Contingency Plan Report
October-December 2001

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 previous quarter.

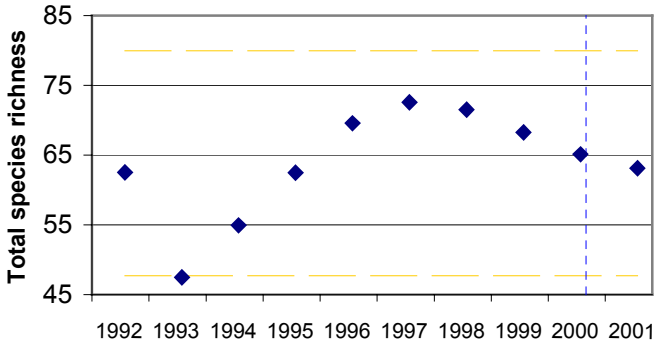
SEDIMENT BIODIVERSITY

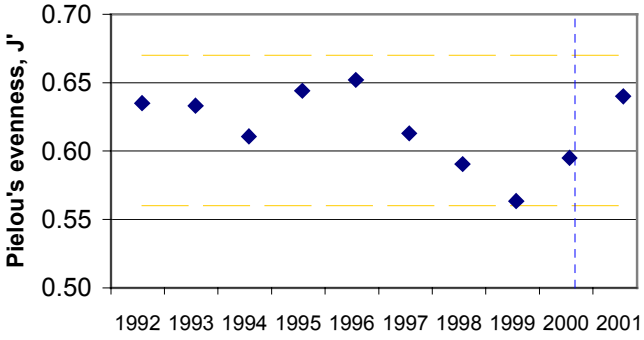
One way to track the status of a marine ecosystem is to measure the diversity of the organisms in the communities that compose the ecosystem, such as the soft-sediment communities in the sediment (benthic infauna.) The benthic diversity thresholds are intended to indicate whether there is a change from 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.

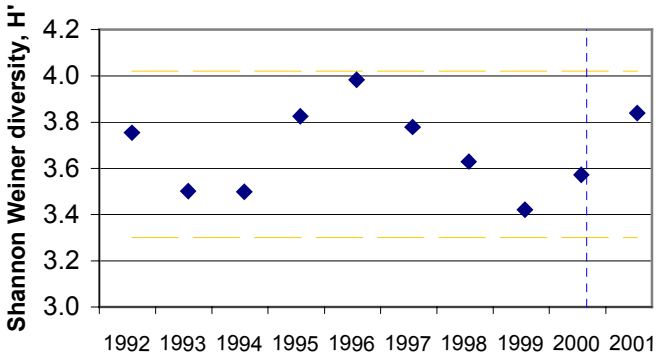
Two of these indices, total number of species per sample and Fisher's log-series alpha, are measures of species richness (how many species are present). Both measurements track species richness while total species per sample is easy to describe to a general audience, Fisher's Log-series alpha has a theoretical 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.

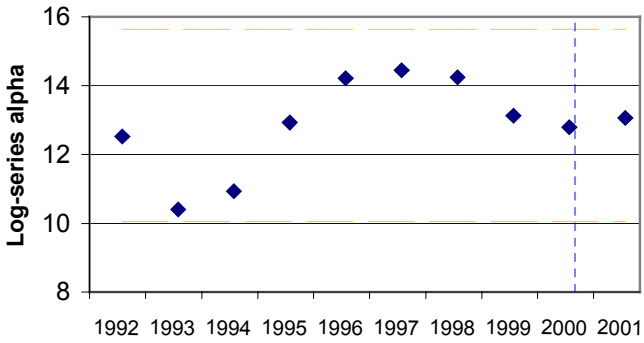
For each diversity measure, these graphs show the annual average for all sediment samples collected within seven kilometers of the outfall discharge. The extreme winter storms of December 1992 caused 24 foot seas in the vicinity of the outfall, moving sediments and burying some areas under inches of sand, mud, or gravel even though the ocean is about 100 feet deep in the area. This physical disturbance was 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).

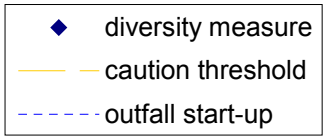
The first annual survey of post-discharge monitoring in 2001 showed that the benthic diversity was normal at the outfall site and did not exceed any of the thresholds.


