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Contingency Plan Report
Fourth Quarter 2004

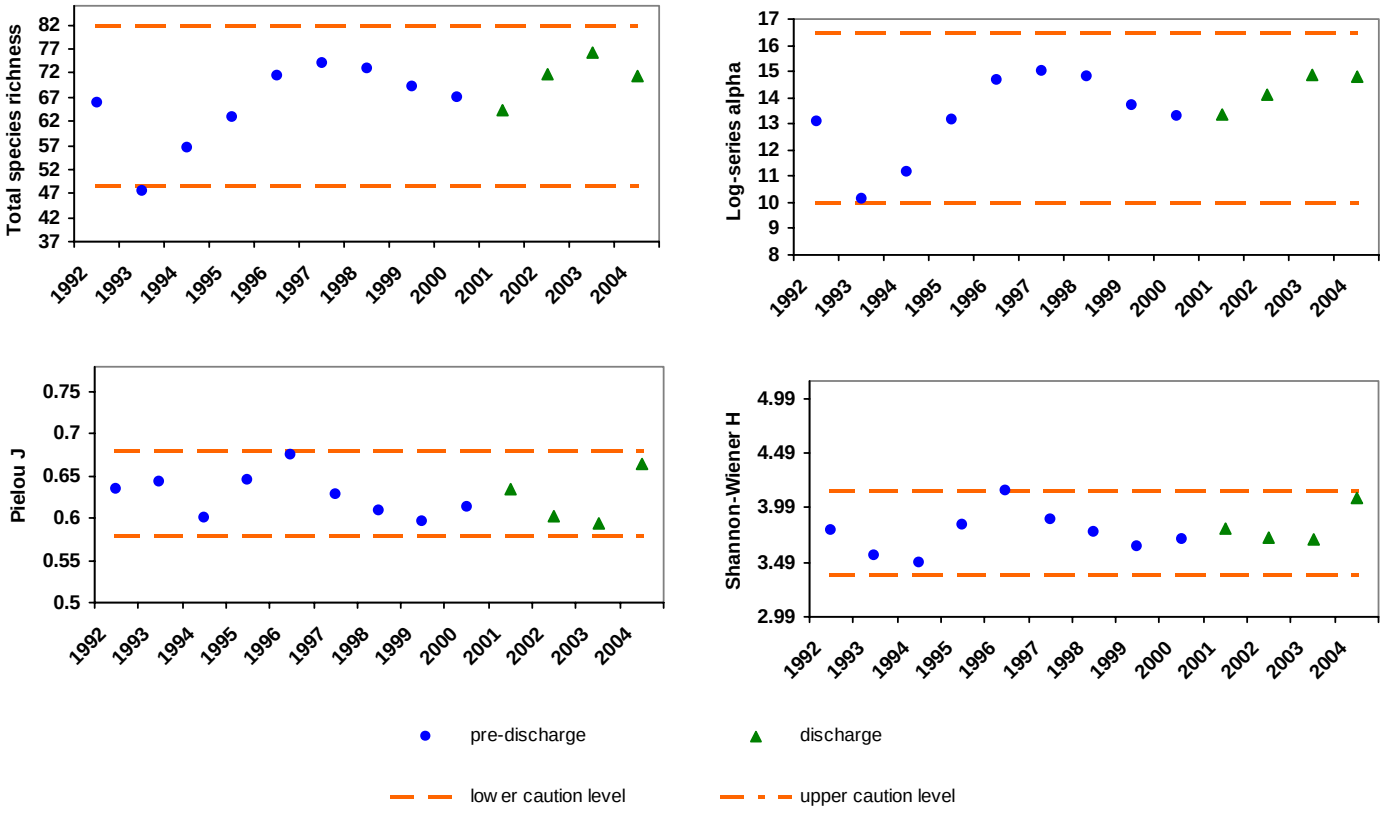
Ambient Monitoring

MWRA gathers data from the outfall location in Massachusetts Bay on various thresholds outlined in its Deer Island outfall discharge permit. This report shows relevant ambient monitoring results that became available in the October-December 2004 time period.

SEDIMENT BIODIVERSITY - 2004

DIVERSITY

The annual survey of post-discharge monitoring in 2004 showed that the benthic diversity was normal at the outfall site and did not exceed any of the thresholds.



