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December 15, 2011

Ms. Ann Lowery
Bureau of Resource Protection
Department of Environmental Protection
1 Winter Street
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Mr. Stephen Perkins
U.S. Environmental Protection Agency
Water Enforcement
OES4-SMR
5 Post Office Square, Suite 100
Boston, MA 02109-3912

RE: Massachusetts Water Resources Authority
Permit Number MA 0103284
MWRA Contingency Plan Threshold Exceedance: Infaunal diversity for August 2011

Dear Ms. Lowery and Mr. Perkins:

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 and in reference areas. In 2011, samples from 11 nearfield stations were collected in August.[1] 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.[2]

On December 12, 2011, 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 2011 monitoring. Those results and results for depth of oxygen penetration (apparent 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. MWRA is evaluating the 2011 data in more detail, however, there are currently no indications that this threshold exceedance was influenced by the outfall discharge, nor are there any indications of a decline in the health of sediment communities.

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[1] 2011 was the first year Revision 2 of the Ambient Monitoring Plan was implemented. See *Massachusetts Water Resources Authority Effluent Outfall Ambient Monitoring Plan Revision 2*. July 2010. Boston: Massachusetts Water Resources Authority. Report 2010-04.
http://www.mwra.state.ma.us/harbor/enquad/trlist.html

[2] *Massachusetts Water Resources Authority Contingency Plan Revision 1*. 2001. Report ms-071.
http://www.mwra.state.ma.us/harbor/enquad/trlist.html

The two other diversity parameters calculated for August 2011 samples, log-series alpha and total species richness, were well 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) was 3.06 cm, nearly twice as deep as the minimum threshold.

Table 1. Infaunal monitoring threshold results, August 2011 Samples

Parameter	Threshold range		Result	Exceedance?
	Low	High		
Total species	43.0	81.9	64.4	No
Log-series Alpha	9.42	15.8	15.04	No
Shannon-Weiner H'	3.37	3.99	4.15	Yes, Caution Level
Pielou's J'	0.57	0.67	0.69	Yes, Caution Level
Apparent RPD	1.18	NA	3.06	No
Percent opportunists		10%	0.19%	No

A similar exceedance of the same two diversity indices was observed in 2010 (http://www.mwra.state.ma.us/harbor/pdf/20110107amx_diversity.pdf). That exceedance was evaluated and discussed at the June 2010 meeting of EPA's Outfall Monitoring Science Advisory Panel (OMSAP), with details of the evaluation included in the 2010 Outfall Benthic Monitoring Report. [3] Those evaluations found that the 2010 exceedance probably represented natural fluctuations in the infaunal communities, and were not influenced by the outfall. Thus far, the 2011 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 were observed in the 2011 monitoring as were seen in 2010.

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.

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 grain size, total organic carbon (TOC), and the effluent solids tracer bacterium *Clostridium perfringens* spores. Sediment profile imaging, done with a camera, is performed at all 23 nearfield stations each year.

The design of MWRA's infaunal monitoring has changed several times since baseline monitoring in 1992-2000. From 2001-2003, monitoring included 23 nearfield stations within 7 km of the outfall sampled every year. From 2004-2010, the 23 nearfield stations were split into "even year" and "odd-year" bins, with 12 or 13 of the stations sampled every August (Figure 1). Sediment profile imaging was carried out at all 23 stations each August. The August 2011 sediment sampling was conducted according to MWRA's revised ambient monitoring plan and included

[3] 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/trlist.html

sediment profile imaging at all 23 nearfield stations in Figure 1 and infaunal sampling and sediment contaminant sampling at the 11 stations shown in Figure 2.

Infaunal thresholds. Infaunal thresholds are triggered by results outside of those during baseline monitoring in 1992-2000. Low levels of enrichment can fertilize communities, increasing diversity, while higher levels 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. [4] 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.[5] *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[6].

The August 2011 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[7] 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.