Total species richness
85
75
65
55
45
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001


Pielou's evenness, J'
0.70
0.65
0.60
0.55
0.50
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001


Shannon Weiner diversity, H'
4.2
4.0
3.8
3.6
3.4
3.2
3.0
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001

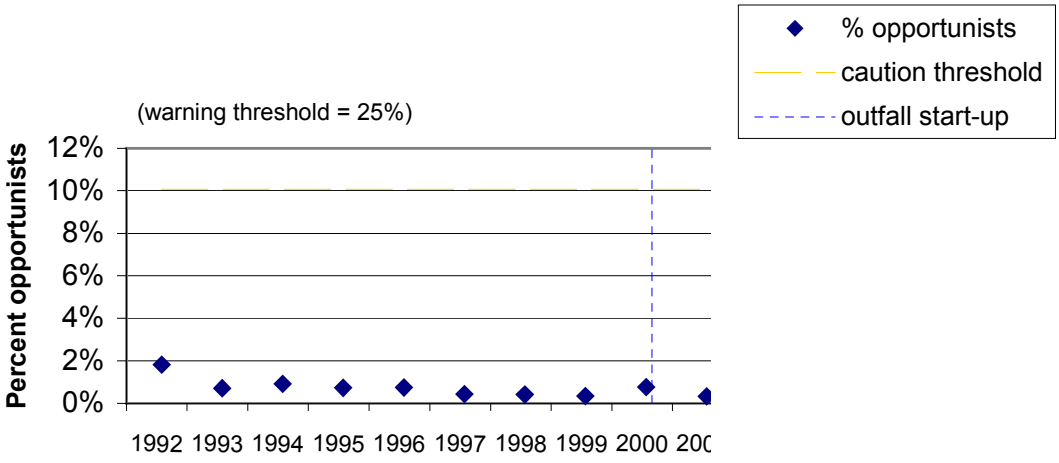

Log-series alpha
16
14
12
10
8
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001


diversity measure
caution threshold
outfall start-up

Another measure of possible pollution impact on sediments in the vicinity of the outfall is the presence of pollution-tolerant or opportunistic species. 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. The first annual sample of post-discharge monitoring showed that the numbers of opportunistic benthic organisms was normal at the outfall site and did not exceed the threshold.



SEDIMENT CONTAMINATION

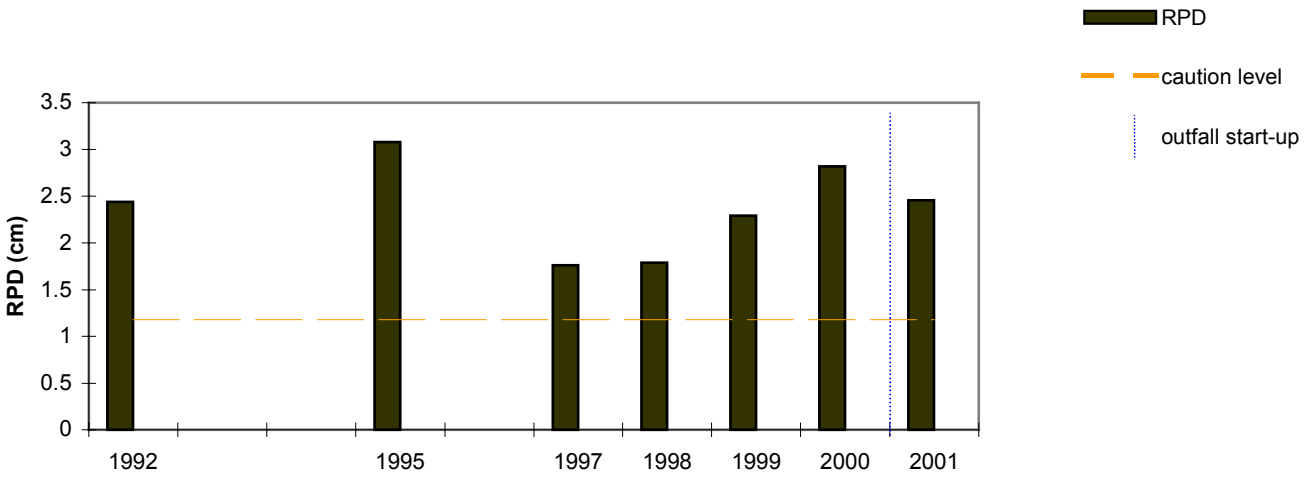
The sediment contamination thresholds will indicate any unexpected accumulation of toxic contaminants in soft sediments near the outfall. Contaminant levels measured each year are compared to sediment guidelines issued by the National Oceanic and Atmospheric Administration (NOAA). These NOAA "ERL-M" levels indicate toxic contaminant concentrations above which adverse effects on marine life are believed to be likely. Baseline sediment contamination levels are all well below the ERL-M levels for all contaminants, with only low molecular weight polycyclic aromatic hydrocarbons (LMWPAH) reaching to more than half the threshold value. The first annual post-discharge monitoring showed that sediment contamination levels at the outfall site were similar to previous years and well below the thresholds.