One way to track the status of a marine ecosystem is to measure the diversity of the organisms in the communities that comprise the ecosystem, such as the soft-sediment communities (benthic infauna) in the sediment. The benthic diversity thresholds are intended to indicate whether there is a change from baseline conditions (either toward more or less diversity) now that the outfall is discharging. Of the dozens of statistical measures of diversity that have been developed by researchers over the past few decades, four are tracked within the MWRA monitoring program to show possible changes in diversity.

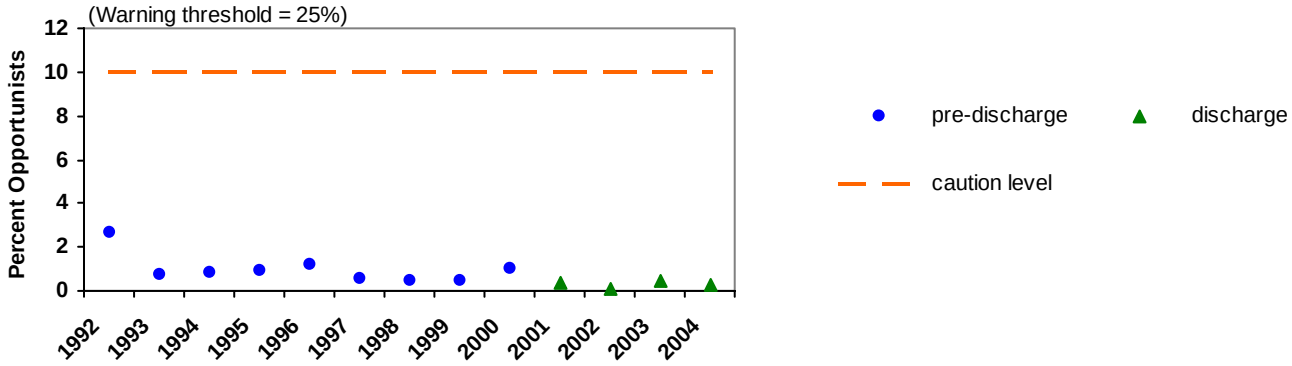
Two of these indices, total number of species per sample and Fisher's log-series alpha, are measures of species richness (how many species are present). Both measures track species richness while total species per sample is easy to describe to a general audience, Fisher's Log-series alpha has a theoretical grounding favored by some researchers. The other two diversity indices tracked by MWRA's monitoring are among those most commonly used by ecologists in many environments. Pielou's *J'* is a measure of how evenly individuals are distributed among species in a community. Samples where most species have about the same number of individuals have

high evenness, while samples where most of the individuals belong to one or a few species have low evenness. Finally, Shannon-Wiener *H'* is a diversity measure that is sensitive both to species richness and to species evenness in a community.

For each diversity measure, these graphs show the annual average[1] for sediment samples collected within seven kilometers of the outfall discharge. The extreme winter storms of December 1992 caused 24-foot seas in the vicinity of the outfall, moving sediments and burying some areas under inches of sand, mud, or gravel even though the ocean is about 100 feet deep in the area. This physical disturbance was at least partially the cause of the decline seen in the two richness indices between 1992 and 1993. The communities recovered rapidly, and by the late 1990s appeared to be showing a several-year cycle in species richness (data from farfield stations also show this apparent trend).

OPPORTUNISTS

The annual sampling in 2004 showed that the numbers of opportunistic benthic organisms remain normal at the outfall site and did not exceed the caution threshold of 10% of the total population.



The presence of pollution-tolerant or opportunistic species is another measure of possible pollution impact on sediments in the vicinity of the outfall. These are species that can build up to high population levels in response to, for example, increased deposition of organic matter. In their selection of an outfall location in 1988, EPA modeled the deposition of organic matter and determined that with a secondary discharge, impacts would be minimal.