[4] In addition to the thresholds discussed here, MWRA tests the average concentrations of 26 organic and heavy metal contaminants in nearfield sediments. Samples for contaminants were collected in August 2011, though sample analysis has not yet been completed.

[5] 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).

[6] Under the revised ambient monitoring design, infaunal thresholds were recalculated using the baseline data collected at the 11 stations to be sampled moving forward.

[7] 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*.

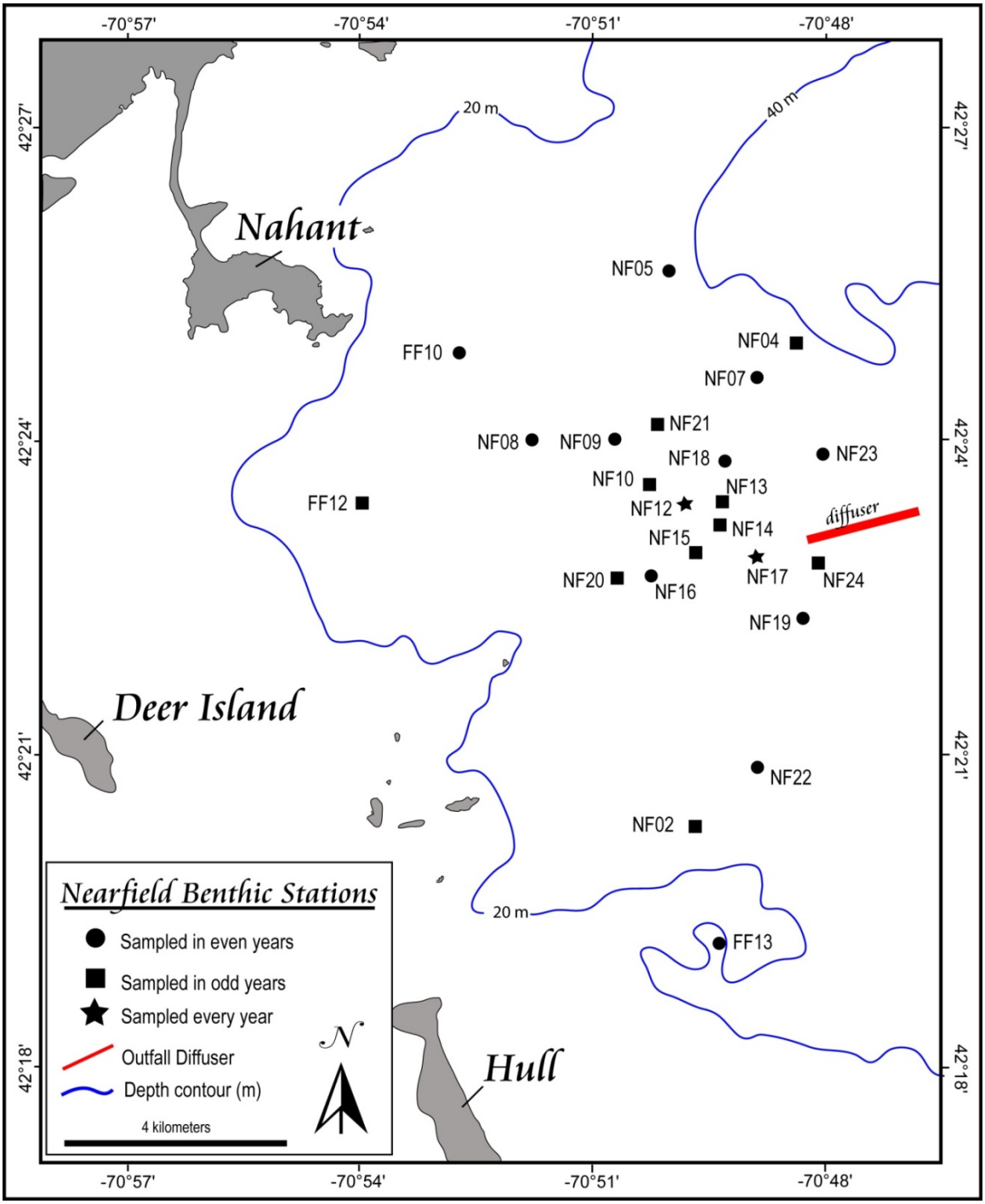

Figure 1. Map of nearfield sediment monitoring stations. Between 2004 and 2010, infaunal sampling was conducted in "odd" and "even" year station sets. All stations were sampled for the sediment profile imaging study, including August 2011.

