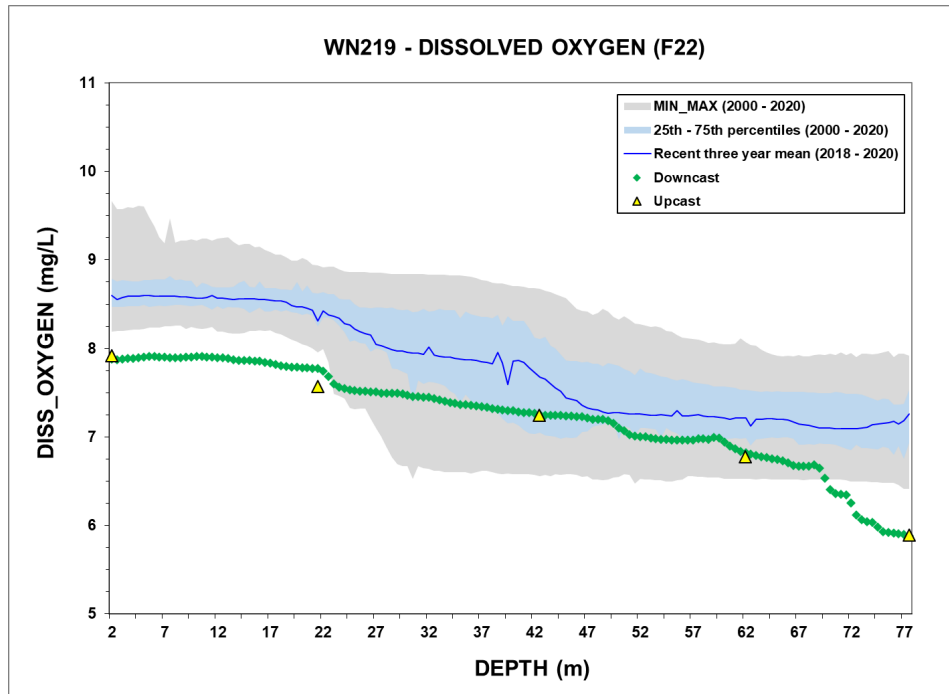


Figure 2. DO concentration results from F22 on the November 2 survey.

Figure 3 shows the DO percent saturation at station F22 from the November 2 survey. The plot elements are the same as in Figure 2.

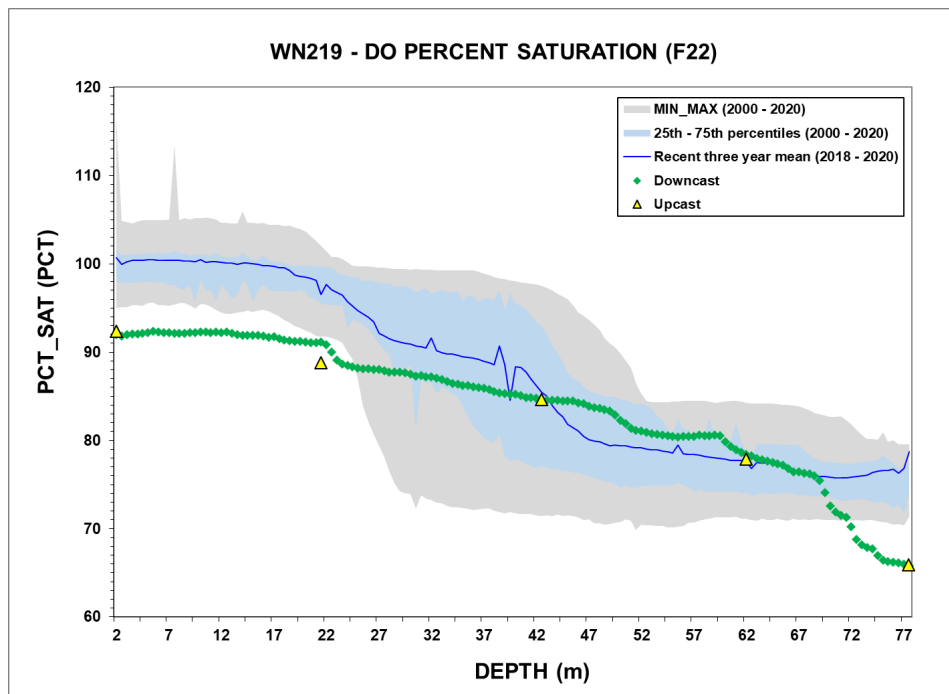


Figure 3. DO percent saturation results from F22 on the November 2 survey.

