WATER QUALITY

Just how clean is your water?

In many locations, it is cleaner than it was when the Clean Water Act was passed in 1972. But in many water bodies, pollution is still a serious concern. Excess bacteria in the water can render beaches unfit for swimming. Contaminants in stormwater can lead to closures of shellfish beds. It is increasingly apparent that human health is reliant on the health of estuaries and the natural environment on the whole. While water quality can be impacted by natural processes, today it is the human-induced environmental stressors that cause the most concern among citizens and scientists.

MUNICIPAL WASTEWATER IN BOSTON HARBOR

Q1 How has the diversion of the MWRA sewage discharge affected conditions in Boston Harbor?

Contributors: Andrea Rex and David Taylor, Massachusetts Water Resources Authority

Why this is important

During the construction of the Deer Island Treatment Plant and offshore outfall, the Massachusetts Water Resources Authority (MWRA) began tracking biological changes in the water and sediment of Boston Harbor. Discharge of sludge to the harbor was discontinued in 1991, and in 1998, wastewater treatment for greater Boston was consolidated on Deer Island and secondary treatment initiated. (Secondary treatment is a biological process that removes organic matter and solids from sewage). In 2000, sewage treatment plant discharges to the harbor ended with the opening of the ocean outfall and diffuser system. This secondary treatment has improved the ecological conditions of Boston Harbor by significantly reducing contaminant discharges.

State of the Bay

Extensive monitoring of Boston Harbor began in 1992 as part of the monitoring program designed by MWRA. The monitoring project measures changes in biological and other conditions in the water column and sediments of the harbor and documents ambient conditions of the adjacent Massachusetts Bay.

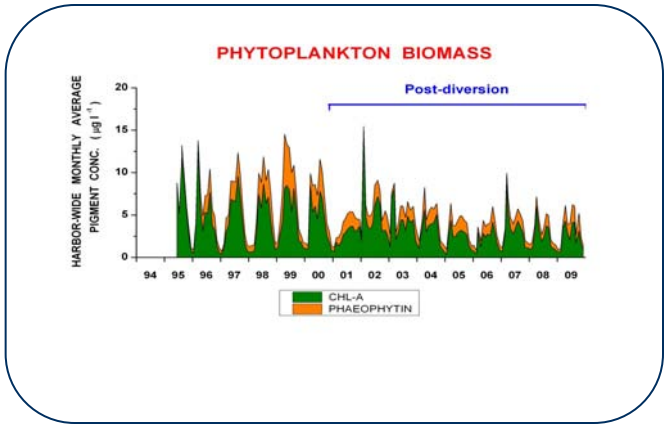


Figure 1.1. The amount of algal growth in Boston Harbor since the wastewater was diverted offshore.

Water Quality: Sewage effluent can contain a large amount of nitrogen and other nutrients, which in some situations can cause excess algal growth. Algal growth can be estimated by measuring the level of their pigments in the water column. Figure 1.1 shows the amounts of two pigments used to indicate the level of phytoplankton (chlorophyll and phaeophytin) found in the harbor from 1995 through 2009. Since 2000, the year the discharges to the harbor were ended, the amounts of algae in the harbor, especially during summer months, has decreased.

Dissolved oxygen (DO) is another key indicator of environmental health and water quality. Low DO indicates the presence of excessive amounts of organic matter, like sewage, and can result in localized zones

in the water column that are unable to support aquatic life. Figure 1.2 shows the average level of DO in Boston Harbor's bottom waters. Since the MWRA discharge was diverted offshore, bottom water DO in the summer has increased by about 0.5 milligrams per liter (mg/L), and is consistently well above the state standard of 6.0 mg/L. Further, water clarity, as measured by the depth where a Secchi disc remains just visible, has increased since the outfall was diverted from the Harbor to Massachusetts Bay.

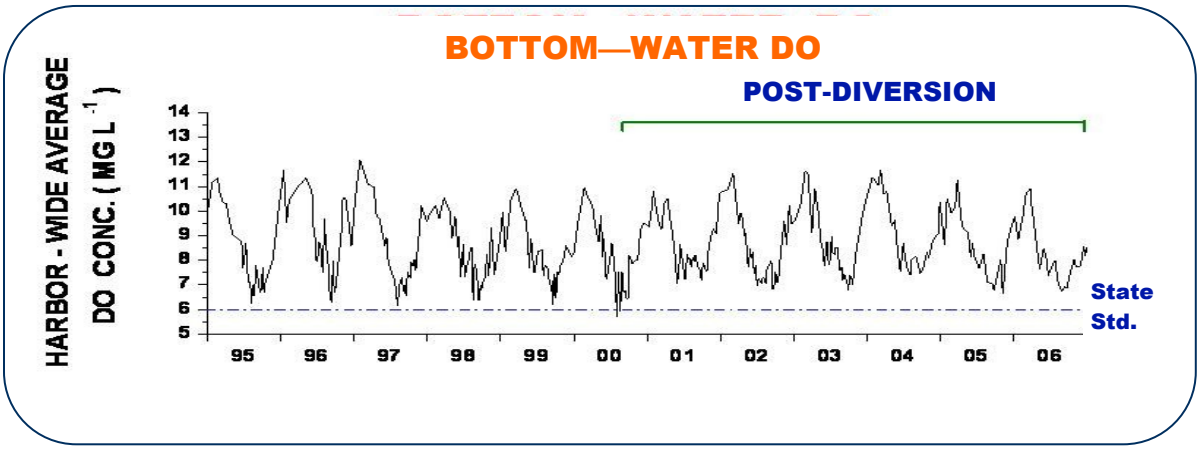


Figure 1.2. Bottom water dissolved oxygen (DO) levels during the most stressed period, summer, have increased by about 0.5 milligrams per liter since the discharge was diverted. After diversion, the average "lows" are consistently well above 6 milligrams per liter.

Habitat: In studying the response of Boston Harbor to the increasingly improved control of sewage discharges, one of the most encouraging stories is found in the animals dwelling in its sediments. The mollusks, worms, and crustaceans, called the benthic infauna, play a critical role in marine ecosystems by serving as a food source for other organisms, stabilizing and aerating sediments, and recycling nutrients and organic matter. Benthic infauna are particularly susceptible to pollution impacts because of their sedentary nature. Measures such as abundance of animals, species diversity, and the types of organisms present can all be used as indicators of ecosystem health.

Monitoring of benthic infauna in Boston Harbor indicates significant improvement over time (Table 1.1). Benthic species that had been mostly absent from the harbor have recently been observed recolonizing the harbor seafloor. Another indicator of improving conditions is the increase in the total number of species found in the harbor over time (Figure 1.3). Additional species not seen during previous years' monitoring are now being found every year. When recovery has stabilized, it is expected that new species would be observed only occasionally.

MWRA also looks at sediment oxygen demand (SOD), a measure of biological activity in the sediment. Very high SOD generally indicates too much organic matter. As bacterial decay occurs, oxygen is used up. During the time period that wastewater was discharged to the harbor, the SOD in the harbor was high (See the top bar in Figure 1.4). Since the wastewater discharges were ended, SOD in the harbor is lower, and this is viewed as another improvement. However, scientists monitoring the harbor have noted that in extremely

impacted environments, the SOD increased as more organisms began to migrate into an improving area. In newly recolonized areas, the SOD can actually increase, as benthic infauna stimulate and accelerate microbial activity and organic degradation. Eventually the excess organic matter is used up, and the sediments return to a natural, relatively low SOD. In 2007 an area of the harbor previously devoid of organisms was noted to have numerous worms and other animals present and a relatively high SOD.

Table 1.1. Changes in benthic animal community measures in Boston Harbor over time show a strong movement toward increased diversity and immigration of species associated with clean waters into the harbor. (Source: James Blake and Nancy Maciolek, AECOM Corp.).

Parameter	Period		
	1991 – 1998 Harbor discharge, before secondary treatment	1999 – 2000 Centralized harbor discharge and initiation of secondary treatment	2001 – 2005 End of discharge within Boston Harbor
Number of Samples	192	47	120
Number of Species	32. 3 ± 14.3	32. 0 ± 12.5	42.3 ± 18.0
Fauna	Higher abundances of opportunistic species such as *Streblospio benedicti* and *Polydora comuta*	Transitional →	Few opportunists, more oligochaetes, some species more typical of Massachusetts Bay

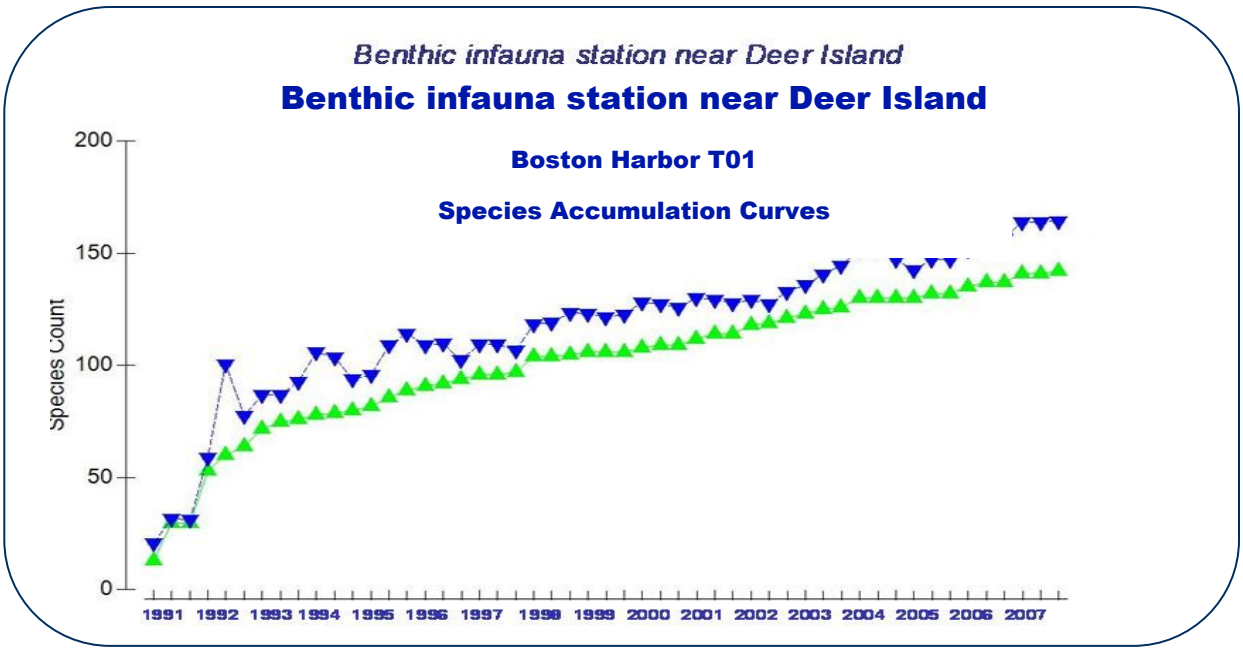


Figure 1.3. Every year since monitoring began in 1991, additional species have been observed in Boston Harbor sediments indicating continuous recovery. Green triangles are number of species observed in a sample, blue triangles represent a statistical predictor of species abundance. (Source: James Blake,

In 2008, a new area of eelgrass was discovered in Boston Harbor near the airport (See Question 8, Eelgrass Habitat). Figure 1.5 provides a schematic depicting the concept of recovery from eutrophication. The MA Division of Marine Fisheries (*MarineFisheries*) has successfully planted eelgrass on the west side of Long Island and on the southwest side of Peddocks Island within Boston Harbor.

