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December 5, 2014

Ms. Susan Studlien
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Mail code OES04-5
Boston, MA 02109-3912

Mr. David Ferris
Division of Wastewater Management
Department of Environmental Protection
1 Winter Street
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RE: Massachusetts Water Resources Authority
Permit Number MA 0103284
MWRA Contingency Plan Threshold Exceedance: Infaunal diversity for August 2014

Dear Ms. Studlien and Mr. Ferris:

In its outfall ambient monitoring program, MWRA measures the numbers and types of infaunal organisms living in sediments in western Massachusetts Bay in the vicinity of the outfall (the nearfield) and in reference areas. In August 2014, samples were collected from 11 stations in the nearfield. Four separate measures of infaunal community diversity in nearfield sediments are in the Contingency Plan. Other measures of the health of sediment communities in the Contingency Plan are the depth of oxygen penetration into nearfield sediments and the abundance of six opportunistic species.[1] Every third year, including 2014, MWRA's sediment monitoring includes sampling for contaminants.

On December 2, 2014, MWRA completed its data quality reviews and calculations of Contingency Plan threshold values for nearfield infaunal diversity and for the abundance of opportunists for its August 2014 monitoring. Those results and results for depth of oxygen penetration (apparent redox potential discontinuity, RPD) are in Table 1. Two of the diversity parameters calculated, Shannon-Wiener H′ and Pielou's J′, were slightly higher (more diverse) than their upper thresholds. Those results are a "Caution Level" threshold exceedance requiring regulatory and public notification. This letter constitutes that notification.

The two other diversity parameters calculated for August 2014 samples, log-series alpha and total species richness, were within their threshold ranges. The six opportunistic taxa made up less than 1% of the animals collected from nearfield sediments (the Caution Level is 10%). The apparent Redox Potential Discontinuity (RPD) depth was 4.01cm, more than three times as deep as the minimum threshold. Sediment contaminant levels in 2014 tend to be lower than measured in the area before outfall start-up in September 2000.

[1] MWRA. 2001. Massachusetts Water Resources Authority Contingency Plan Revision 1. Boston: Massachusetts Water Resources Authority. Report 2001-ms-71. 47 p. http://www.mwra.state.ma.us/harbor/enquad/pdf/2001-ms-71.pdf

Table 1. Infaunal monitoring threshold results, August 2014 Samples

Parameter	Threshold range		Result	Exceedance?
	Low	High		
Total species	43.0	81.9	62.73	No
Log-series Alpha	9.42	15.8	13.35	No
Shannon-Weiner H'	3.37	3.99	4.03	Yes, Caution Level
Pielou's J'	0.57	0.67	0.68	Yes, Caution Level
Apparent RPD	1.18	NA	4.01	No
Percent opportunists	10% (Caution) 25% (Warning)		0.12%	No

Similar exceedances of the same two diversity indices were observed in 2010 – 2013 (http://www.mwra.state.ma.us/harbor/pdf/20110107amx_diversity.pdf , http://www.mwra.state.ma.us/harbor/pdf/20111215amx_diversity.pdf , http://www.mwra.state.ma.us/harbor/pdf/20121214_amx.pdf , and http://www.mwra.state.ma.us/harbor/pdf/20131213_amx.pdf).

The 2010 through 2013 exceedances have been evaluated and discussed at meetings of EPA's Outfall Monitoring Science Advisory Panel (OMSAP) in June 2011 (the 2010 exceedance), in an April 2013 meeting and May 2013 conference call (2011 and 2012), and in September 2014 (2013 results). The exceedances have been evaluated in detail in the Outfall Benthic Monitoring Reports for 2010[2], 2011[3], 2012[4] and 2013[5]. Those evaluations found that the exceedances probably represented natural fluctuations in the infaunal communities, and were not influenced by the outfall. OMSAP concurred with these conclusions at their meetings.

Thus far, the 2014 data support the same conclusion.