	contaminant	range over baseline	threshold	2001 value
PAHs (ng/g dry weight)				
	acenaphthene	23-41.3	500	35
	acenaphthylene	38.3-58.4	640	48
	anthracene	114.1-171	1100	165
	benz(a)anthracene	221.4-302	1600	277
	benzo(a)pyrene	223.6-287	1600	283
	chrysene	217.3-288	2800	278
	dibenzo(a,h)anthracene	30.5-42	260	47
	fluoranthene	465-592	5100	581
	fluorene	37.9-60.9	540	52
	naphthalene	53.5-83.2	2100	86
	phenanthrene	296.4-405	1500	422
	pyrene	440.3-540	2600	538
	sum HMWPAH	2986.4-3754	9600	3644
	sum LMWPAH	1420.1-2004	3160	1683
	total PAH	4482.5-5726	44792	5327
Other organic contam. (ng/g)				
	p,p'-DDE	0.28-1.25	27	0.5
	total DDT	2.59-5.27	46.1	3
	total PCB	10.4-28.6	180	13
Metals (ug/g dry weight)				
	cadmium	0.09-0.23	9.6	0.1
	chromium	61.9-86.8	370	75
	copper	19.2-27.6	270	24
	lead	42.9-47.2	218	46
	mercury	0.2-0.29	0.71	0.27
	nickel	15.5-18.5	51.6	18
	silver	0.47-0.71	3.7	0.5
	zinc	56.6-69.7	410	60

SEDIMENT ENRICHMENT

The depth of the oxygenated layer in marine sediment is a measure of ecosystem health. In 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 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.

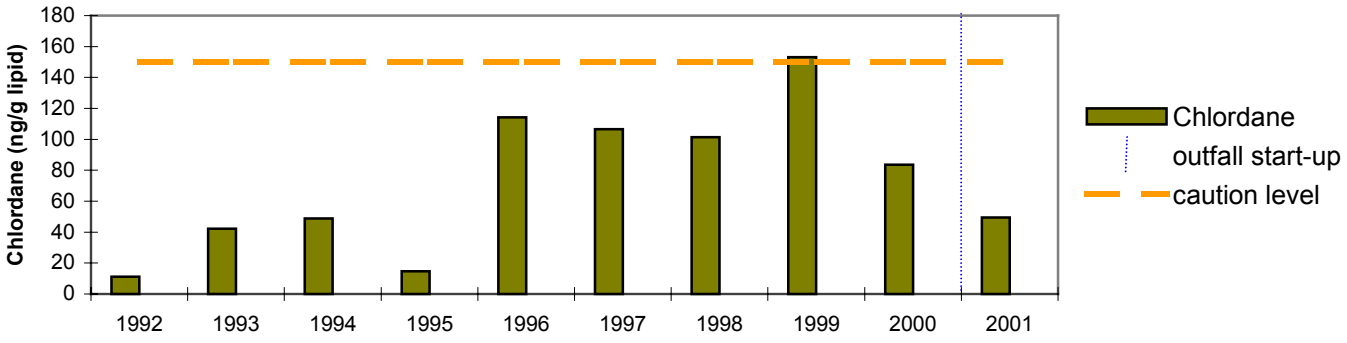
The first annual post-discharge monitoring showed that the RPD depth was normal at the outfall site and did not exceed the threshold (did not fall below the minimum RPD threshold.)