Based on water quality criteria and hydrography, *MarineFisheries* identified several sites in Boston Harbor that now meet eelgrass habitat suitability criteria in places where sediments were probably too rich in organic matter, most likely the result of 200 years of waste mismanagement in the harbor. Considering Boston Harbor sites for eelgrass bed restoration would not have been possible 10 years ago. Thus, the decrease in the amounts of algae, the increase in bottom-water dissolved oxygen, and eelgrass recolonization in the harbor, all point to a reversal of the historic trend of over-enrichment of the harbor.

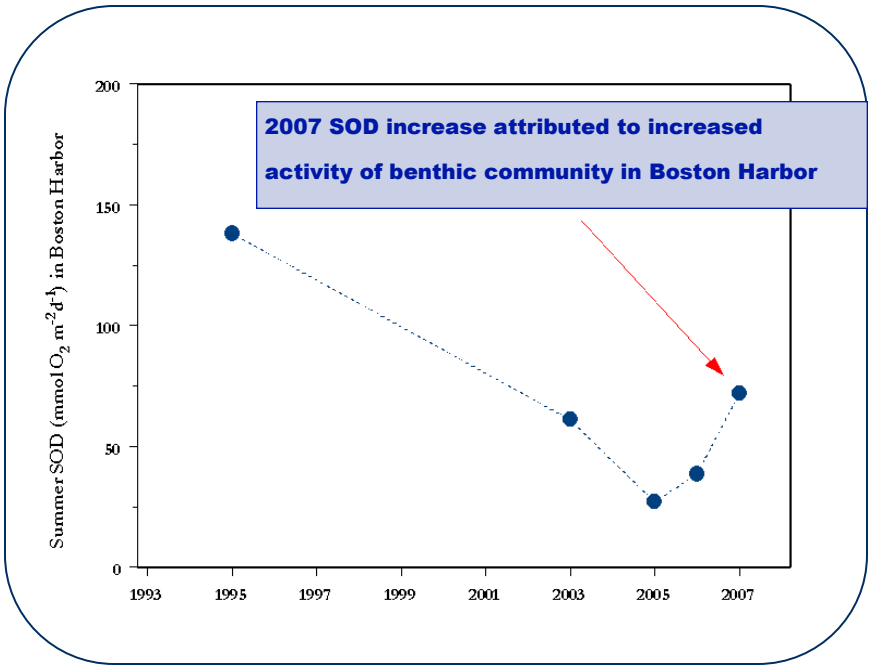


Figure 1.4. Changes in Sediment Oxygen Demand (SOD) in Boston Harbor from monitoring data by MWRA for the period of 1993—2007. In 2007, SOD increased, but scientists do not view this as degradation, rather it may signal another step toward recovery of a previously barren locations in the inner harbor. (Source: Jane Tucker, Marine Biological Laboratory, Woods Hole).

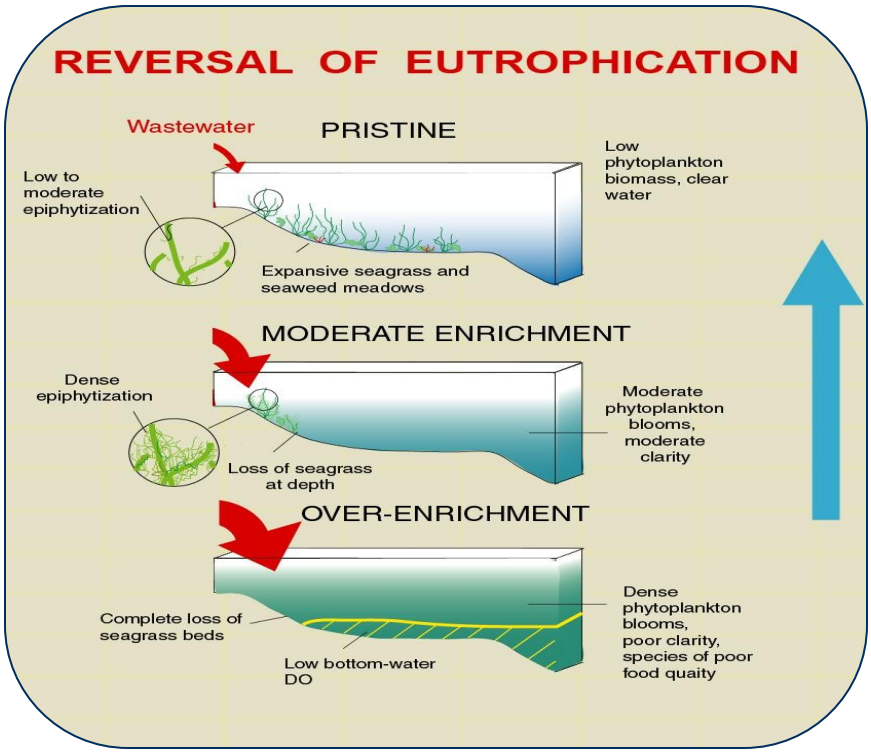


Figure 1.5. Boston Harbor may be a rare example of reversal of eutrophication.

MUNICIPAL WASTEWATER IN THE BAYS

Q2 What are the impacts of the MWRA discharge to Massachusetts and Cape Cod Bays?

Contributor: Wendy Leo, Massachusetts Water Resources Authority

Why this is Important

As indicated in the previous section, the Massachusetts Water Resources Authority (MWRA) stopped discharging all treated sewage generated in the Metropolitan Boston area into Boston Harbor in 2000. Sewage is now diverted to the Deer Island sewage treatment plant and treated wastewater effluent is discharged nine miles offshore in Massachusetts Bay. Advances in the level of treatment, combined with discharging further offshore are measures implemented to improve environmental conditions of Boston Harbor while minimizing the impacts to Massachusetts and Cape Cod Bays.

State of the Bay

In order to better understand water quality variability and provide a baseline for comparing environmental data gathered since the outfall began discharging in Massachusetts Bay, extensive monitoring by the MWRA began in 1992, prior to the major changes in wastewater discharge management.(Figure 2.1). This monitoring, which is required by U.S. Environment Protection Agency (EPA), includes characterizing the discharged sewage effluent as well as the Massachusetts Bay receiving waters. MWRA's monitoring focuses on potential impacts of nutrients, organic material, toxic contaminants, pathogens, and solids.

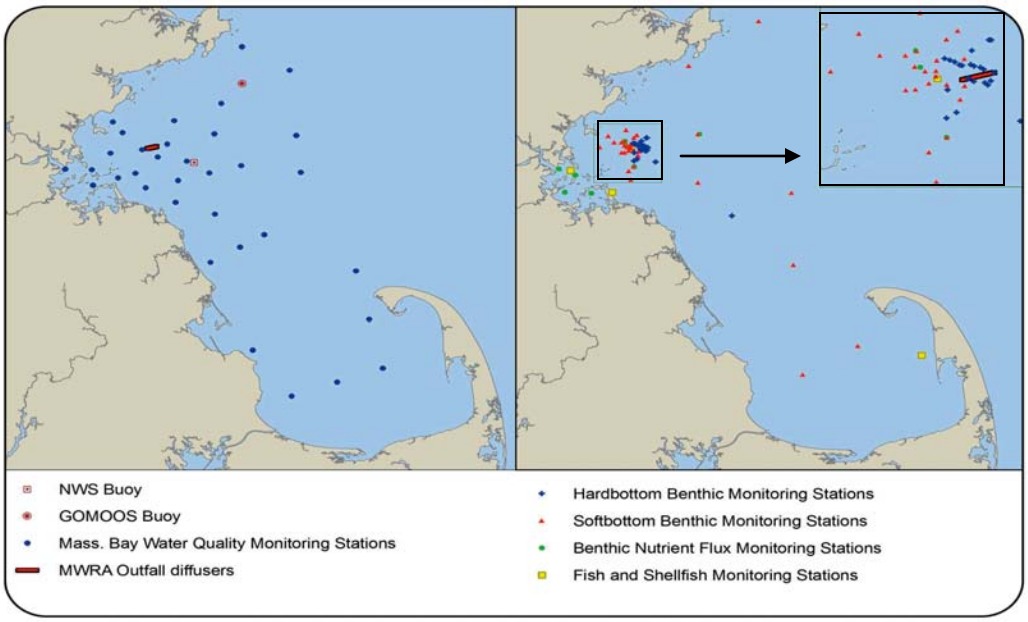


Figure 2.1. Map of outfall location, long-term monitoring buoys, and MWRA monitoring stations. NWS = National Weather Service; GoMOOS = Gulf of Maine Ocean Observing System.

***Wastewater Quality*:** The Deer Island Treatment Plant reliably meets its National Pollution Elimination Discharge System (NPDES) permit requirements. However, from the time that the permit became effective in August 2000, some of the threshold levels established by the NPDES permit were exceeded. In 2009, MWRA reported a cumulative total of 12 NPDES violations (5 of which were due to exceeding toxicity standards) out of thousands of required tests since the NPDES permit was issued in 2000. Since July 2007 there have been no permit violations. In addition to the treatment standards, the MWRA permit has an additional safeguard in that adequate and rapid dilution of the wastewater occurs at the outfall site. The amount of solids, organic material, and toxic contaminants in the effluent has decreased substantially, and has remained consistently low since implementing more stringent influent requirements and initiating modern treatment at the Deer Island Treatment Plant. Discharges of solids and metals from the MWRA wastewater treatment facility are shown in Figures. 2.2 and 2.3, respectively.

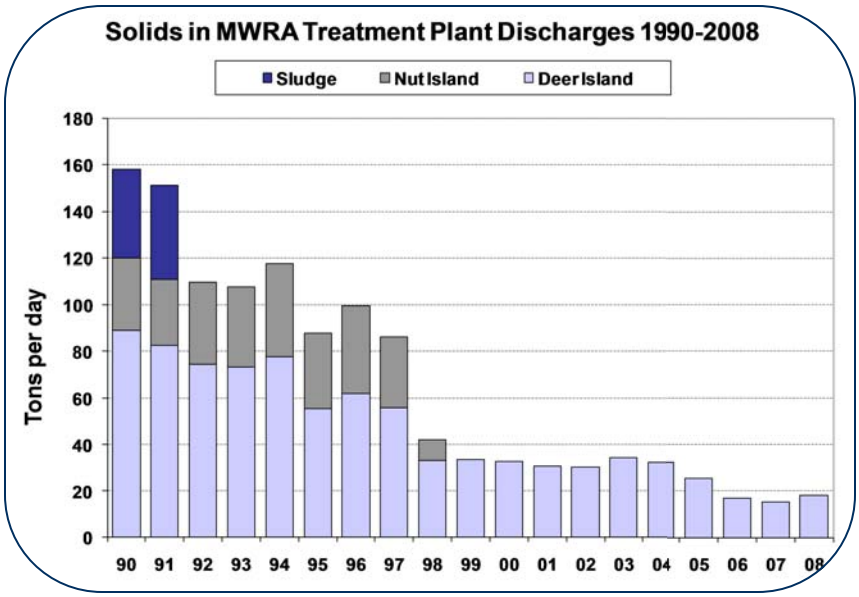


Figure 2.2. Annual solids (tons per day) 1990-2008. Note: Sludge discharge from Boston Municipal waste treatment ends by 1992. The Nut Island discharge was transferred via pipe to the Dear Island facility by 1999.