Given the strong year-to-year similarity normally observed in infaunal communities during MWRA's monitoring, it is not surprising that similar exceedances in the same parameters have been observed in each of the past 5 years.

Background

Sediment monitoring in the vicinity of the outfall was designed to address questions about potential effects of the relocated discharge on the offshore seafloor including eutrophication and related low levels of dissolved oxygen, accumulation of toxic contaminants in depositional areas, and smothering of animals by particulate matter.

[2] Maciolek NJ, Dahlen DT, Diaz RJ, Hecker B. 2011. Outfall benthic monitoring report: 2010 results. Boston: Massachusetts Water Resources Authority. Report 2011-14. http://www.mwra.state.ma.us/harbor/enquad/pdf/2011-14.pdf

[3] Nestler EC, Diaz RJ, Hecker B, Pembroke AE. 2012. Outfall benthic monitoring report: 2011 results. Boston: Massachusetts Water Resources Authority. Report 2012-08. 38 pages plus appendices. http://www.mwra.state.ma.us/harbor/enquad/pdf/2012-08.pdf

[4] Nestler EC, Diaz RJ, Pembroke AE. 2013. Outfall benthic monitoring report: 2012 results. Boston: Massachusetts Water Resources Authority. Report 2013-12. 36 pages plus appendices. http://www.mwra.state.ma.us/harbor/enquad/pdf/2013-12.pdf

[5] Nestler EC, Diaz RJ, Pembroke AE, Keay KE. 2014. Outfall benthic monitoring report: 2013 results. Boston: Massachusetts Water Resources Authority. Report 2014-10. 35 p. plus appendices. http://www.mwra.state.ma.us/harbor/enquad/pdf/2014-10.pdf

Monitoring design. Soft sediment samples are collected for the identification and enumeration of the benthic infaunal community. Samples are also collected for the analysis of sediment contaminants (every third year), grain size, total organic carbon (TOC), and spores of the effluent solids tracer bacterium *Clostridium perfringens.* Sediment profile imaging, done by camera, provides a rapid assessment of sediment quality.

The August 2014 sediment sampling was conducted according to MWRA's ambient monitoring plan[6] and included sediment profile imaging at 23 nearfield stations (Figure 1) and infaunal sampling and sampling for sediment grain size, contaminants, total organic carbon, and *Clostridium perfringens* spores at the 11 nearfield and three farfield stations shown in Figure 2.

Infaunal thresholds. Infaunal thresholds are triggered by nearfield results outside of those found during baseline monitoring in 1992-2000. Low levels of enrichment can fertilize communities, increasing diversity, while higher levels of enrichment can cause stress, leading to lower species richness, lower evenness, and lower biodiversity and increases in the abundance of opportunistic species, which are able to persist in degraded environments. The Contingency Plan defines the Caution Level as "appreciable change" in the following six infaunal thresholds:

Four biodiversity thresholds. *Total species* is the number of species identified and is the simplest measure of how many species are present. *Log-series alpha* is another measure of species richness with some theoretical advantages over total species. *Pielou's J′* measures how evenly individuals are distributed among species.[7] *Shannon-Wiener H′* is a commonly used diversity index affected by both species richness and evenness. The infaunal thresholds were chosen to be triggered if the nearfield mean diversity for a discharge year was *lower* than the 2.5th percentile of the distribution of baseline means, or *higher* than the 97.5th percentile.

The August 2014 results for Shannon-Wiener H′ and Pielou's J′ are slightly higher than the upper threshold (Table 1) triggering the exceedance.

Percent opportunistic species. Increased deposition of organic solids can increase abundances of opportunistic species. The Caution Level threshold for the abundance of six opportunistic species[8] was set at 10% of total nearfield infaunal abundances, roughly 20% of their abundance in Boston Harbor during 1991-1998.

Depth of penetration of oxygen. The depth below the sediment-water interface where sediments change from light-colored, oxygenated mud to black anoxic mud is called the depth of the apparent redox potential discontinuity (RPD). Microbial breakdown of organic material uses up oxygen, decreasing the thickness of the RPD, so deeper, bigger RPDs are considered healthier. The threshold was set at half the average RPD measured during baseline.