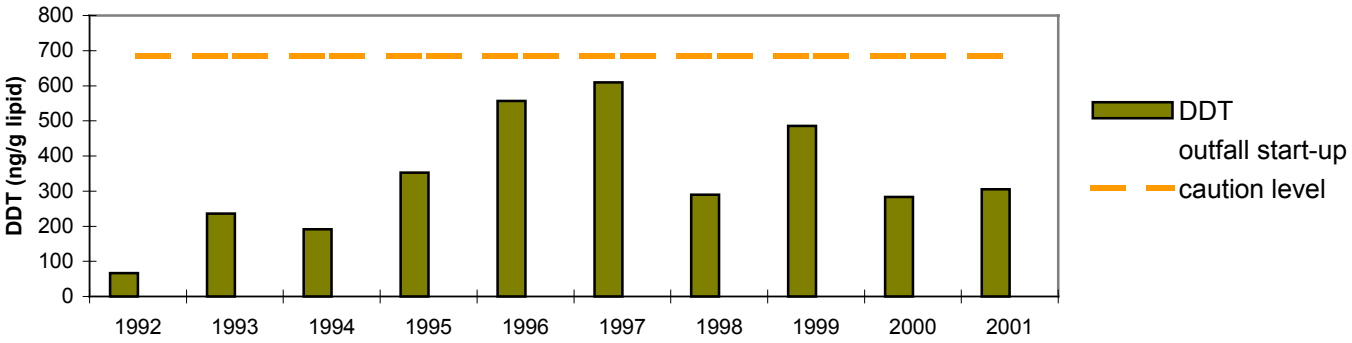


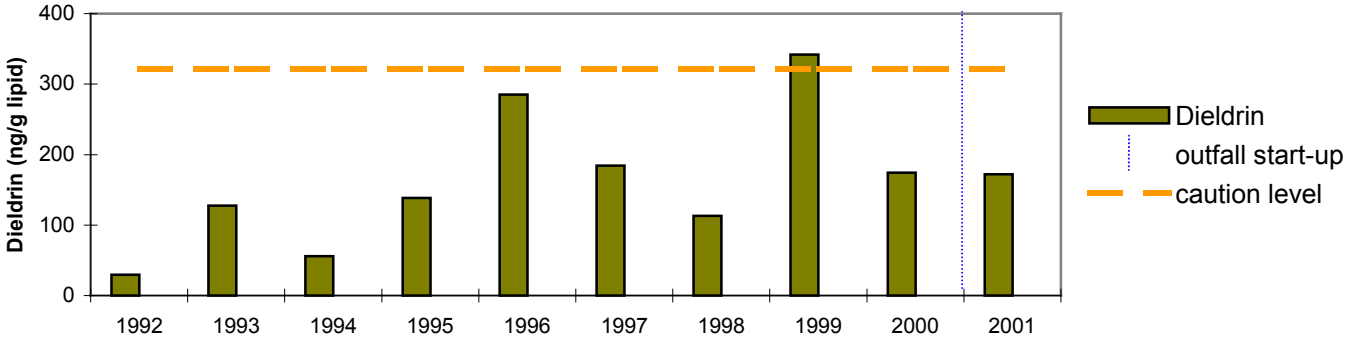
FISH AND SHELLFISH TISSUE CONTAMINATION

The edible fish tissue contamination thresholds are designed to identify unexpected effects on marine life. Contaminants are measured in three species of seafood: flounder, lobster, and mussels. FDA Action Limits are available for mercury and PCBs in flounder, lobster, and mussels; for these measurements, caution and warning thresholds are set at 50% and 80% of the FDA limits. The threshold for lead in mussels is based on EPA risk assessment of lead in drinking water. Other fish/shellfish tissue contamination thresholds are based on change from baseline conditions at the outfall site.

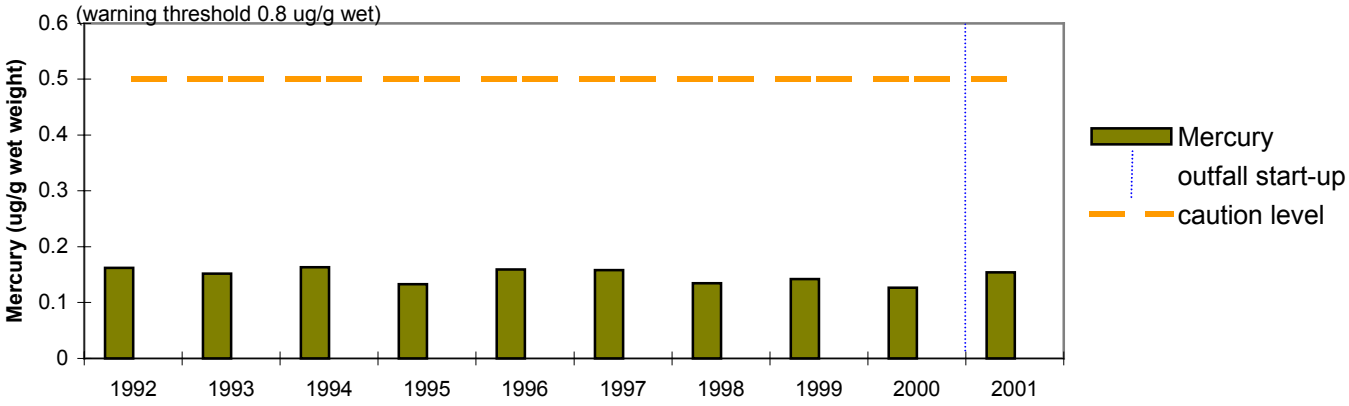
Post-discharge data available this quarter include tissue contamination in lobster, which were sampled in August 2001. Contaminant values were similar to baseline years, and well below threshold values.