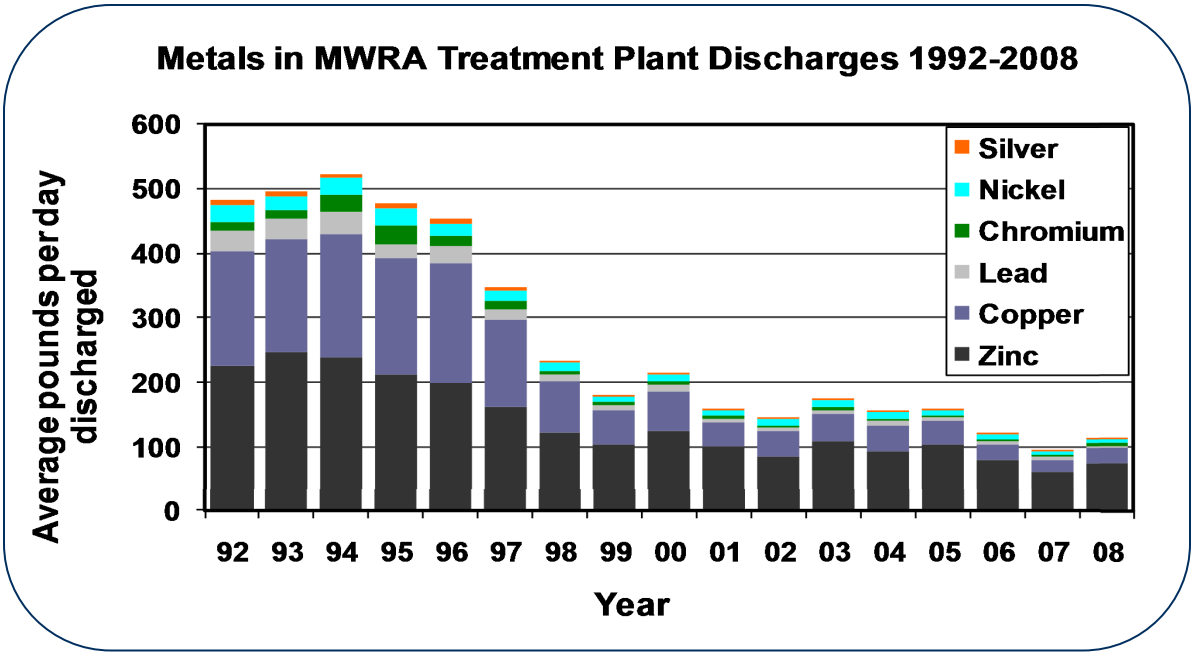


Figure 2.3. Annual volume of metals (pounds per day) discharged between 1991-2008.

***Water Quality*:** The outfall was designed to provide adequate initial dilution to ensure that levels of chemical and microbial contaminants meet water quality standards. Most contaminants actually meet standards as the effluent leaves the treatment plant, even before dilution.

Because the discharged effluent is rich in nutrients, MWRA monitors key water quality indicators of possible nutrient-related ecosystem changes. Slightly elevated ammonium levels near the outfall are observed and are attributed directly to the outfall discharge. Dissolved oxygen in bottom waters near the outfall and in the deep Stellwagen Basin nearby shows no change from pre-diversion conditions. Chlorophyll concentrations throughout the Bays have tended to be higher in the spring and lower in the fall since 2000. Changes in chlorophyll levels are the result of large scale Gulf of Maine phytoplankton dynamics and are not attributed to the outfall discharge. There are year-to-year changes in the phytoplankton production and zooplankton communities, but these changes have been within pre-discharge ranges, and no adverse effects of the outfall nutrients have been observed.

There have been two notable changes in the phytoplankton community in recent years, but both are regional phenomena with no apparent relation to the outfall discharge. The nuisance alga *Phaeocystis pouchettii* has changed from only occasionally dominating the spring bloom community, to doing so in nearly every year, probably due to larger scale factors like those associated with climate change. The organism causing paralytic shellfish poisoning (red tide) in the Gulf of Maine, *Alexandrium fundyense,* typically blooms at levels high enough to close shellfish beds every year along the Maine coastline. Red tide in Massachusetts Bay had been seen only at very low levels from 1993-2004. However, in 2005, 2006, and 2008, red tide blooms originating off the coast of Maine were transported into Massachusetts Bay causing extensive shellfish bed closures (See Question 3, Harmful Algal Blooms).

Fish & Shellfish: With several years of monitoring data before and after outfall discharge began, MWRA examined whether there have been changes in contaminant levels in fish and shellfish tissues due to the outfall. Tests conducted on flounder and lobster tissue showed no statistically significant increase in any contaminant levels after outfall diversion. For mussels placed within the mixing zone of the outfall, there were measurable increases in several organic contaminants. However, the concentrations in the mussels remained well below levels of concern to human health.

Flounder liver disease remains low at the outfall site and elsewhere in Massachusetts and Cape Cod Bays. Skin ulcers were first detected on flounder in 2003 throughout western Massachusetts Bay and Boston Harbor. After peaking in 2004, the levels of ulcers occurring in flounder have been declining, and there is no evidence of an outfall connection.

Sea Floor: Because organic material and toxic contaminants accumulate in quiescent areas of the sea floor, the sediments and bottom-dwelling organisms can be affected by sewage discharges. Sophisticated statistical analyses have also been applied to seafloor measurements of contaminants, organic carbon, soft-bottom dwelling communities, and the sewage tracer bacterium *Clostridium perfringens*. The only clear outfall association detected is a localized increase in *C. perfringens*, indicating that sewage-derived solid material is

indeed settling to the sea floor near the outfall, but there is no known effect of contamination on the seafloor ecosystem. There are natural year-to-year changes in biodiversity (Figure 2.4) but these are similar near the outfall and at more distant. The MWRA monitoring has also shown that oxygen penetrates the sediment as deeply as before and that measured sediment oxygen demand has remained low, similar to that measured in other healthy bays.

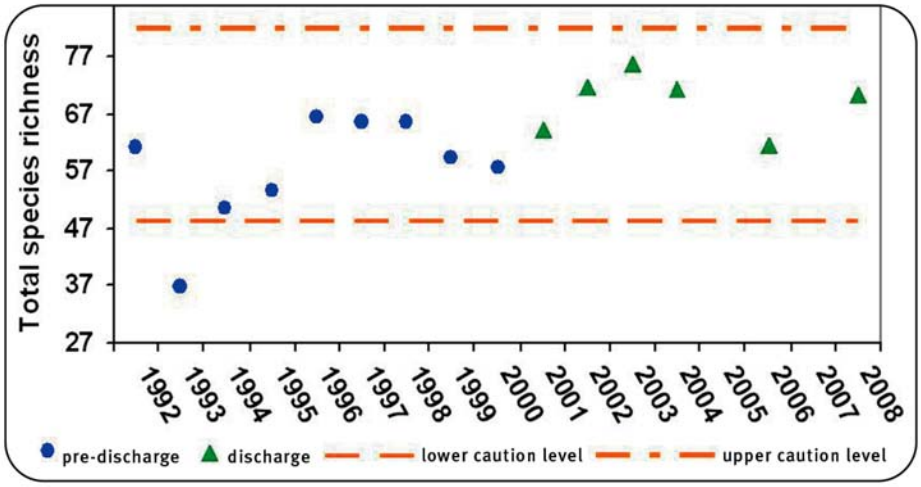
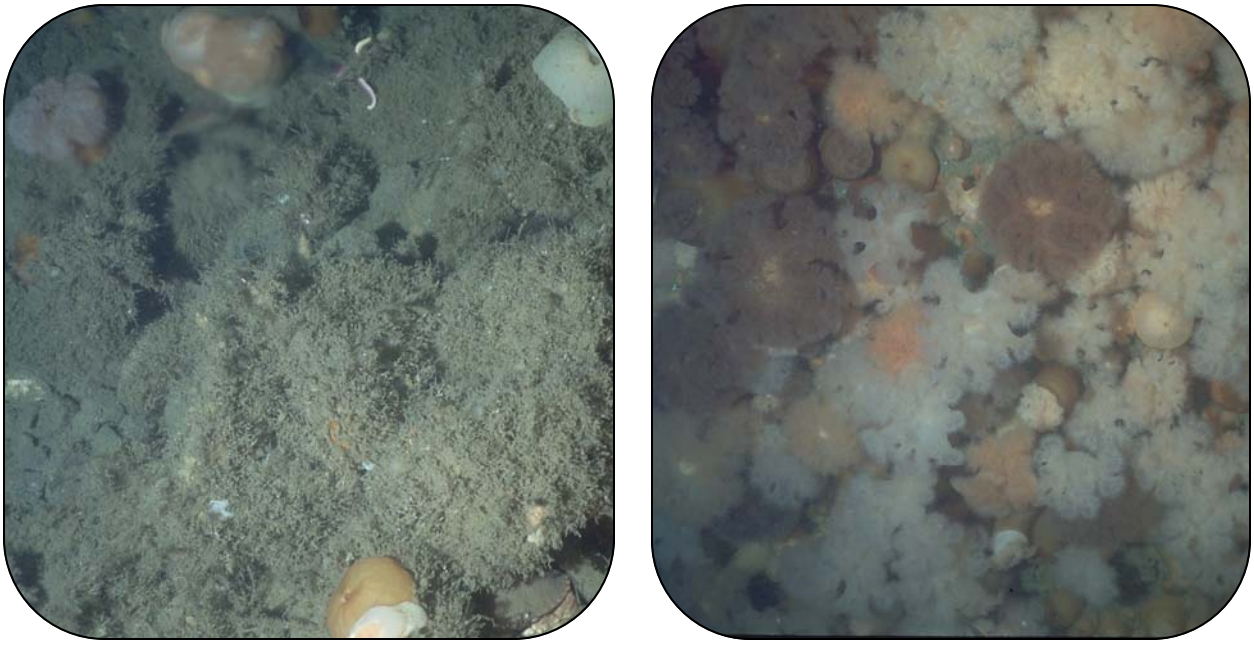


Figure 2.4. Benthic species richness has varied only within expected limits (dashed orange lines) near the outfall since the diversion in 2000.

Communities of organisms dwelling on and among the rocks near the outfall have remained relatively stable from 1996 to 2008. Semi-quantitative monitoring by MWRA has shown some subtle shifts in community structure over time, but post-discharge changes have been modest, and lush growth continues on the outfall riser caps (Figure 2.5).



Photos: Maciolek et al, 2009

Figure 2.5. Photographs taken in 2008 showing colonization of encrusting taxa and the sea anemone *Metridium senile* (left) on the head of an active diffuser.

Q3 What conditions contribute to harmful algal blooms in Massachusetts Bay?

Contributors: Donald Anderson, Woods Hole Oceanographic Institution, and Scott Libby, Battelle Memorial Institute

Why this is important

Prior the early 1970's, paralytic shellfish poisoning (PSP) toxicity was restricted to the far eastern sections of Maine near the Canadian border. However in 1972, a massive, visible red tide of *Alexandrium fundyense*, a major cause of PSP, stretched from southern Maine through New Hampshire and into Massachusetts, causing toxicity in the southern Gulf of Maine for the first time in recorded history. A potent neurotoxins (chemicals that have negative impacts on the nervous system) called saxitoxin produced by *A. fundyense* are accumulated by filter feeding shellfish and are passed on to humans and animals that consume them, leading to illness, incapacitation, and even death.