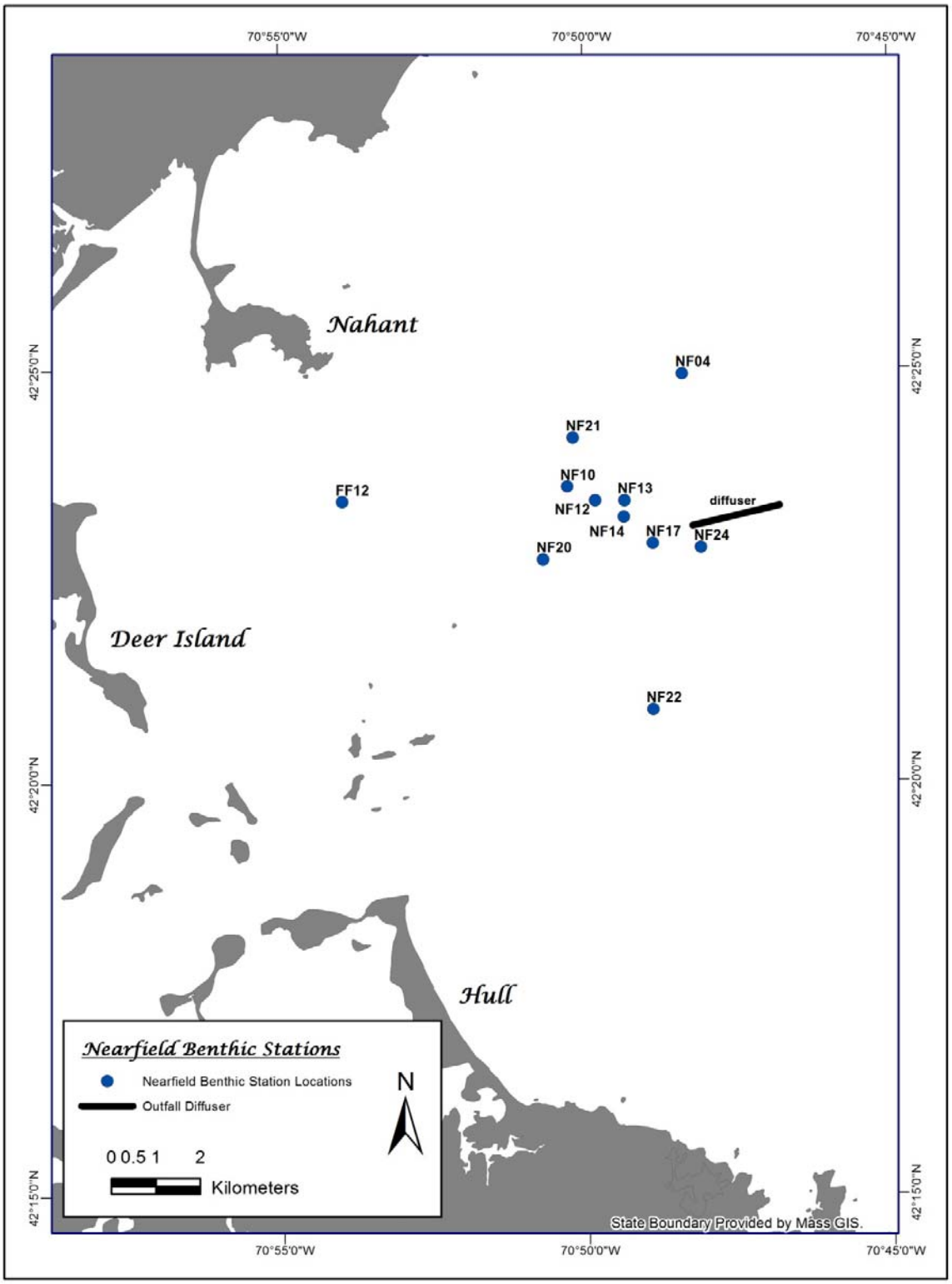

Figure 2. Map of nearfield infaunal community monitoring stations sampled in August 2011.

2011 results

It is important to note that the evaluation of the 2011 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 2011 were normal. Preliminary review of the sediment profile image results from all 23 nearfield stations in August 2011 suggested that conditions were similar to observations made in 2010, with deeper oxygen penetration into the sediments than seen since 2007 (Figure 3) and evidence for robust biological reworking of sediments at many sites (for example burrows and subsurface feeding voids).