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[6] MWRA. 2010. Massachusetts Water Resources Authority effluent outfall ambient monitoring plan Revision 2. July 2010. Boston: Massachusetts Water Resources Authority. Report 2010-04. 107 p. http://www.mwra.state.ma.us/harbor/enquad/pdf/2010-04.pdf

[7] Communities with a similar number of individuals from a number of different species, (for example a temperate forest with similar numbers of oak, maple, elm, etc.) are more diverse than ecosystems with the same number of species but with the overwhelming majority made up of one species (for example a wheat field where 99% of the plants are wheat but a few different types of weeds are growing among the crop).

[8] The six species include the polychaete worms *Capitella capitata* species complex, *Streblospio benedicti*, and *Polydora cornuta*, the amphipod crustaceans *Ampelisca abdita* and *A. vadorum*, and the bivalve mollusk *Mulinia lateralis.*

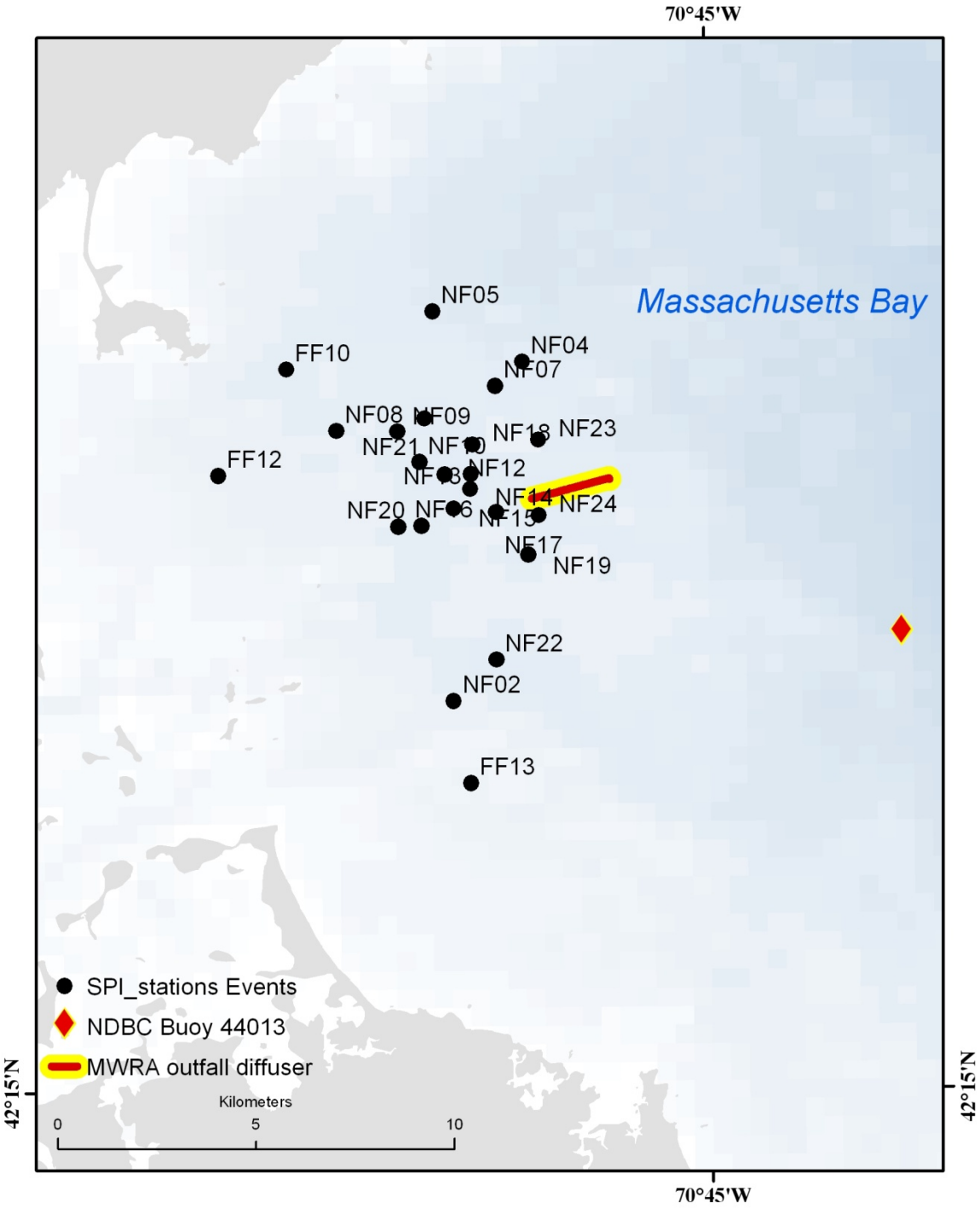

Figure 1. Map of sediment profile imaging stations.