The profiles in Figures 2 and 3 suggest that low DO (both concentration and percent saturation) is restricted to the bottom 10 m of the water column, and only in the very bottom 5 m do both concentration and percent saturation drop below the warning threshold levels.

Discussion

Like the September 2021 DO percent saturation exceedance, there is currently no evidence the Deer Island Treatment Plant outfall discharge relates to these two exceedances. Both warning level thresholds and background condition values for DO percent saturation and concentration thresholds were met in the nearfield at five monitoring locations closest to the outfall. If this DO exceedance was directly attributable to the outfall, one would reasonably expect to see DO depletion in the nearfield, as well as in Stellwagen Basin.

Under stratified water column conditions – as partially existed for this survey – it is normal for DO concentrations and percent saturation to decrease in the bottom waters (Figure 4). When the water column is stratified, there is no physical mechanism for the water below the thermocline to have any exchange with the atmosphere. Therefore, natural biological consumption processes will cause DO to decline. Although there was a strong storm on October 26 that resulted in water column mixing and destratification at a number of other monitoring locations, the deeper portion of the water column at station F22 remained stratified, and the low oxygen portions of the DO profiles (Figures 2 and 3) were beneath the pycnocline. At 80 m in depth, station F22 is the deepest of all the monitoring locations. Station N07, at approximately 51 m in depth, is the second deepest, and showed very slight stratification in the deepest 10 m, where there was a small decrease in DO (not shown).

It is interesting to note the history of dissolved oxygen threshold established in MWRA's Ambient Monitoring Plan. In December 1997, the Outfall Monitoring Task Force (the predecessor to OMSAP, the Outfall Monitoring Science Advisory Panel) noted “the DO thresholds appear to be overly sensitive.” In January 2000 EPA published the *Draft Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras*, which stated that “If the DO exceeds the chronic protective value for growth (4.8 mg/L), the site meets objectives for protection.”⁷ In February 2000, MWRA proposed to OMSAP changing the warning level threshold from 6.0 mg/L to 4.8 mg/L, consistent with the draft criteria. OMSAP agreed to review the issue once the final criteria were issued.⁸ This same phrase appeared in the final version of the criteria issued in November 2000.⁹ 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.¹⁰

⁷ <https://nepis.epa.gov/Exe/ZyPDF.cgi/20003HJJ.PDF?Dockey=20003HJJ.PDF>. While the document is dated November 1999, it was not actually issued until January 2000.

⁸ 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>

⁹ <https://www.epa.gov/sites/default/files/2018-10/documents/ambient-al-wqc-dissolved-oxygen-cape-code.pdf>

¹⁰ In recognition of the inability of the bottom waters of a stratified water column to recover from depletion of DO, Rhode Island sets different standards for DO above and below a seasonal pycnocline. Above the pycnocline, the standards are stricter than they are below the pycnocline, where DO concentrations are allowed to drop below the standard of 4.8 mg/L on a sliding scale based on larval survival – the lower the concentration below 4.8 mg/L is, the