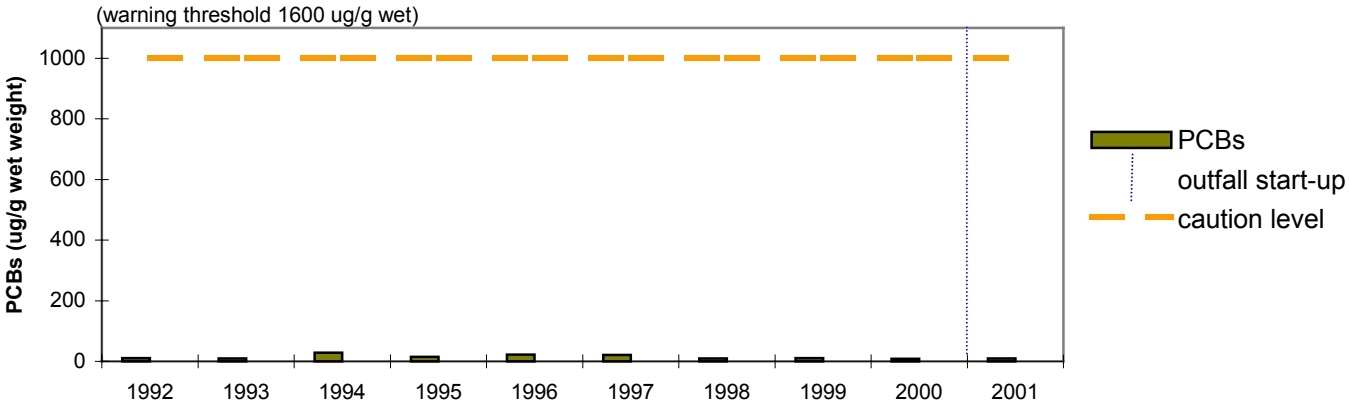






Lobster tissue contaminant levels (continued on next page)


(warning threshold 0.8 ug/g wet)
Mercury (ug/g wet weight)
0.6
0.5
0.4
0.3
0.2
0.1
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Mercury
outfall start-up
caution level


(warning threshold 1600 ug/g wet)
PCBs (ug/g wet weight)
1000
800
600
400
200
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
PCBs
outfall start-up
caution level