Total organic carbon and grain size measured at the nearfield stations in 2011 were also well within baseline and outfall discharge ranges for these stations, as was the effluent solids tracer, spores of the bacterium *Clostridium perfringens* (Figure 4).

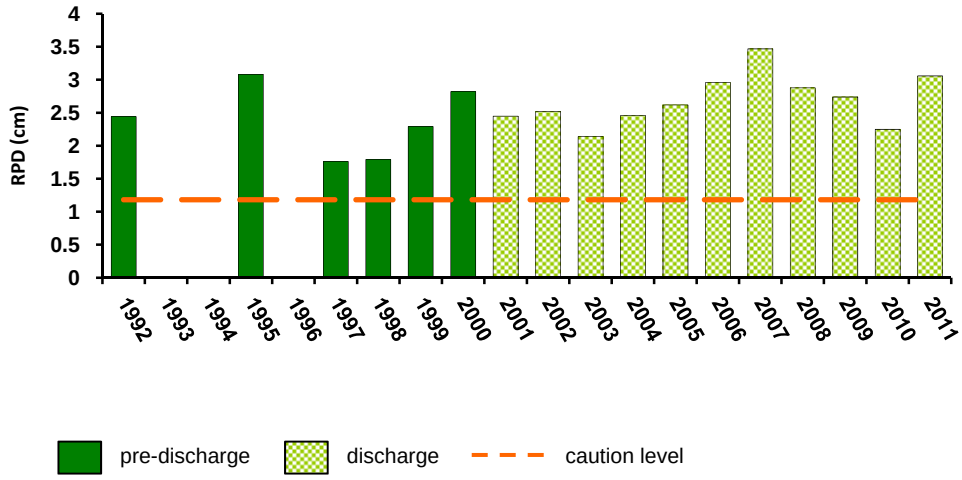

Figure 3 . Depth of the average redox potential discontinuity (RPD) in nearfield sediments as measured from sediment profile images, 1992-2011. RPDs in 2011 are among the deepest measured during discharge monitoring.