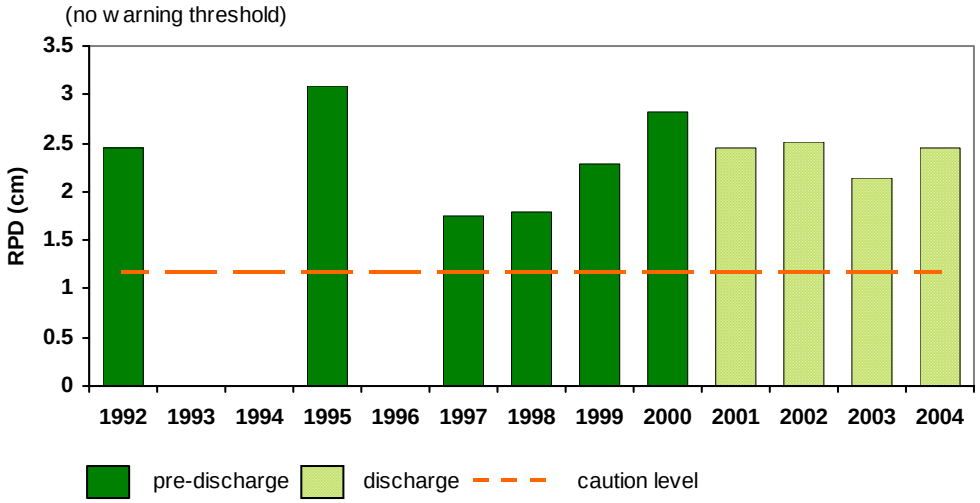
Based on a review of the species found in Boston Harbor, Massachusetts Bay, and Cape Cod Bay sediments during baseline sampling, several species have been identified as opportunists: *Capitella* spp. *and Capitella capitata* complex, *Polydora cornuta*, *Streblospio benedicti*, *Ampelisca abdita*, *Ampelisca vadorum*, *Ampelisca macrocephala*, and *Mulinia lateralis*. The *Ampelisca* species were included in the list because they are tolerant to moderate levels of organic enrichment, even though they cannot tolerate high levels. For example, the appearance of large populations of *Ampelisca* in Harbor sediments in the mid-1990s was one of the early signals of the Harbor's recovery.

The Contingency Plan thresholds for percent opportunists were set well below levels seen in Boston Harbor throughout the 1990s.

[1] Thresholds recalculated for new sampling design: in 2004, MWRA implemented a new outfall sampling design, which included sampling most sediment stations in alternate years. The baseline means and the thresholds (the central 95th percentile of the baseline means) were recalculated mathematically using the separate station sets sampled in "even" and "odd" years. The recalculated thresholds for benthic diversity applicable to even years are very slightly different from those calculated using all stations. On the graph, the results for all years are calculated using the new "even year" station set and thus the 2001-2003 values differ from the then-effective threshold results, which were reported in earlier quarterly reports.