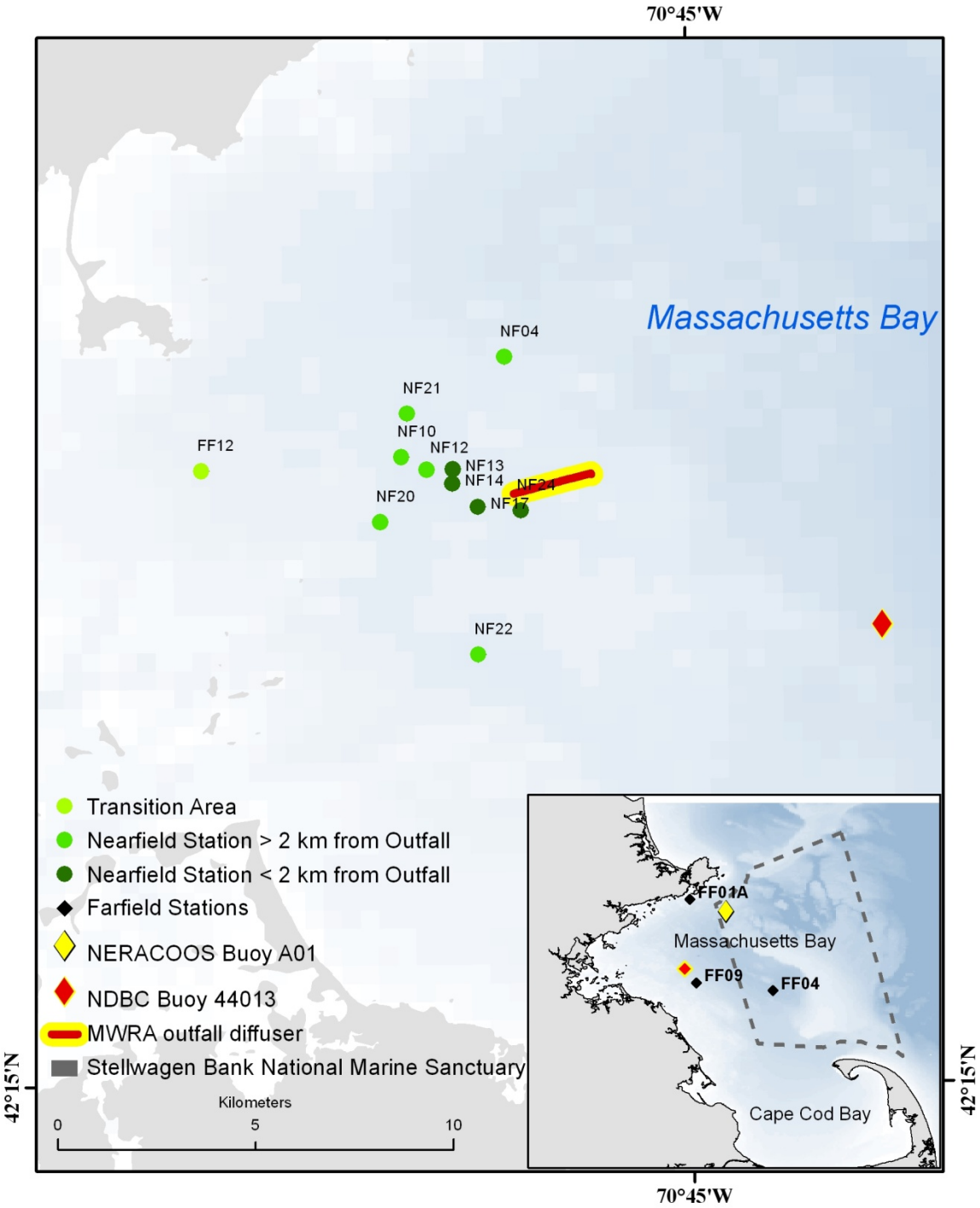

Figure 2. Map of infaunal community monitoring stations sampled in 2011 through 2014.

2014 results

It is important to note that the evaluation of the 2014 infaunal results is just beginning, and will continue in the weeks and months to come.

Sediment conditions. All indications available at this time are that conditions in nearfield sediments in 2014 were normal. Preliminary review of the sediment profile image results from all 23 nearfield stations in August 2014 suggested that conditions were similar to observations made in previous years, but had the deepest oxygen penetration into the sediments yet measured (Figure 3) and evidence for robust biological reworking of sediments at many sites (for example burrows and subsurface feeding voids). Grain size measured at the nearfield stations in 2014 was also well within baseline and outfall discharge ranges for these stations, as was the effluent solids tracer, spores of the bacterium *Clostridium perfringens*. Sediment contaminant results for 2014 were all well below the relevant Contingency Plan thresholds.

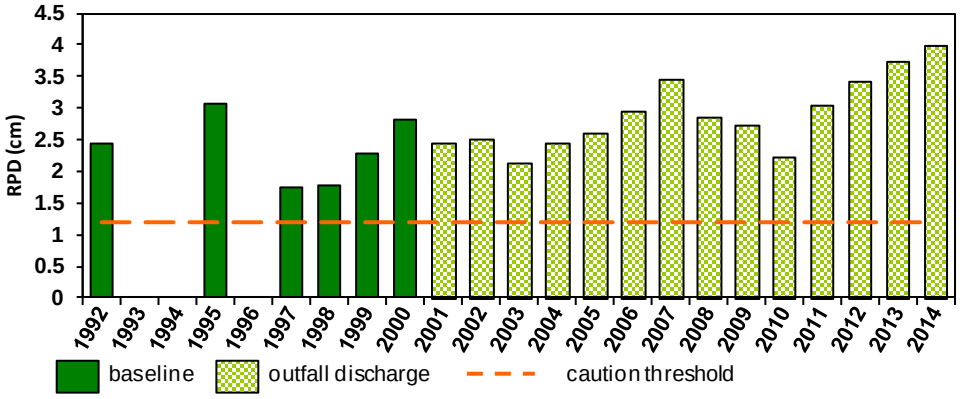

Figure 3. Depth of the average redox potential discontinuity (RPD) in nearfield sediments as measured from sediment profile images, 1992-2014. RPDs in 2014 are the deepest measured during discharge monitoring, indicating healthy sediment oxygenation.

So far, MWRA's review of the 2014 nearfield infaunal results provides no indications that the slightly elevated Pielou's J′ and Shannon-Wiener H′ diversities (Figure 4) reflect a response to the outfall discharge. Since both of the diversity indices sensitive to species richness were in the middle of the threshold ranges (that is, not extremely high) in 2014 (Figure 5) it is likely that increased species evenness is responsible for the threshold exceedance, both for J′, a measure of evenness, and H′, affected both by species richness and by evenness in samples. This was also observed in MWRA's evaluations of the 2010 through 2013 threshold exceedances. Infaunal densities in 2014 (approximately 38,000 animals/m^2) were somewhat higher than was observed in 2013, but were similar to abundances seen in 2012. High evenness in abundant, species-rich samples is not typical of stressed communities, therefore it is likely that the results observed since 2010 represent a natural fluctuation in the nearfield infaunal communities not observed during baseline monitoring prior to September 2000. The observation of continued very low abundances of opportunistic taxa (Figure 6) also supports this.