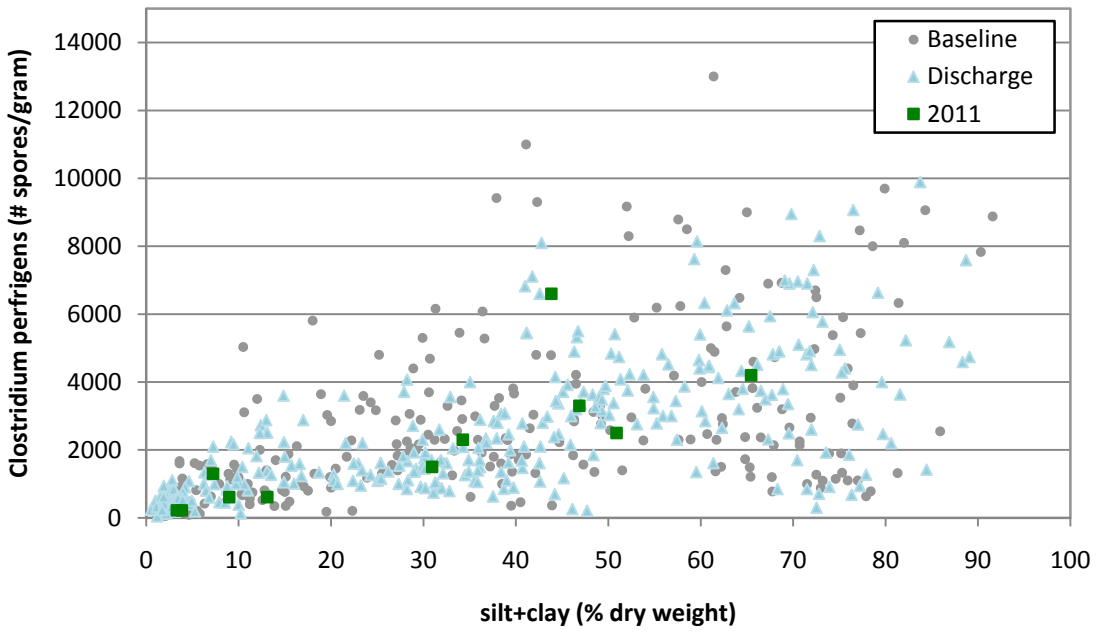

Figure 4. Scatterplot of *Clostridium perfringens* spores and percent silt/clay in sediments, 1992-2011. 2011 data are well within previous measurements.

So far, MWRA's review of the 2011 nearfield infaunal results provides no indications that the slightly elevated Pielou's J′ and Shannon-Wiener H′ diversities (Figure 5) reflect a response to the outfall discharge. Since both of the diversity indices sensitive to species richness were high but not extremely high in 2011 (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 threshold exceedances. Infaunal densities in 2011 were slightly lower than previously observed, but were robust, averaging about 29,000 animals/m^2. High evenness in abundant, species-rich samples is not typical of stressed communities, therefore it is likely that the results observed represent a natural fluctuation in the nearfield infaunal communities. The continued very low abundances of opportunistic taxa (Figure 6) also supports this.

Evaluation of the 2011 sediment nearfield monitoring data is continuing.