DISSOLVED OXYGEN

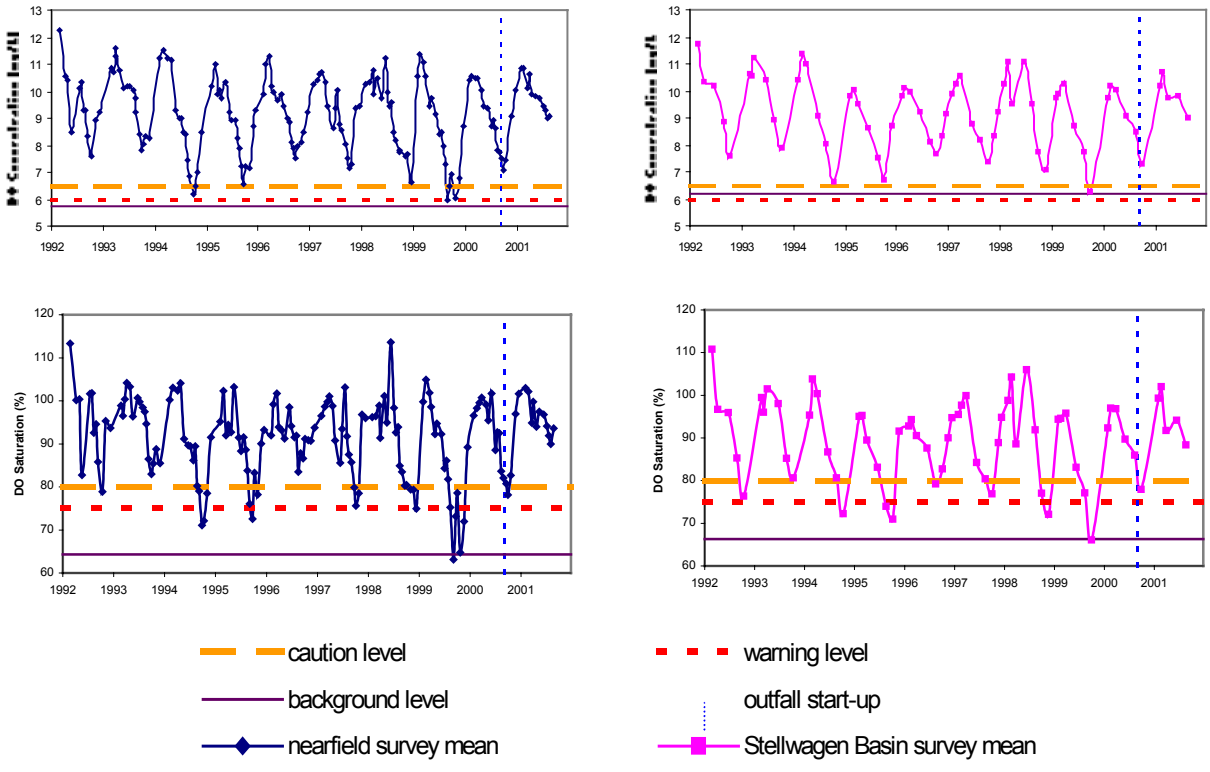
The concentration of dissolved oxygen (DO) in the water indicates the balance between production by algae and consumption by aquatic organisms and the decomposition of organic matter. Excessive organic matter may result in oxygen depletion, which may in turn adversely affect the aquatic ecosystem. The 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 five miles from the outfall, and "Stellwagen Basin", a deep area nine miles east of the outfall. 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 and August 2001. During this period there were three nearfield surveys and one combined nearfield/farfield survey.

Dissolved oxygen concentration and percent saturation naturally fall below the numerical thresholds on occasion during the baseline period. The state standard, on which the thresholds were based, allows an exception if background conditions are lower, as is the case here. The thresholds have accordingly been modified (see www.mwra.state.ma.us/harbor/html/20010601cpr.pdf) to mirror the state standard, and a threshold is not exceeded unless the value falls below the threshold and below background.

Parameter	Location	Caution	Warning	Background
Dissolved Oxygen (mg/L)	Nearfield	6.5	6.0	5.75
	Stellwagen Basin	6.5	6.0	6.2
Percent Oxygen Saturation (%)	Nearfield	80	75	64.3
	Stellwagen Basin	80	75	66.3

Measurements of dissolved oxygen (DO) concentration and percent saturation in July 2001 did not exceed thresholds. Because of a sensor failure, fewer DO data were collected in August 2001. The graphs below 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 fall.

NEARFIELD **STELLWAGEN BASIN**



CHLOROPHYLL

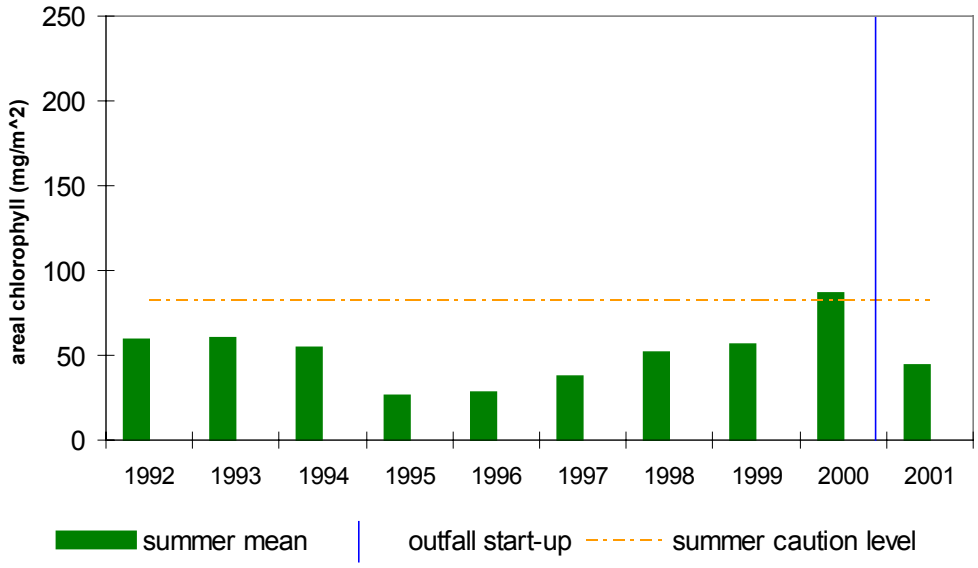
In this report we compare post-discharge chlorophyll data to the thresholds for summer 2001 (May through August), which included six nearfield surveys.