Evaluation of the 2014 sediment nearfield monitoring data is continuing.

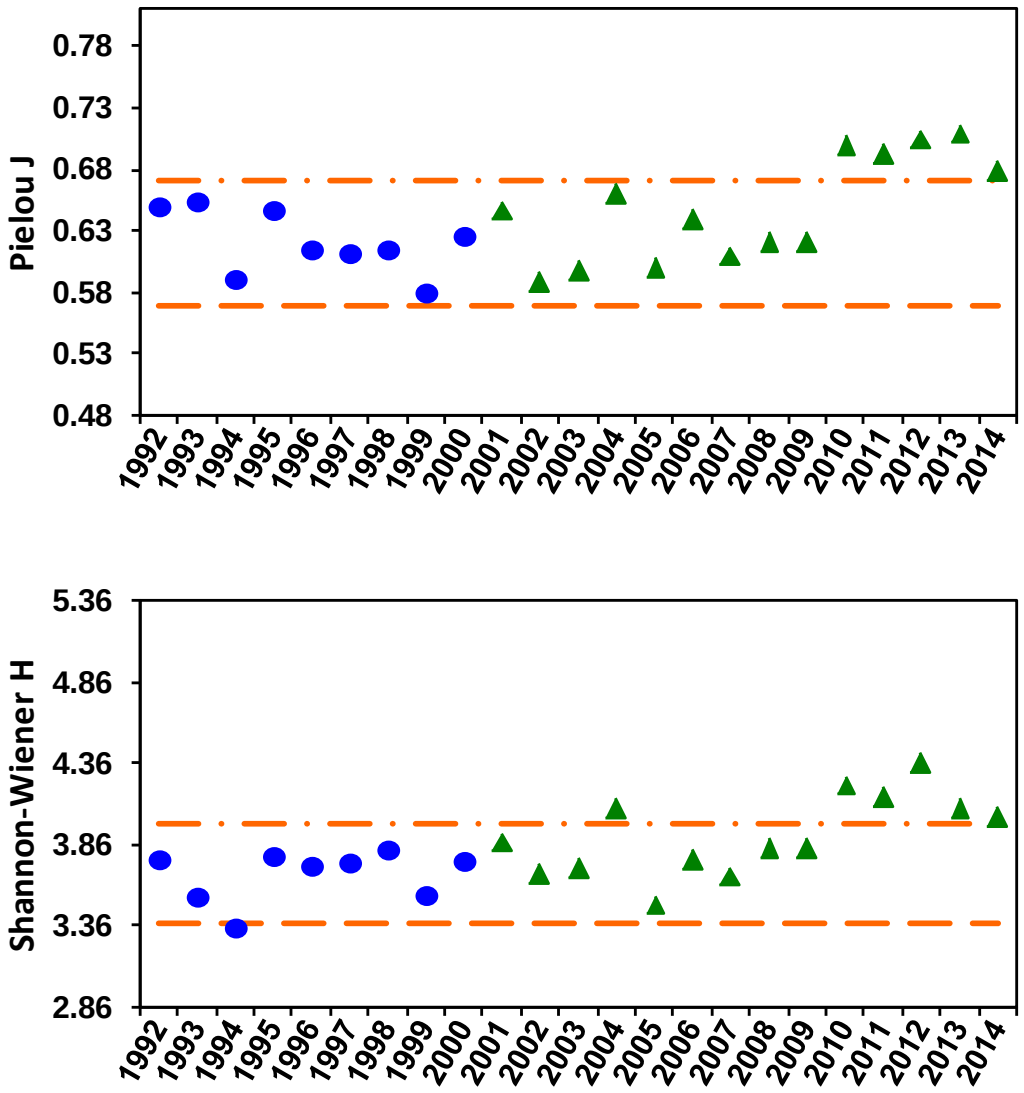

Figure 4. Pielou's J′ evenness (top) and Shannon-Wiener H′ diversity (bottom) measured at nearfield monitoring stations, 1992-2014. For most years results for current monitoring stations are shown; 2004 through 2010 results are the averages for the odd and even-year stations sampled then. Blue points are baseline period data, and green triangles reflect outfall discharge period data. The threshold levels varied slightly through the monitoring period, for simplicity only the current thresholds are shown (dotted lines are the current upper and lower thresholds). H′ diversity in 2004 (H′ = 4.08) did not exceed the threshold (4.14) for even-year stations applicable in 2004.