Since the 1972 outbreak, the western Gulf of Maine has experienced PSP outbreaks on an annual basis. Frequent outbreaks were observed in Massachusetts waters as well through the early 1990s (Figure 3.1). Then, after more than a decade of limited recurrence in Massachusetts Bay, a large bloom again appeared along the Massachusetts coast in 2005. Three of the last five years had significant blooms, raising questions about the cause and predictability of red tides.

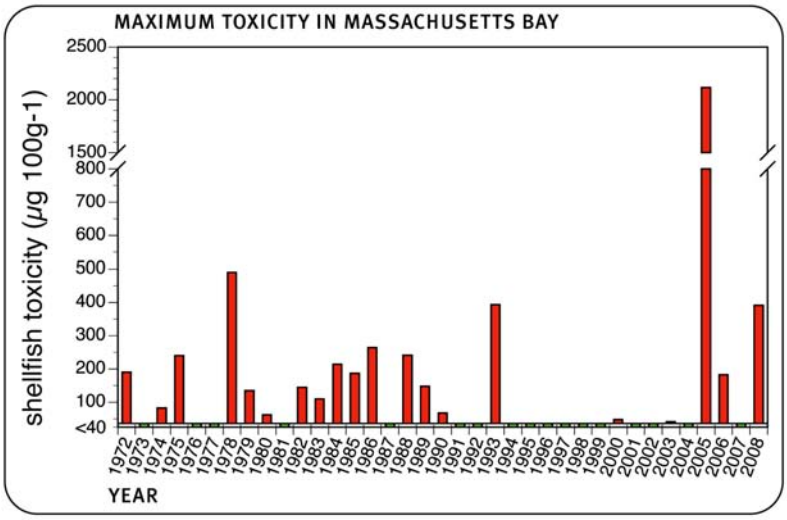


Figure 3.1. Maximum levels of PSP toxicity in Massachusetts Bay, 1972- 2009. Units are µg saxitoxin per 100 g shellfish tissue.

State of the Bay

Current research on *Alexandrium* blooms that affect Massachusetts Bay suggests that they originate off the mid-coast of Maine and are transported southward with the western segment of the Maine coastal current (Figure 3.2). Fresh water runoff from rivers draining into the Gulf of Maine and localized wind patterns are important factors that contribute to the nature of the Maine coastal current. The blooms may enter Massachusetts Bay under suitable conditions – when a bloom passing off Cape Ann in the western

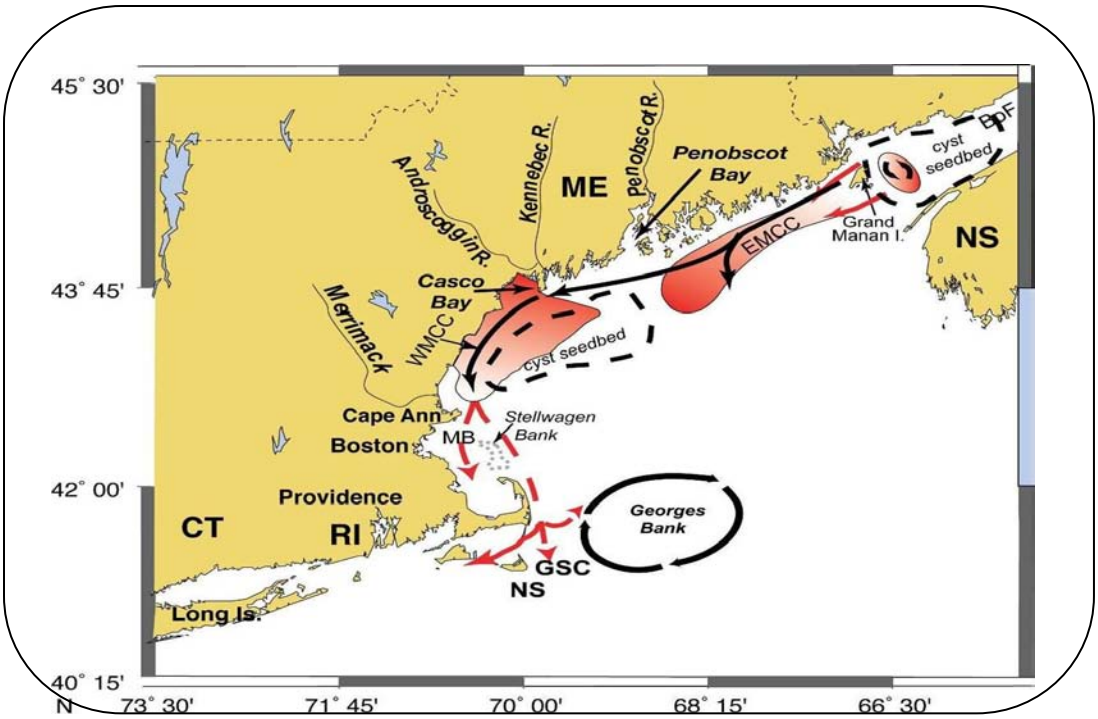


Figure 3.2. Conceptual model of *Alexandrium* bloom dynamics and PSP toxicity. Shown in solid black lines are the eastern Maine coastal current (EMCC) and western Maine coastal current (WMCC) systems, and in dashed black lines the cyst seedbeds in the Bay of Fundy (BoF) and mid-coast Maine. The red shaded zones show areas where *Alexandrium* vegetative cells accumulate at higher concentrations relative to adjacent waters. Red dashed lines show the delivery or transport pathways of these established bloom populations to southern waters. GSC = Great South Channel; NS = Nantucket Shoals; MB = Massachusetts Bay.

Maine coastal current is blown shoreward into northern Massachusetts Bay by sustained northeast winds. In addition to weather patterns, life history characteristics of *Alexandrium* likely influence the recurrence of red tides in Massachusetts. For approximately three months in 2005, a massive bloom of *Alexandrium* invaded Massachusetts Bay (Figure 3.3). This outbreak was the largest since the 1972 event, and ultimately resulted in shellfish harvesting closures that extended from eastern Maine through Massachusetts to its offshore islands of Martha's Vineyard and Nantucket (Figure 3.4). Three primary factors were cited as contributing to the extraordinary 2005 bloom: strong northeast winds, very high river flow, and abundant over-wintering *Alexandrium* reproductive cysts. Numerical model sensitivity tests showed that cysts were the most important factor causing the Gulf-wide bloom. The high abundance of cysts in western Gulf of Maine sediments provided a large vegetative cell source for the bloom, though the source of those cysts is not well documented. Given the abundant cysts, the model simulation showed a substantial Gulf-wide bloom whether or not 2005's unusual river flow and winds were taken into account.

In the five years since the 2005 bloom, there have been relatively large *Alexandrium* blooms in the western Gulf of Maine. Prevailing winds (Nor'easters in May) have been such that in 2006, 2008, and 2009, substantial PSP toxicity was present in the bays (Figures 3.2 and 3.4). In 2007, there were no strong northeasterly winds and the bloom stayed offshore.

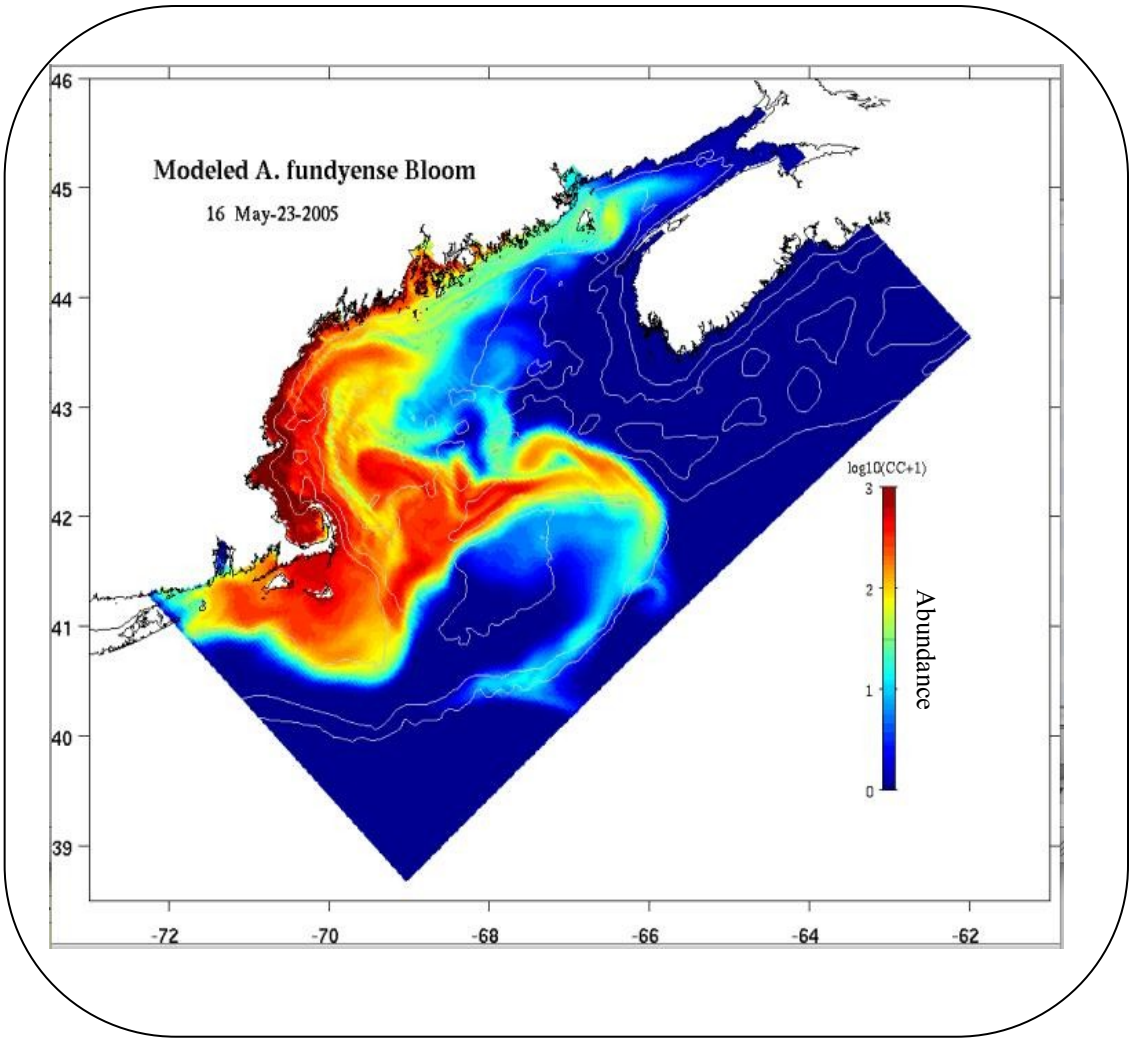


Figure 3.3. Abundance of *Alexandrium fundyense* in the Gulf of Maine as estimated by the WHOI model for May 23, 2005.