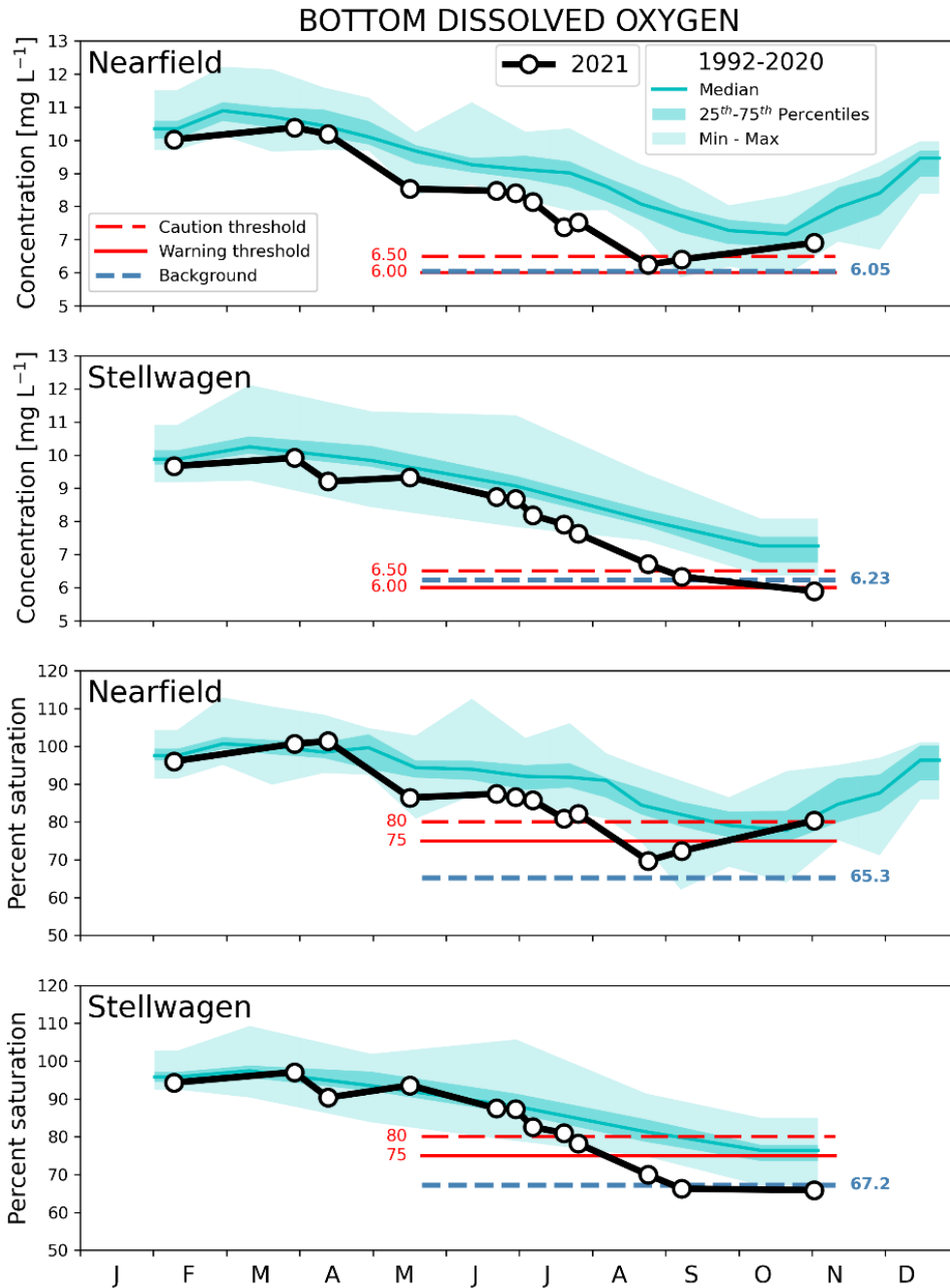


Figure 4. 2021 DO results compared to 1992-2020 historical results in the nearfield and in Stellwagen Basin.

Although DO concentration is a state water quality standard (for Class SA marine waters, such as Massachusetts Bay, the standard is 6.0 mg/L), it is also worth noting that DO percent saturation is not in the current state water quality standards.¹¹ Percent saturation was removed from EPA's

shorter the allowed time below the standard is. Rhode Island Water Quality Regulations, 250-RICR-150-05-1. <https://rules.sos.ri.gov/regulations/part/250-150-05-1>

¹¹ 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>

National Recommended Water Quality Criteria in 2002 and from MA DEP Water Quality Standards in 2006. The Contingency Plan thresholds were implemented in 2000 and have not been updated to reflect the removal of DO percent saturation from the National Recommended Water Quality Criteria and the Massachusetts Water Quality Standards.

It is also important to note that the background values were calculated as the 5th percentile of the set of annual minimum values in the years before the outfall discharge was moved from Boston Harbor to Massachusetts Bay. The minimum dissolved oxygen values vary from year-to-year (Figure 5). If there is no change in the distribution of dissolved oxygen values, one would expect the annual minimum to fall below the background value, on average, once every twenty years, by random chance.