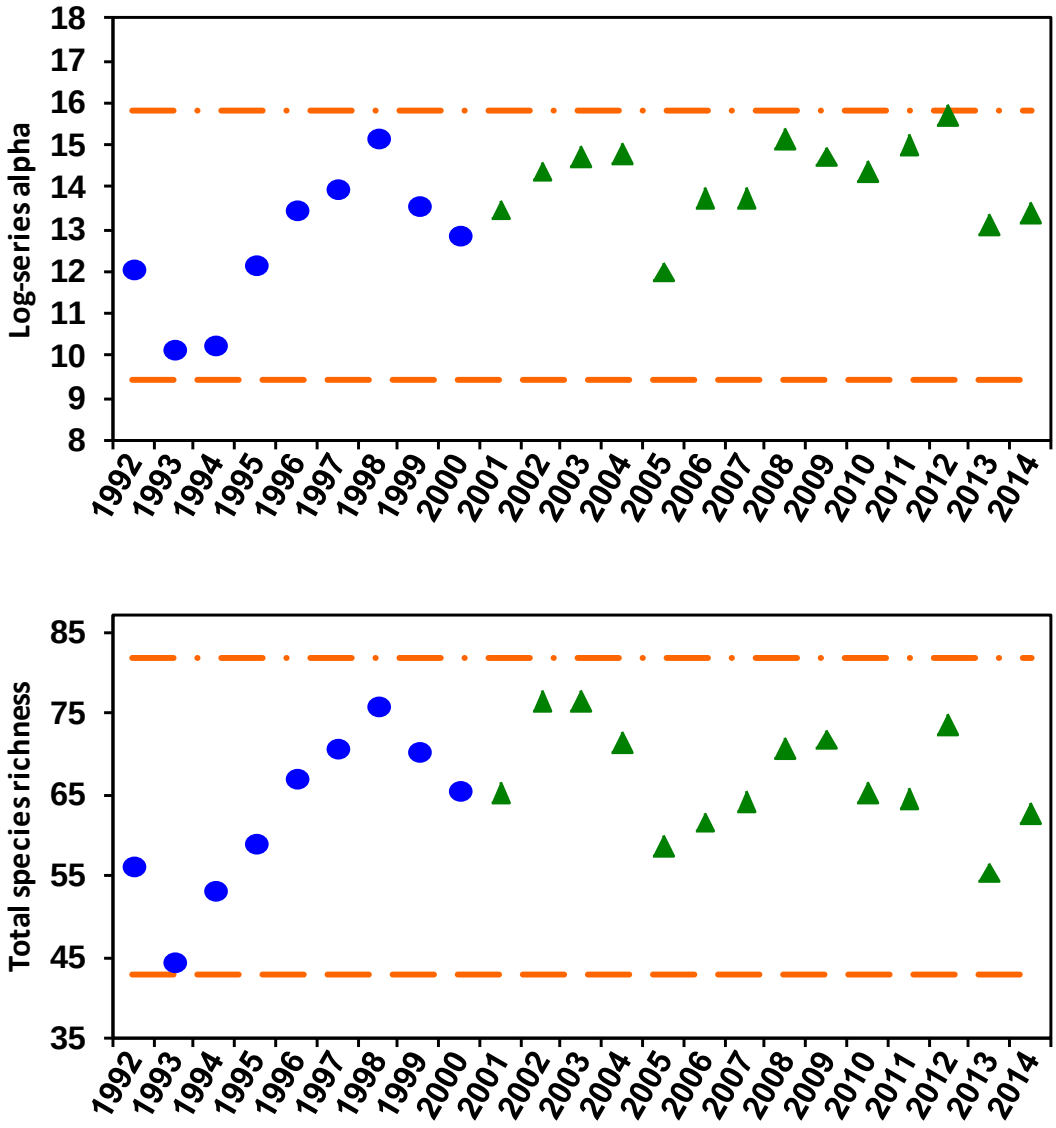

Figure 5. Log-series alpha and total species richness measured at nearfield monitoring stations, 1992-2014. For most years results for current monitoring stations are shown; 2004 through 2010 results are the averages for the odd and even-year stations sampled then. Blue points are baseline period data, and green triangles reflect outfall discharge period data. The threshold levels varied slightly through the monitoring period, for simplicity only the current thresholds are shown (dotted lines are the current upper and lower thresholds).

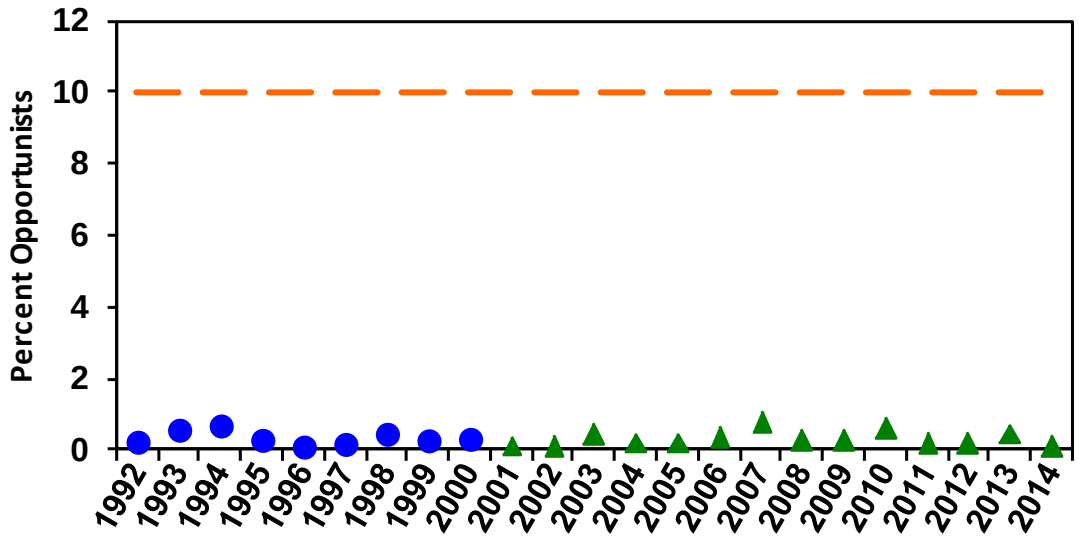

Figure 6. Abundance of opportunist taxa measured nearfield monitoring stations, 1992-2014. The dotted line reflects the 10% caution threshold. The 25% warning threshold is not plotted. For most years results for current monitoring stations are shown; 2004 through 2010 results are the averages for the odd and even-year stations sampled then.Blue points are baseline period data, and green triangles reflect outfall discharge period data. The thresholds have remained the same throughout the monitoring.

MWRA will continue its evaluation of the 2014 infaunal results and, if requested by regulators or the OMSAP, will discuss this threshold exceedance at the next Outfall Monitoring Science Advisory Panel meeting.

If you have questions or need additional information, please feel free to call Dr. Betsy Reilley at (617) 788-4940.

Sincerely,

Michael J. Hornbrook
Chief Operating Officer

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