From the cyst abundance patterns, and the long term pattern of shellfish toxicity, it appears that we have entered an era of frequent red tide bloom events in the western Gulf of Maine. In effect, the 2005 red tide, and the factors that led to the high cyst abundance in 2004, have "reset" the system. Conditions now resemble those after the 1972 outbreak, which was followed by several decades of high and frequent toxicity in the western Gulf of Maine. Fortunately, cyst levels in Massachusetts Bay remain low and the occurrence of *Alexandrium* blooms in these waters still depends upon meteorological conditions conducive to drawing the western Gulf of Maine coastal waters into the Bay. It is anticipated that Massachusetts Bay will continue to see frequent PSP toxicity closures over the next decade or two, similar to those in the 70s and 80s.

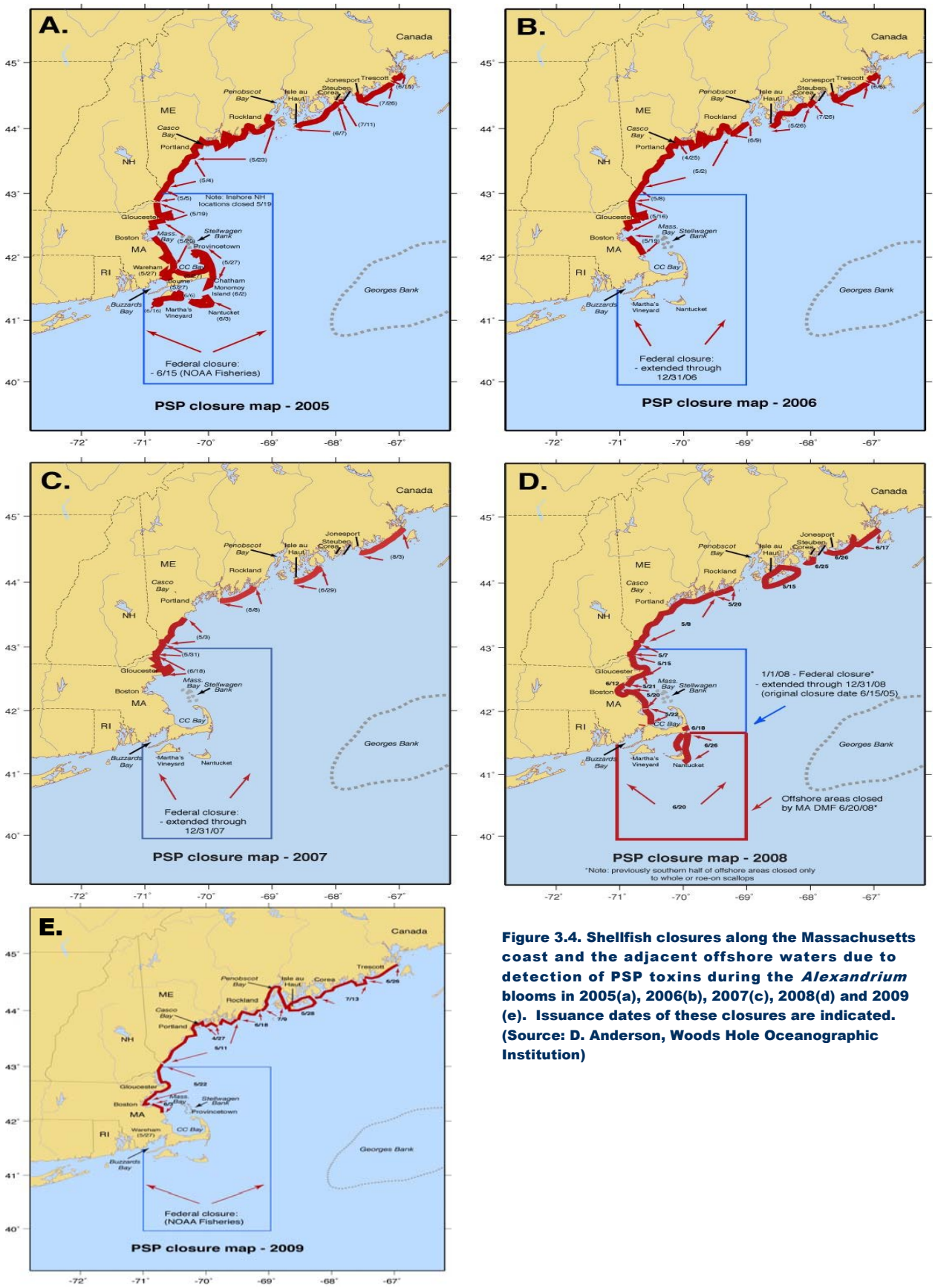


Figure 3.4. Shellfish closures along the Massachusetts coast and the adjacent offshore waters due to detection of PSP toxins during the *Alexandrium* blooms in 2005(a), 2006(b), 2007(c), 2008(d) and 2009 (e). Issuance dates of these closures are indicated. (Source: D. Anderson, Woods Hole Oceanographic Institution)

Q4 What levels of contaminants have been found in blue mussels in the Massachusetts and Cape Cod Bay regions?

Contributor: Christian Krahforst, Massachusetts Bays Program

Why this is important

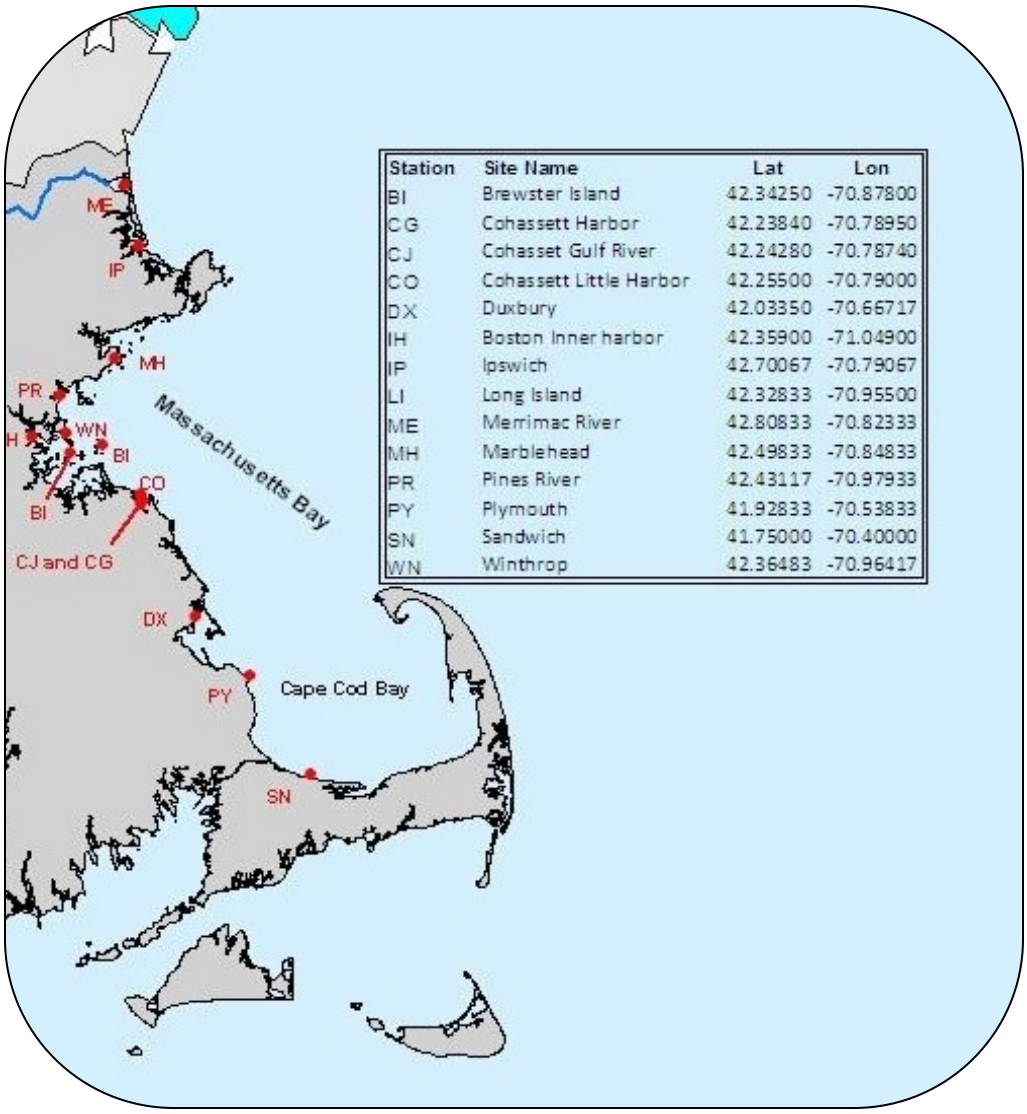
Coastal waters nation-wide continue to face the threat of degradation in spite of efforts to improve resource management. Degradation of coastal waters is due, in part, to the continued release of contaminants such as metals, pesticides, and organic pollutants that result from human activities and the legacy of pollution in coastal watersheds. Contaminants from sewage and industrial discharge, stormwater runoff, atmospheric deposition, and other sources of pollution pose hazards to fish, wildlife, and humans when concentrations reach excessive levels. The actual threat posed by contaminants depends on the level of contamination, the sensitivity of resident organisms, and long-term environmental fate and persistence of the pollutants.

One method used to assess the importance of contaminants in both aquatic and terrestrial systems is to measure the accumulation of pollutants in resident organisms. The blue mussel, *Mytilus edulis,* is particularly useful for these types of assessments because it is an abundant, immobile, resident organism in the Gulf of Maine (GOM) that is relatively easy to collect. In partnership with the GOM Council on the Marine Environment, the Massachusetts Bays Program (MBP) has helped monitor contaminant levels in blue mussels since 2003 through the Gulfwatch program. While statistically valid conclusions are still difficult to draw because of the relatively small sample size to date, spatial and temporal trends in contaminant levels are beginning to emerge in the MBP planning area and throughout the region.

State of the Bay

Since 1993, Gulfwatch program scientists and volunteers have been collecting mussels at over 60 stations throughout the GOM. Of these, 14 stations are located along the coast of Massachusetts and Cape Cod Bays (Figure 4.1). Tissue samples from mussels collected at these sites are used to measure the quantity of trace metals and important classes of organic contaminants such as DDT, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) that have accumulated in the tissues of *M. edulis* (Table 4.1). Results can be compared regionally within Massachusetts Bay and the Gulf of Maine as well as nationally with parallel assessments conducted by the National Oceanic and Atmospheric Administration's (NOAA) Mussel Watch Program.

As observed in the 2004 State of the Bays report, concentrations of contaminants in mussels tended to be



Station	Site Name	Lat	Lon
BI	Brewster Island	42.34250	-70.87800
CG	Cohassett Harbor	42.23840	-70.78950
CJ	Cohasset Gulf River	42.24280	-70.78740
CO	Cohassett Little Harbor	42.25500	-70.79000
DX	Duxbury	42.03350	-70.66717
IH	Boston Inner harbor	42.35900	-71.04900
IP	Ipswich	42.70067	-70.79067
LI	Long Island	42.32833	-70.95500
ME	Merrimac River	42.80833	-70.82333
MH	Marblehead	42.49833	-70.84833
PR	Pines River	42.43117	-70.97933
PY	Plymouth	41.92833	-70.53833
SN	Sandwich	41.75000	-70.40000
WN	Winthrop	42.36483	-70.96417

Figure 4.1. Contaminant monitoring sites in the Massachusetts Bays region where blue mussels (*Mytilus edulis*) are collected.

higher in the southwestern portion of the GOM where coastal watersheds are more industrialized, and locally in areas near or adjacent to urban centers along the coast. Many of the contaminants monitored by Gulfwatch are found to be in greater concentration in mussels collected in Massachusetts waters. Notable exceptions are mercury and PAHs, which are equal or higher at locations within the Great Bay Estuary of New Hampshire. A site in Boston Harbor still shows the highest concentrations of many of the monitored contaminants when compared to all the Gulfwatch monitoring sites. Except for lead in Boston Harbor, no contaminant concentrations in mussels collected from coastal Massachusetts exceeded the U.S. Food and Drug Administration federal standards for human consumption.