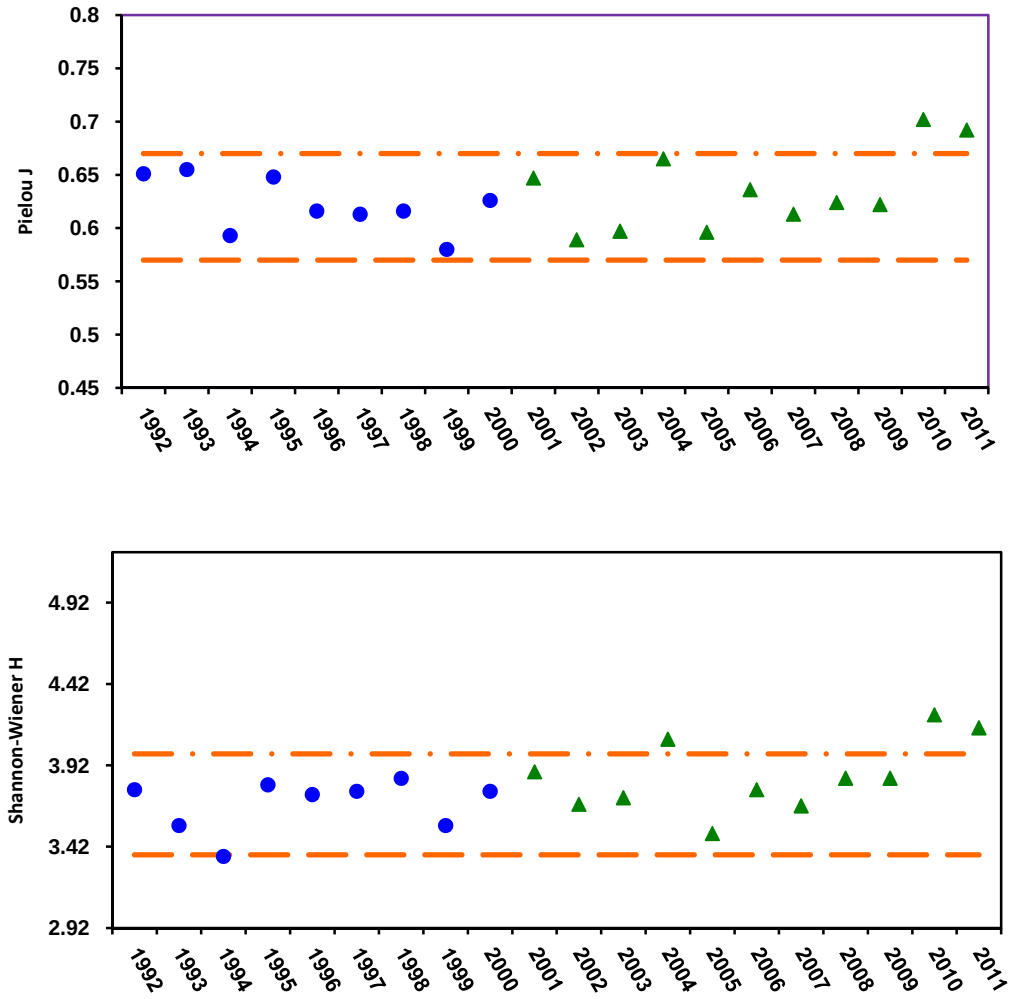

Figure 5. Pielou's J′ evenness (top) and Shannon-Wiener H′ diversity (bottom) measured at current nearfield monitoring stations, 1992-2003 and 2011. Data from 2004 through 2010 are the averages for the odd and even-year stations sampled then. Blue points are baseline data, and green triangles reflect outfall discharge 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 for even-year stations (4.14) applicable in 2004.