SEDIMENT ENRICHMENT

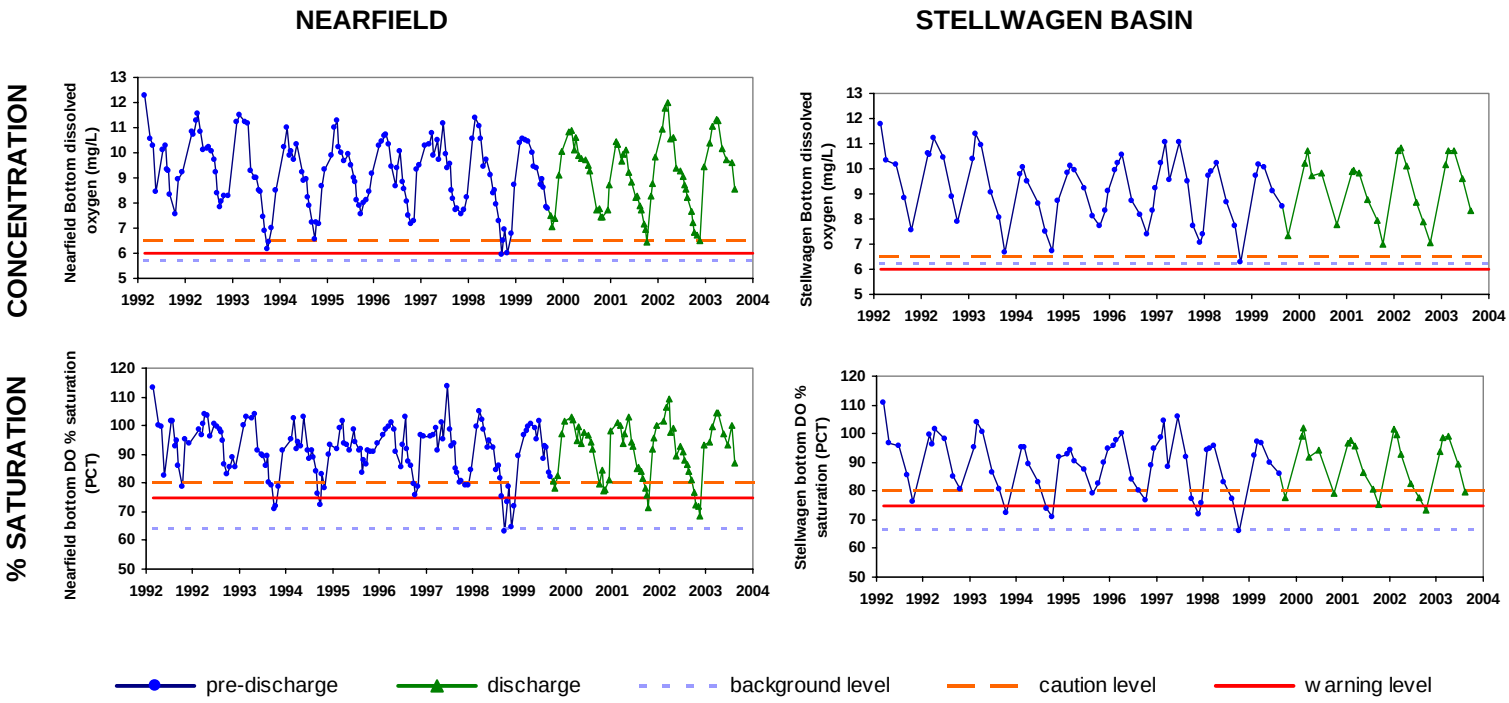
The 2004 annual post-discharge monitoring showed that the RPD depth was normal at the outfall site and did not exceed the threshold (did not fall below the minimum RPD threshold.)



The depth of the oxygenated layer in marine sediment is a measure of ecosystem health. A diverse bottom-dwelling community includes organisms that mix water and oxygen down into the sediment. In an over-enriched environment, organic material deposited on the sediment surface can use up the available oxygen and smother the bottom-dwelling community. Such areas, including some areas of Boston Harbor, have a thin or nonexistent oxygenated layer. The thickness of the oxygenated layer is called the redox potential discontinuity (RPD) depth. In MWRA's monitoring program, the RPD depth is estimated from sediment-profile images, cross-sections of the upper several centimeters of the sediment taken with a special mud-penetrating prism and camera. The threshold for RPD is half the mean measured in the baseline period (that is, if the thickness of the oxygenated layer fell to less than half the thickness measured pre-discharge, a caution threshold would be exceeded.)

DISSOLVED OXYGEN – July-August 2004

Measurements of dissolved oxygen (DO) concentration and percent saturation in late summer 2004 did not fall below background levels and thus did not exceed thresholds.



The concentration of dissolved oxygen (DO) in the water indicates the balance between production by algae and consumption by aquatic organisms and the decomposition of organic matter. Excessive organic matter may result in oxygen depletion, which may in turn adversely affect the aquatic ecosystem. The amount of oxygen that the water can hold is related to water temperature, salinity, and pressure; thus, the percent saturation of dissolved oxygen is a measure that takes these factors into account. Monitoring locations for which there are DO thresholds include the "nearfield," the group of stations within about three miles from the outfall, and "Stellwagen Basin," a deep area nine miles east of the outfall. DO thresholds apply to the part of the year when the water column is stratified, *i.e.* from June - October. The current reporting period for dissolved oxygen thresholds is July-August 2004. During this period there were two nearfield surveys and one farfield survey.