INORGANIC CONTAMINANTS:

Ag (silver), Al (aluminum), Cd (cadmium), Cr (chromium), Cu (copper), Fe (Iron), Hg (mercury), Ni (Nickel), Pb (lead), Zn (zinc)

ORGANIC CONTAMINANTS:

Aromatic Hydrocarbons(ΣPAH_{24})	***Chlorinated Pesticides($\Sigma PEST_{21}$)***
Naphthalene	Hexachlorobenzene (HCB)
1-Methylnaphthalene	γ-Hexachlorocyclohexane (γ-HCH)
2-Methylnaphthalene	α-Hexachlorocyclohexane (α-HCH)
Biphenyl	Heptachlor
2,6-Dimethylnaphthalene	Heptachlor epoxide
Acenaphthylene	Aldrin
Acenaphthalene	cis-Chlordane
2,3,5-Trimethylnaphthalene	γ-Chlordane
Fluorene	trans-Nonachlor
Phenanthrene	Dieldrin
Anthracene	α-Endosulfan
1-Methylphenanthrene	β-Endosulfan
Fluoranthene	Endrin
Pyrene	Metoxychlor
Benz [a] anthracene	Mirex
Chrysene	***DDT and Homologues (incl. in $\Sigma PEST_{21}$)***
Benzo [b] fluoranthene	2,4'-DDE 4,4'-DDE
Benzo [k] fluoranthene	2,4'-DDD 4,4'-DDD
Benzo [e] pyrene	2,4'-DDT 4,4'-DDT
Benzo [a] pyrene	***PCB Congeners (ΣPCB_{24})***
Perylene	PCB 8+5, PCB 18+15, PCB 28, PCB 29,PCB 44, PCB 50, PCB 52, PCB 66+95,PCB 77, PCB 87, PCB 101+90, PCB 105, PCB 118, PCB 126, PCB 128, PCB 138, PCB 153+132, PCB 169, PCB 170+190, PCB 180, PCB 187, PCB 195+208, PCB 206, PCB 209
Indeno [1,2,3-cd] pyrene	
Dibenz [a,h] anthracene	
Benzo [g,h,I] perylene	

Table 4.1. Inorganic and organic compounds analyzed by the Gulfwatch Program in mussel tissue collected from sites in the nearshore coastal region of the Gulf of Maine.

Temporal Trends

Only two of the Gulfwatch stations in Massachusetts coastal waters, the lower Merrimack Estuary and Town Beach in Sandwich, have been sampled enough times (i.e., greater than 5 individual years) where confidence can be placed in observed trends. For the Merrimack Estuary, chromium concentrations (Figure 4.2) have significantly decreased during the Gulfwatch monitoring period, probably the result of the reduction in paper mills and tanning industries over the last century. Silver concentrations in mussels collected at the Sandwich site have also decreased since 1993, possibly due to improved wastewater treatment, both in terms of contaminant reduction within waste streams and the relocation of the Boston municipal outfall site from Boston Harbor to further offshore into Massachusetts Bay (See Questions 1 & 2, MWRA discharge).

No other significant trends were observed for monitored contaminants in Massachusetts Bay. Some other Massachusetts stations indicate possible trends, however they have not been sampled frequently enough to provide the basis for statistically significant trends analyses.

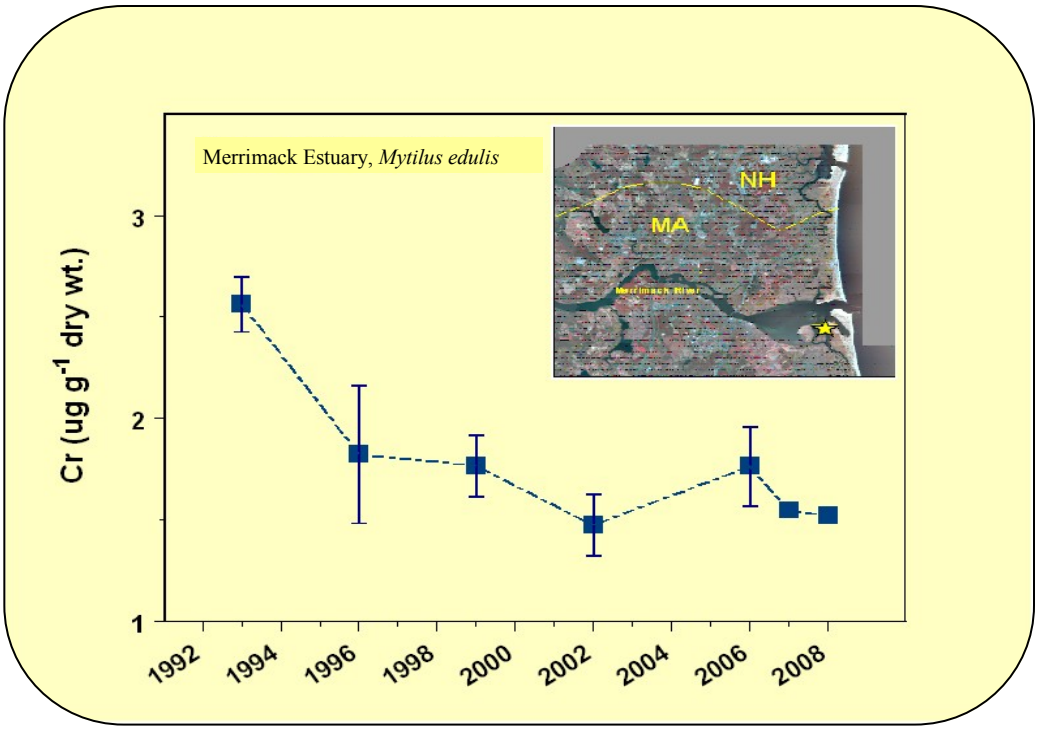


Figure 4.2. Chromium (Cr) found in mussel tissue collected in the lower Merrimack Estuary, 1993 –2008. (Error bars represent one standard deviation of replicate analyses). Data source: GOMC Gulfwatch Program.

Spatial Trends

In order to provide a contemporary view of contaminant exposure, changes in contaminants accumulated in the soft tissue of mussels across the GOM region were evaluated using the median of annual values from the Gulfwatch data over the period of 2004-2008. The median values for mercury, lead, copper, DDT, PAH, and PCBs in each of the jurisdictions within the GOM region as well as summary values for the United States, are shown in Figure 4.3. Within the GOM, only mercury and lead exceeded the median values reported by the national Mussel Watch Program of NOAA. Both of these contaminants have strong atmospheric sources and may reflect the downwind orientation of the Northeast and the cumulative atmospheric loading of these contaminants from a trajectory that extends to the continental mid-west. For Massachusetts, mercury, lead, DDT, and PCB significantly exceeded the NOAA Mussel Watch national median values for contaminants in mussels. Massachusetts had the highest median values of all the five GOM jurisdictions (Massachusetts, New Hampshire, Maine, New Brunswick, and Nova Scotia) for lead, copper, DDT, and PCB. DDT, a chlorinated pesticide that was used to control mosquitoes and banned in Canada and the U.S. in 1972, still persists in the environment and was most likely more extensively used in Massachusetts compared to the other states along the GOM.

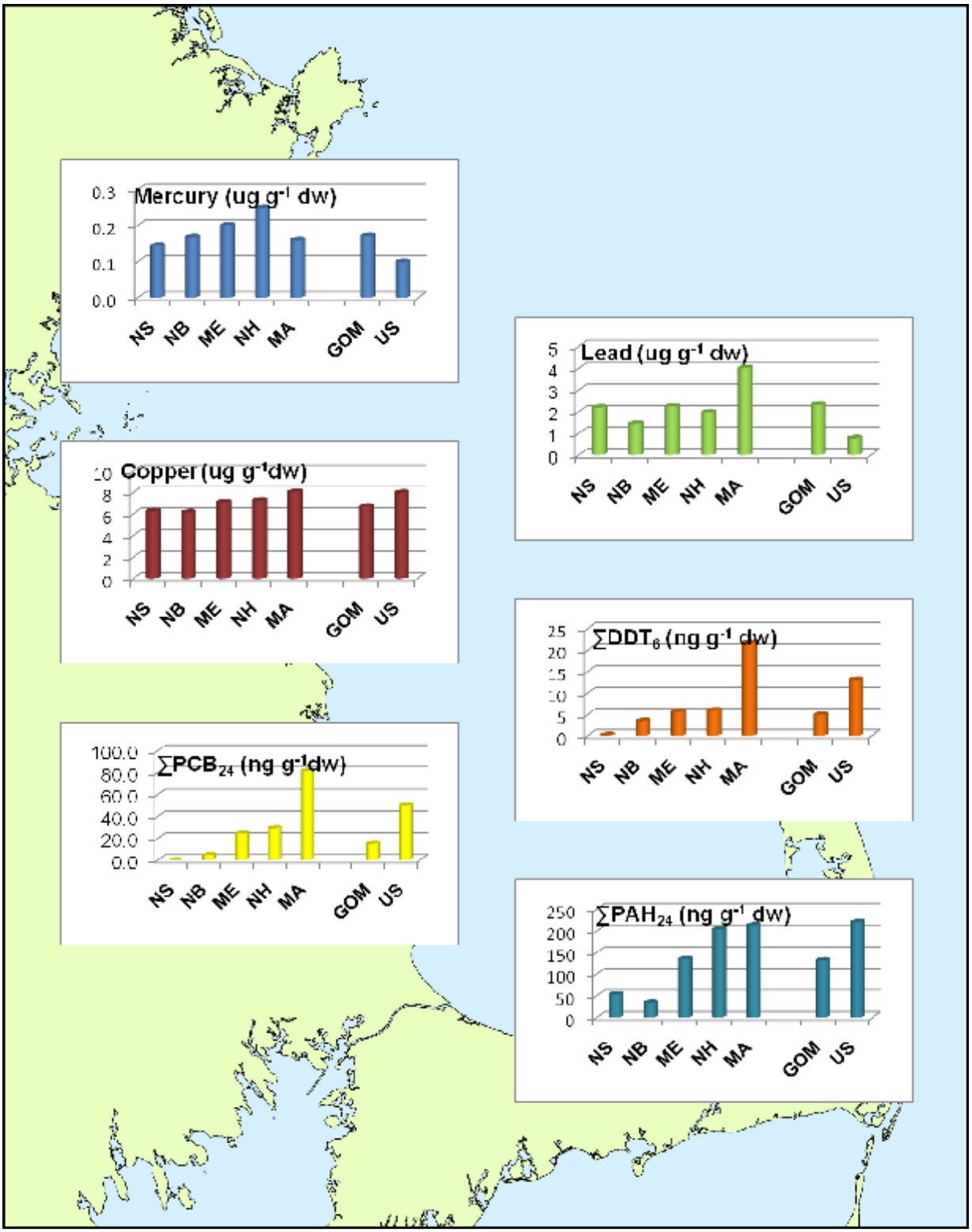


Figure 4.3. Selected contaminants in mussels from the jurisdictions along the Gulf of Maine (GoM): Nova Scotia (NS), New Brunswick (NB), Maine (ME), New Hampshire (NH), and Massachusetts (MA). Averaged data from the National Oceanic and Atmospheric Administration's national monitoring program, Mussel Watch, are shown for comparison (US).