Measurements of chlorophyll concentration taken since the activation of the outfall tunnel exceeded the seasonal caution level threshold in the autumn of 2000, but then dropped below the seasonal threshold in the winter/spring season of 2000. The nearfield mean areal average in summer 2001 was 45 mg/m^2. Based on the baseline measurements, the caution level threshold for summer is 80 mg/m^2 (areal average of nearfield).

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 five miles from the outfall which 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.

The graphs include data since the start of the monitoring program in 1992, and reflect the natural fluctuation of chlorophyll. In summer 2001, chlorophyll was below the threshold, and within the range seen in the baseline period. The seasonal mean was about half the summer 2000 mean.



NUISANCE ALGAE

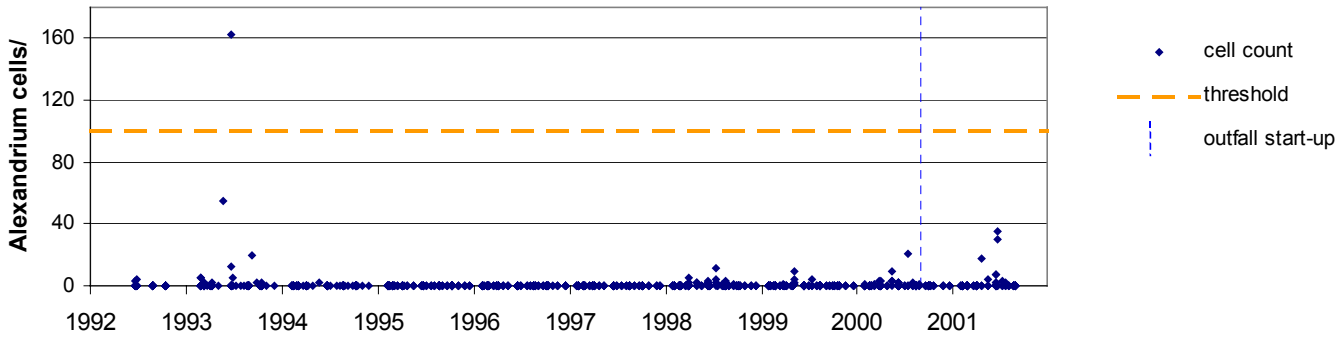
Nuisance algal blooms are less predictable than the normal, beneficial algal blooms that produce food and oxygen; some nuisance blooms did occur during the baseline monitoring period. There is public concern that effluent nutrients could feed a red tide bloom in the vicinity of the new outfall, or otherwise 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. The data available for threshold reporting this quarter include per-sample results for *Alexandrium* in July and August, and summer average results for *Phaeocystis pouchetii* and *Pseudonitzschia*. The summer season included six nearfield surveys.

ALEXANDRIUM

No samples exceeded the threshold of 100 cells/liter during the present reporting period (early summer). *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 *Alexandrium* cells (*Alexandrium tamarense* plus unidentified *Alexandrium* spp.) were observed in only two samples.

Late summer *Alexandrium* per-sample abundance (cells/l)	
caution threshold	100
July-August 2001*	3

* maximum of all samples collected between July 1, 2001 and August 31, 2001.



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 are poor food for zooplankton. No Phaeocystis was observed in summer 2001 samples.

Summer *Phaeocystis* mean abundance (cells/l)	
caution threshold	334
Summer 2001	0

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 in four of the 28 summer 2001 nearfield samples, at very low abundances.

Summer *Pseudonitzschia* mean abundance (cells/l)	
caution threshold	37,900
Summer 2001	100