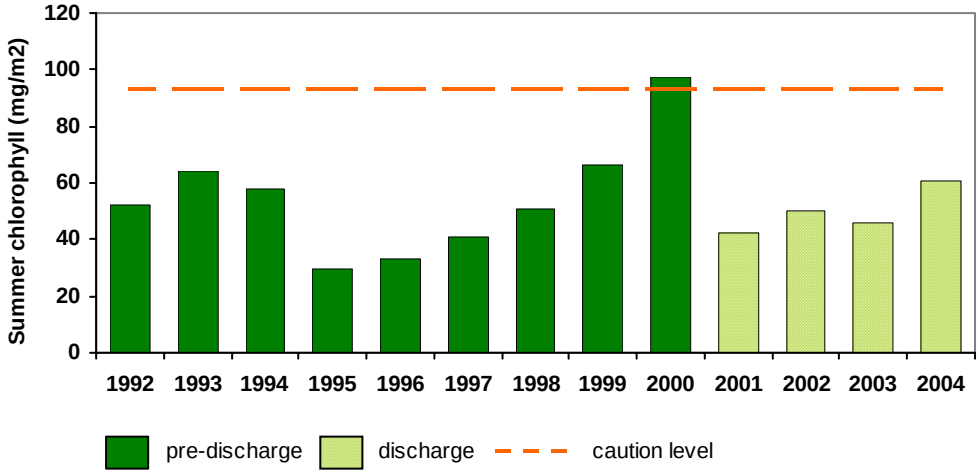
Dissolved oxygen concentration and percent saturation naturally fell below 6 mg/l on occasion during the baseline period. The state standard, on which the thresholds were based, allows an exception to numerical thresholds if background conditions are lower, as is the case here; thus, the threshold is not exceeded unless the value falls below the threshold and below background.

Oxygen levels were similar to those seen in several baseline years. The graphs above include data since the start of the monitoring program in 1992, and reflect the natural fluctuation of DO and percent saturation, which is typically lowest in early autumn.

CHLOROPHYLL – May-August 2004

The nearfield mean areal average chlorophyll in summer 2004 was 61 mg/m^2, well below the caution level threshold[2] for summer of 93 mg/m^2, and similar to the levels in the summers of 1992-94 and 1999.

SUMMER



In this report, we compare post-discharge chlorophyll data to the thresholds for summer 2004 (May-August), which included four surveys. The graph includes data since the start of the monitoring program in 1992.

Chlorophyll is a measure of the amount of microscopic plants (phytoplankton or algae) in the water. In Massachusetts Bay, production of algae is the basis of the food web. However, excessive growth of algae can lead to undesirable consequences, such as oxygen depletion at depth due to decomposition of organic matter. Effluent from the outfall is rich in nutrients, and therefore could potentially cause excessive algal growth.

There are annual and seasonal chlorophyll thresholds for the "nearfield," the group of stations within about three miles from the outfall that are most likely to be affected by nutrient-rich effluent. Because the levels of chlorophyll in the water naturally vary over the year, there are separate thresholds for different seasons. In most years, Massachusetts Bay experiences a “spring bloom” characterized by high chlorophyll levels as lengthening days provide enough sunlight for algae to grow quickly. Chlorophyll typically drops in summer, as the nutrients in well-lit surface waters are used up. When the weather cools, the surface and bottom waters mix, which usually gives rise to a “fall bloom” as nutrient-rich bottom waters are mixed up into the well-lit surface layers. As the days become short, chlorophyll levels drop again since there is not enough light for algae to grow.

[2] Threshold recalculated for new survey schedule: in 2004, MWRA implemented a new outfall sampling design, which included dropping two surveys in the summer. The baseline means and the thresholds (the 95th percentile of the baseline mean) were recalculated mathematically deleting baseline data corresponding to the dropped surveys. The recalculated summer threshold for chlorophyll is higher than the old threshold of 80 mg/m^2. On the graph, the results for all years are calculated using the new survey schedule, and thus the 2001-2003 values differ from the then-effective threshold results, which were reported in earlier quarterly reports.

NUISANCE ALGAE – July-August 2004

As previously reported, *Phaeocystis pouchetii* exceeded the very low summer threshold in summer 2004 (See http://www.mwra.state.ma.us/harbor/pdf/20040723amx.pdf).