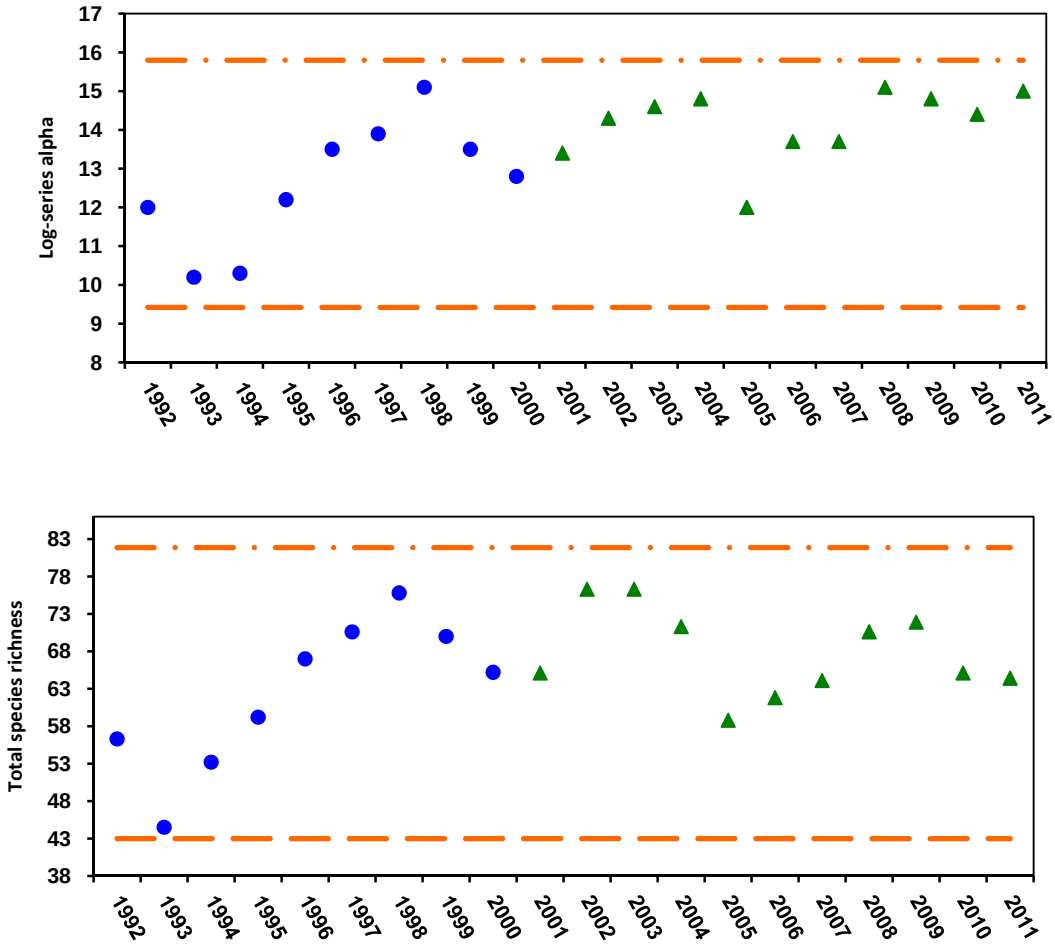

Figure 6. Log-series alpha and total species richness measured at nearfield monitoring stations, 1992-2011.

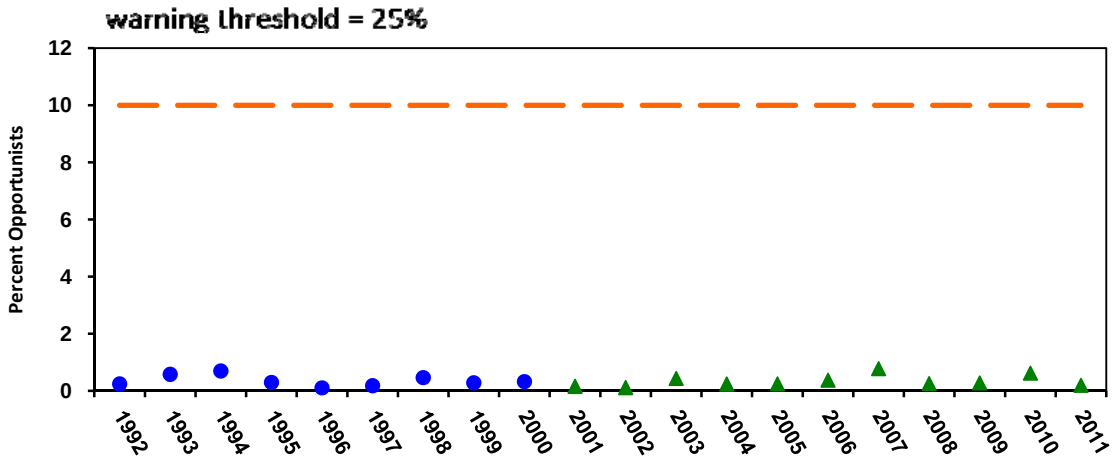

Figure 7. Abundance of opportunist taxa measured nearfield monitoring stations, 1992-2011. The dotted line reflects the 10% caution threshold.

MWRA 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. Andrea Rex at (617) 788-4940.

Sincerely,

Michael J. Hornbrook

Chief Operating Officer

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