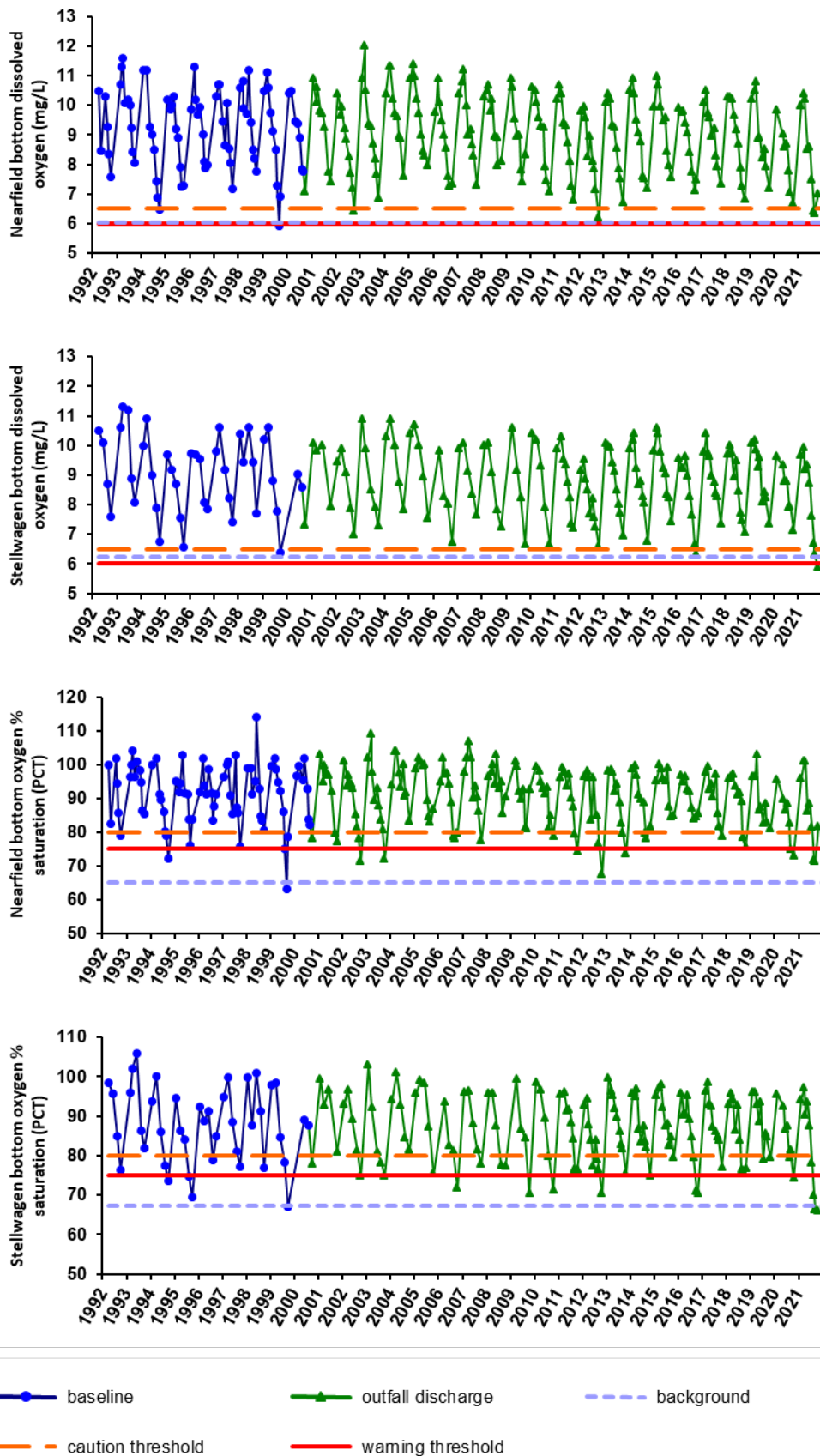


Figure 5. Long-term (1992-2021) DO trends in the nearfield and in Stellwagen Basin.

Based on long-term trends, MWRA does not believe that nitrogen discharged from the outfall contributed to the DO threshold exceedances in the Stellwagen Basin. Figure 6 shows depth-averaged ammonium at several monitoring locations, including station F22.¹² While there are appreciable changes at several locations closer to the outfall, at station F22 there is no obvious trend over time. While Figure 6 presents data until 2020, currently there is no reason to believe that ammonium levels in 2021 will be significantly different than in the past.