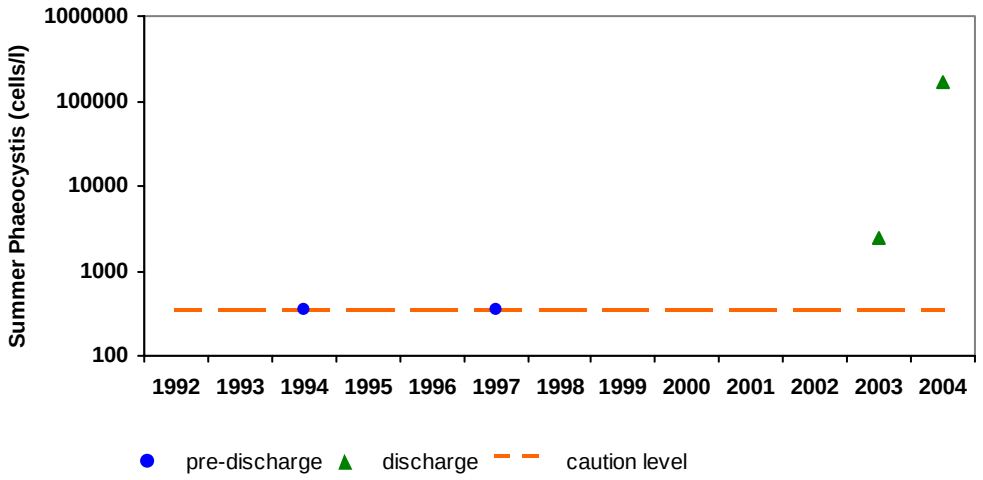
Pseudonitzschia was present only at low abundances in the nearfield in summer 2004, well below the threshold.

No samples of *Alexandrium tamarense* exceeded the threshold of 100 cells/liter during the present reporting period (late summer 2004.)

In this report, we compare post-discharge *Phaeocystis* and *Pseudonitzschia* data to the thresholds[3] for summer 2004 (May through August), which included four surveys. We also compare the per-sample results for *Alexandrium* in the two July-August surveys to the threshold.

PHAEOCYSTIS

Summer

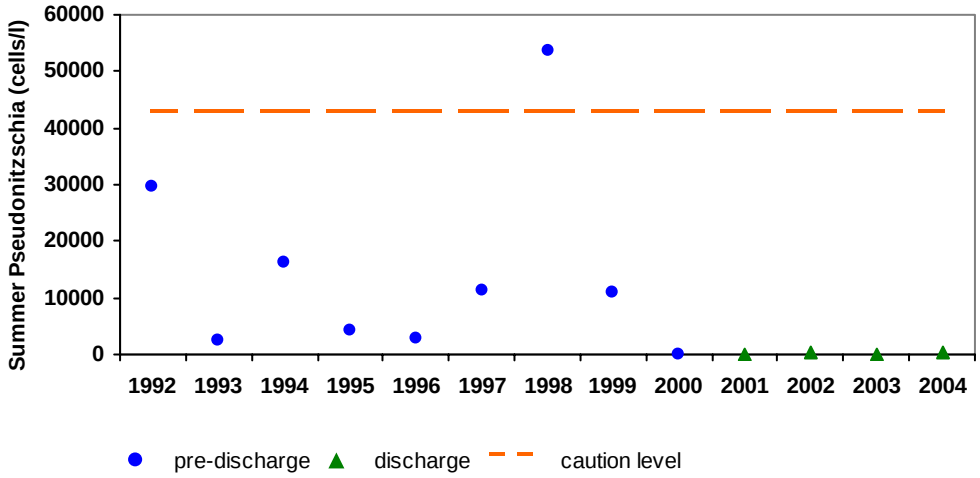


Note logarithmic scale. Years with no data point had zero average *Phaeocystis*.