Q5 Is it safer to swim at Massachusetts beaches than it was five years ago?

Contributors: Michael Celona, Massachusetts Department of Public Health, and Matt Liebman, U.S. Environmental Protection Agency

Why this is Important

Beaches, and the recreational opportunities they provide, are clearly an important part of recreation and tourism industry in Massachusetts, the state's economy, and the culture of the Commonwealth. The Massachusetts Bays region boasts excellent and diverse beaches for wading, swimming, surfing, fishing, and boating. Thus it is important that beach water quality meet or exceed standards for pathogens to help protect human health. Pathogens are disease-causing organisms, which are often associated with fecal contamination. Pathogens associated with fecal contamination are one of the major health threats facing people who swim in the coastal waters of the Massachusetts Bays.

One of the main sources of pathogens in our coastal waters is stormwater, which is often discharged near swimming beaches via small coastal streams that drain the surrounding developed areas. Stormwater often carries elevated levels of bacteria. Scientists use certain types of indicator bacteria, such as *Escherichia coli* and *Enterococcus*, to test for the possible presence of pathogens from both human sources (e.g., septic systems and illicit sewer connections) and animal waste (e.g., pets, livestock, waterfowl, and wildlife). In Boston area beaches, combined sewer overflows are also a major source of fecal contamination (see Question 6, Combined Sewer Overflows). People who swim or recreate in fecal-contaminated waters are at increased risk of contracting diseases or illnesses, such as gastroenteritis, hepatitis, and dysentery.

If water quality standards are not met, the public is advised to avoid contact with the waters via signage at the beach or through traditional and electronic news sources. At beaches where bacteria levels exceed water quality standards, communities are required to post notices at access points stating that the water is unsuitable for swimming. The Massachusetts Department of Public Health (DPH) now operates a web site (http://mass.digitalhealthdepartment.com/public_21) that reports water quality data and closure status on a daily basis; data are reported about 24 hours after samples are collected. As a result of increased monitoring and improvements in the quality of monitoring, the number of beach postings and closings has actually increased since the law went into effect. Increased monitoring and improved notification of water quality conditions reduces human contact with contaminated waters.

All Massachusetts coastal beaches are monitored at least weekly for fecal indicator bacteria. The

exception are those beaches that are granted waivers from regular weekly monitoring based on historical water quality data that have met water quality standards and from sanitary surveys that documented no nearby pollution sources

State of the Bay

The amount of rainfall and associated volume of stormwater runoff can significantly contribute to the contamination of coastal waters. The number of beach water closures, or the percent of water quality samples that exceed water quality standards roughly tracks the summer rainfall in coastal Massachusetts (Figure 5.1). For example, in the early summer of 2009, above-average rainfall levels caused a record-breaking number of beach closures in Massachusetts.

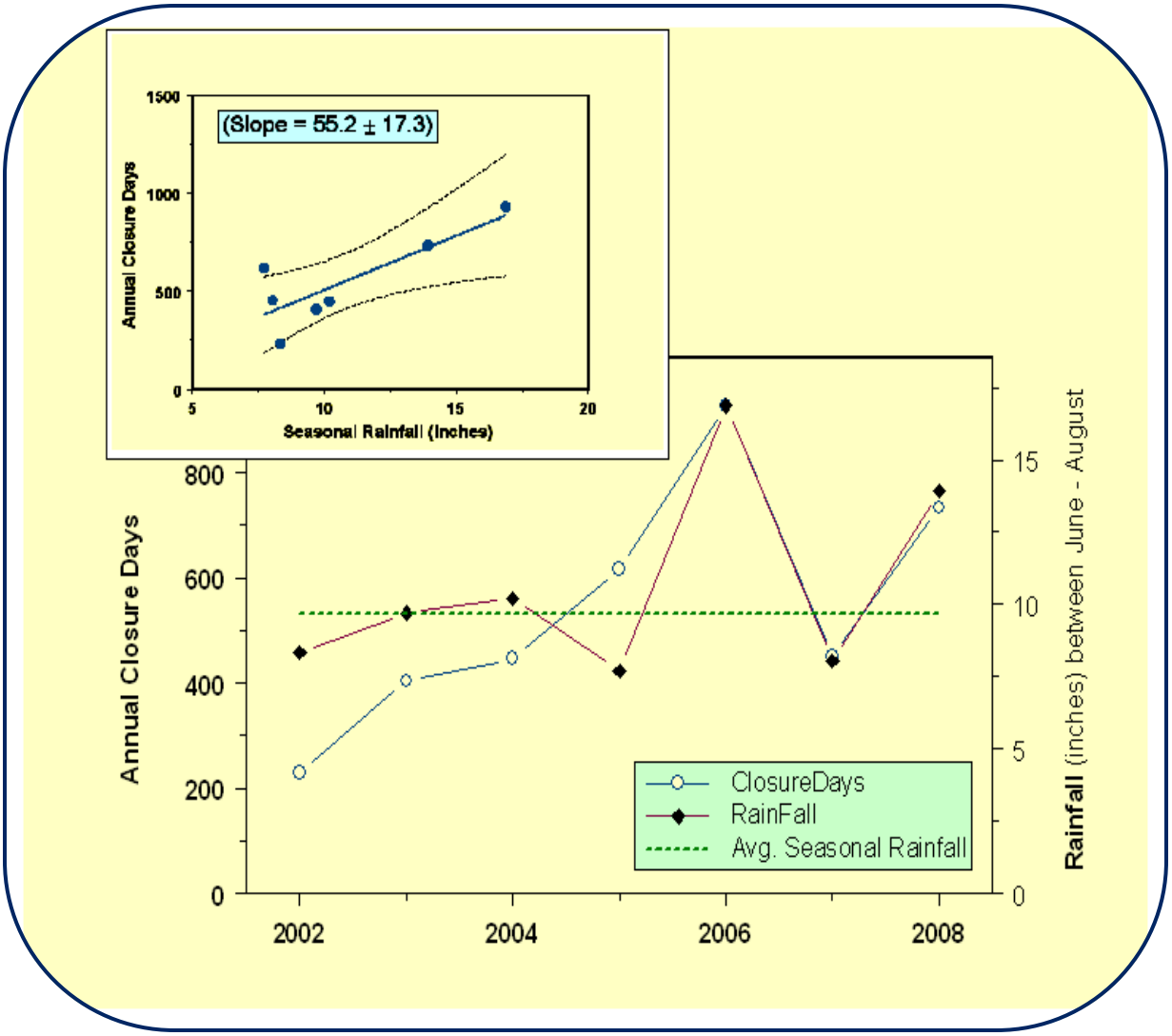


Figure 5.1. The percent of beach monitoring water quality samples in communities bordering Massachusetts and Cape Cod Bays that exceed the bacteria standard associated with summer rainfall as measured at Logan Airport. Graph insert shows the relationship between area closures and seasonal rainfall (r^2 0.67) for beach seasons 2002—2008.

Remediation of stormwater discharges, in turn, can result in reduced bacterial contamination. Some beaches have shown improvements in water quality and, subsequently, reduced beach closures. For instance, the city of Salem's Juniper Beach experienced a reduction in beach water closures after stormwater outfall modification and periodic cleaning prior to the 2006 beach season (Figure 5.2). Annual cleaning of storm drains and remediation efforts by local communities generally reduce the level of bacterial contamination. Regular testing of water quality at individual beaches needs to be maintained because stormwater quality is so variable.

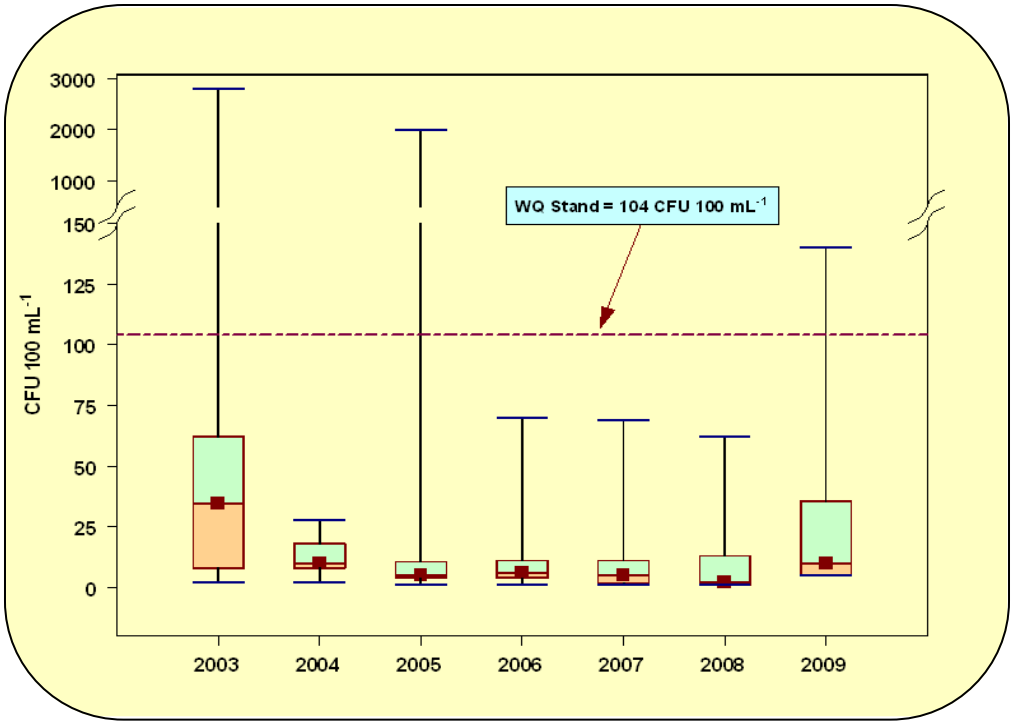
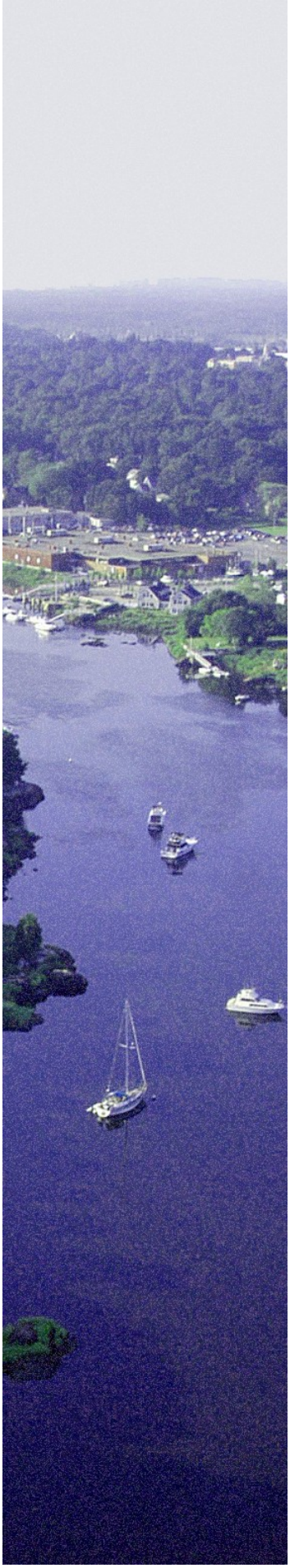


Figure 5.2. Beach water quality data (*Enterococci*, cfu/ 100 mL) reported by the Massachusetts Department of Public Health for Juniper Beach in Salem, MA. After stormwater outfall cleaning and remediation with a "duckbill" tide gate prior to the 2006 beach season, Juniper Beach closures were reduced. For more information on how to read "box and whisker" plots see *Box Note* at the end of this section.