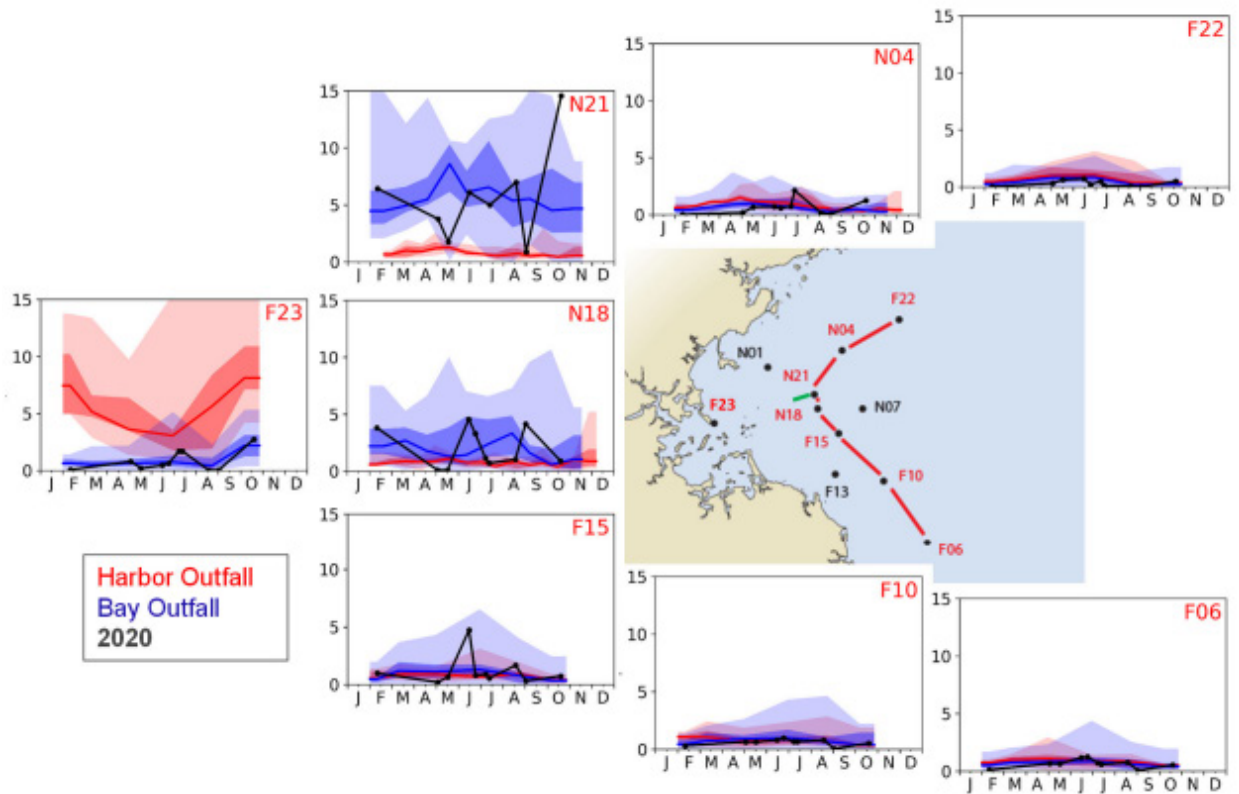


Figure 6. Depth-averaged NH₄ (µM) at selected stations in Massachusetts Bay for 2020 compared to prior years. 2020 results are in black, baseline (1992-August 2000) results are in red; and post-diversion (September 2000-2019) results are in blue. For baseline and post-diversion, dark shading spans the 25th to 75th percentile, and light shading spans the range. F22 is in the top right corner.

¹² Werme C, Codiga DL, Libby PS, Carroll SR, Charlestra L, Keay KE. 2021. *2020 Outfall monitoring overview*. Boston: Massachusetts Water Resources Authority. Report 2021-10. Available at <http://www.mwra.com/harbor/enquad/pdf/2021-10.pdf>

Conclusion

The conclusion of MWRA's evaluation, based on the information presented here, is that the exceedance is not related to the outfall. It may be due to natural variability, or 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. MWRA will continue to evaluate our monitoring datasets.

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,



Carolyn M. Fiore
Deputy Chief Operating Officer

cc:

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