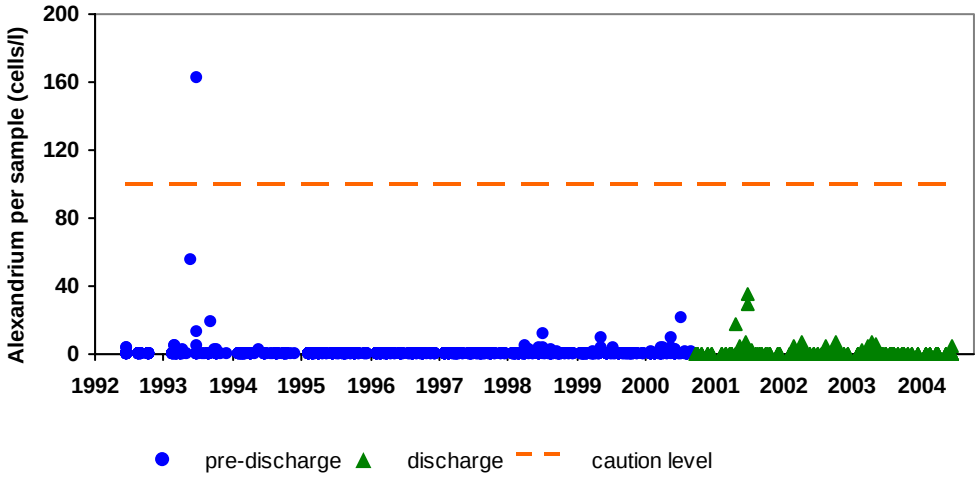
[3] Threshold recalculated for new survey schedule: in 2004, MWRA implemented a new outfall sampling design, which included dropping two surveys in the summer. The baseline means and the thresholds (the 95th percentile of the baseline mean) were recalculated mathematically deleting baseline data corresponding to the dropped surveys. The recalculated summer threshold for *Pseudonitzschia* is higher than the old threshold of 21,000 cells/l. The recalculated summer *Phaeocystis threshold* is very slightly higher than the old threshold of 334 cells/l. On the graph, the results for all years are calculated using the new survey schedule, and thus the values for 2001-2003 differ from the then-effective threshold results, which were reported in earlier quarterly reports.

PSEUDONITZSCHIA

Summer



ALEXANDRIUM



Nuisance algal blooms are less predictable than the normal, beneficial algal blooms that produce oxygen and food for marine life; some nuisance blooms did occur during the baseline monitoring period. There is public concern that effluent nutrients could feed a red tide bloom in the vicinity of the new outfall, or otherwise increase the abundance of nuisance algae. Therefore, the Contingency Plan has thresholds for abundance of *Alexandrium*, *Phaeocystis pouchetii*, and *Pseudonitzschia*, which are triggered if the abundance of any of these becomes unusually high.

PHAEOCYSTIS

Phaeocystis pouchetii blooms usually occur during February to April but can occur at any time. The species is not toxic, but individual cells can aggregate in gelatinous colonies that may be poor food for zooplankton. *Phaeocystis* exceeded the very low threshold in summer 2004; this was a remnant of a spring *Phaeocystis* bloom that persisted later than usual. (See http://www.mwra.state.ma.us/harbor/pdf/20040723amx.pdf).

There were no indications of adverse impacts from this bloom. Zooplankton communities were generally within the normal range and bottom water dissolved oxygen levels continue to be relatively high into September (>8 mg/L). Right whales were present in Cape Cod Bay during the spring in relatively abundant numbers, and levels of the zooplankton *Calanus*, the locally preferred prey of right whales, were normal to abundant based on Center

for Coastal Studies data. There is no obvious association between the magnitude or duration of the 2004 *Phaeocystis* bloom and MWRA's outfall.

Summer *Phaeocystis* mean abundance (cells/liter)	
Caution threshold	357
Summer 2004	164,000

PSEUDONITZSCHIA

Pseudonitzschia multiseries blooms can occur during November to March and produce domoic acid, which can cause a condition known as amnesic shellfish poisoning. The group of algae including the toxic species *Pseudonitzschia multiseries*, the closely related *Pseudonitzschia pungens*, and any unidentified *Pseudonitzschia* species was present only at low abundances in the nearfield in summer 2004, well below the threshold.

Summer *Pseudonitzschia* mean abundance (cells/liter)	
Caution threshold	43,100
Summer 2004	380

ALEXANDRIUM

Alexandrium tamarense typically may bloom during April to June and can cause paralytic shellfish poisoning, known as PSP or red tide; it has been periodically found in Massachusetts since the 1970s. Toxicity is generally not found in shellfish until much higher cell counts are seen in the overlying waters. In the late summer of 2004 *Alexandrium* cells (*Alexandrium tamarense* plus unidentified *Alexandrium* spp.) were not observed in any samples.

July-August *Alexandrium* per-sample abundance (cells/liter)	
Caution threshold	100
July-August 2004*	0

*** maximum of all samples collected between July 1, 2004 and August 31, 2004.**