The number of beaches monitored for fecal indicator bacteria increased by 30% in 2003, due in part to passage of the Federal Beaches Environmental Assessment and Coastal Health Act of 2000 and the subsequent allocation of funding for beach monitoring. Additionally, the Massachusetts Beach Act, which is implemented by the DPH, requires all communities to monitor bacteria levels at public and semi-public bathing beaches while the beaches are in operation. Acceptable bacteria levels have been set in accordance with new, stricter U.S. Environmental Protection Agency standards for indicator bacteria. As a result of the stronger legislation, it is safer to swim at a number of area beaches due to an increase in the number of sanitary surveys used to identify and remediate pollution sources, increased frequency of monitoring, and improved public notification of water quality conditions through various media (e.g., signage, website).

The number of beaches with closures, however, is still significant. Although many communities have made progress in improving water quality at beaches through implementation of wastewater and stormwater permit requirements as well as other strategies, such as installing trash containers that prevent access by birds and other wildlife using it as a source of food. Many communities, such as Provincetown, Salem, and Quincy, are also using best management practices such as more frequent catch basin cleaning, which can reduce the number of pollutants that are discharged from the stormwater system. Local communities continue to face technical and budgetary challenges for identifying and remediating indicator bacteria sources, but in spite of these challenges, local, state, and federal authorities are finding new and innovative ways to improve water quality in Massachusetts.

Box Note*:* Box and whisker plots (e.g., Figure. 5.2) are used to convey summary statistics like the median (i.e., the value that is exactly in the middle of the ordered data set), lower and upper quartiles (upper and lower edges of the box) and the lower and upper extremes (the "whiskers") of the data of interest in graphical form.

COMBINED SEWER OVERFLOWS

Q6 How many CSOs remain in the Massachusetts Bay Program's planning area?

Contributor: Cathy Vakalopoulos and Kevin Brander, Massachusetts Department of Environmental Protection

Why this is important

Combined sewer overflows (CSOs) are found in older cities where household and industrial wastewater as well as stormwater flow through the same pipes. When the system is subject to very high flow associated with large rainstorms or snowmelt events, there are "relief locations" known as CSOs. CSOs are designed to discharge directly to waterways in order to prevent street flooding or backups through service connections into basements. These discharges of untreated wastewater can result in dramatically diminished water quality, resulting in beach closures, restrictions to recreational activities, fish and shellfish contamination, and other adverse impacts to the aquatic habitat. Pollutants include pathogens, particles, elevated water temperatures, and excess nutrients that can contribute to eutrophication. Unfortunately, reducing or eliminating CSO discharges is an extremely complex and costly endeavor. Reduced discharge from CSOs and resulting water quality improvements are difficult to track because rain and snowfall amounts vary from year to year. In addition, increases in impervious areas often result in increased discharges to combined sewers, thus increasing the likelihood of untreated discharges at CSOs.

State of the Bay

CSOs are regulated by the U.S. Environmental Protection Agency's (EPA) and Massachusetts Department of Environmental Protection's (MassDEP) CSO Policies as well as the state Water Quality Standards. EPA's CSO Control Policy provides national guidance for controlling CSO discharges through the National Pollutant Discharge Elimination System (NPDES) permitting program. Communities with CSOs are first required to implement minimum controls that reduce the frequency and volume of CSO discharges without requiring major planning or construction. Communities with CSOs are also required to develop Long-Term CSO Control Plans in order to comply with the Clean Water Act and meet state Water Quality Standards.

Massachusetts Bays communities that have CSOs are Gloucester, Lynn, Chelsea, Somerville, Boston, and Cambridge. CSOs in Chelsea, Somerville, Boston, and Cambridge are either maintained by the municipalities or the Massachusetts Water Resources Authority (MWRA). Figures 6.1 and 6.2 show approximate locations of known CSO outfalls in the MBP planning area (Metro Boston and North Shore, respectively).

Gloucester has seven active CSO outfalls that discharge to Pavilion Beach and Gloucester's inner harbor. Figure 6.2 shows five locations since two locations each have two CSOs located close together (004/004A and 006/006A). Gloucester remains under a state/federal order to move forward with measures to address CSO discharges, in accordance with an approved $14.6 million Final Long Term CSO Control Plan (Control Plan). The most critical elements of the Control Plan address CSO discharges from outfall 002 to Pavilion Beach.

Gloucester has completed substantial construction work to address discharges from CSO 002. This work, along with efforts to maximize flows to the wastewater treatment facility through modifications of the CSO 002 regulator structure, have served to dramatically reduce CSOs to Pavilion Beach. The Control Plan indicates that the work will reduce CSO discharges to once a year with typical rainfall.

Figure 6.1. CSO locations in the Metro Boston region (includes Chelsea, Somerville, Boston, and Cambridge). Data source: MWRA.

Figure 6.2. CSO locations in the city of Gloucester. Data source: EPA, Region I.

The approved Control Plan also recommended sewer separation work in CSOs 004, 005, and 006 subareas. During the course of the design work, the City noted that not all CSO outfalls are included in the original Control Plan (004A and 006A), and has requested a new compliance schedule to re-evaluate the most cost-effective alternatives for addressing discharges from other CSOs. EPA and MassDEP are currently reviewing this request.

The Lynn Water and Sewer Commission (LWSC) treats wastewater from Lynn, Saugus, Swampscott, and Nahant and has four active CSOs that directly discharge to Lynn Harbor, Stacy Brook, and the Saugus River. To date, $80 million in abatement work has been completed, resulting in near elimination of CSOs to King's Beach. However, stormwater flows to the beach continue to cause water quality impairments. LWSC has submitted a

supplemental CSO control plan requiring an additional $55 million to address CSO pollution issues. This plan is currently under review by EPA and MassDEP.

The MWRA is proceeding with approximately $1 billion in work to address CSO discharges in their system. They have reduced the number of CSOs that discharge to the Charles, Mystic, and Neponset Rivers and Boston Harbor from 84 in 1987 to 24 currently. Further, the total volume of untreated discharge through CSOs has been reduced by 81% since 1987 (see *Box Note*, next page). Three CSO facilities screen, chlorinate, and store wastewater until it can be pumped to the MWRA Deer Island Treatment Plant. However, if the capacity of the existing sewer system is exceeded by excessive and prolonged storm events, they are still able to discharge directly to receiving waters. The remaining CSO facilities are located in Union Park in Boston, and Cottage Farm and Prison Point in Cambridge. The Somerville Marginal Facility can also partially treat wastewater, but there are no storage facilities. During intense storm events, wastewater flowing to Somerville Marginal is discharged once it is screened, chlorinated, and dechlorinated.

One of the MWRA CSO mitigation projects currently underway is outlined in the North Dorchester Bay CSO Control Plan. The purpose of this project is to reduce CSO discharges and control stormwater along South Boston beaches, Pleasure Bay, and Reserved Channel. Components of this project include the installation of the North Dorchester Bay CSO storage tunnel, new stormwater piping, and a remote odor control facility. Once completed, it is expected that CSO discharges will be eliminated with the exception of "greater than 25-year storms". Currently, these CSOs, on average, discharge 16 times per year.

Box Note: Much of the information about the Metro Boston region's CSOs can be found in technical and outreach documents provided by MWRA at: http://www.mwra.state.ma.us/harbor/html/bhrecov.htm.

Though significant progress has been made in reducing the frequency and amount of untreated CSO discharges to coastal waters, more work still needs to be done. CSO projects are costly, time consuming, and potentially disruptive to local neighborhoods. The public desire to swim, boat, and fish in clean waters continues to serve as impetus for improving the regulatory process that mandates CSO improvements needed to meet compliance with the mandates of the Clean Water Act.

POINT SOURCE POLLUTION

Q7 How have the amount and quality of point source pollution discharges changed in Massachusetts and Cape Cod Bays?

Contributor: Todd Callaghan, Massachusetts Office of Coastal Zone Management

Why this is important

Point source pollution discharges emanating from sewage treatment plants, power generating facilities or other industrial operations can cause a variety of water quality impairments due to contaminant loading and thermal pollution. For example, sewage treatment plants discharge large enough quantities of nitrogen to increase undesirable macroalgae or phytoplankton, decrease water clarity and dissolved oxygen levels, and cause changes in benthic communities through changes in predominant invertebrate species. Sewage treatment plants also discharge microorganisms that lead to shellfish bed closures and illness in swimmers if the effluent is not treated properly.

Due to the large quantities of heat that they discharge, power plants can change the biological communities in the water bodies into which they discharge and can kill millions of organisms when they get trapped in power plant cooling systems. Most industrial discharges in coastal Massachusetts have been eliminated, but the ones that remain, like power plants, discharge heat to coastal waters and can potentially have negative effects. In 1972, the federal Clean Water Act gave the U.S. Environmental Protection Agency the authority to regulate these and other point sources of pollution by requiring that parties dumping pollutants into national waters obtain a National Pollutant Discharge Elimination System (NPDES) program permit. The Act also authorized funds for the construction and upgrade of sewage treatment plants or Publicly Owned Treatment Works (POTWs), which were required to achieve secondary treatment (advanced removal of pollutants) by July 1, 1977.

Ultimately, the goal of the Clean Water Act and associated programs has been to reduce and eventually eliminate pollutants discharged to the nation's surface waters. The 2004 State of the Bays report documented an overall decrease in the number of discharges between 1991 and 2003, but an increase in permitted discharge volume due to increased demand for cooling water by power plants. More recent trends suggest that both the number and volume of discharges have decreased since 2003.

State of the Bay

In 2003, there were 30 NPDES discharges permitted (those allowed to release more than 1 million gallons per day), a decrease from 33 major discharges in 1991. These 30 major discharges registered a total flow of 2.82 billion gallons of effluent per day (BGD). In 2008, there were 27 major NPDES permittees discharging 2.25 BGD, a decrease of 20% by volume (Figure 7.1).

Thermal Discharge

In 2004, eight power plants discharged 2.23 BGD of thermal effluent to the bays. In 2008, the number of plants remained the same but the amount of thermal discharge decreased by 24% to 1.70 BGD. Most of this decrease was due to the addition of two new energy-generating units by Mystic Station in Everett that use closed-cycle cooling and thus do not have large thermal discharges. These highly efficient units have taken the place in the electrical grid of older, less efficient and water-use-intensive units.

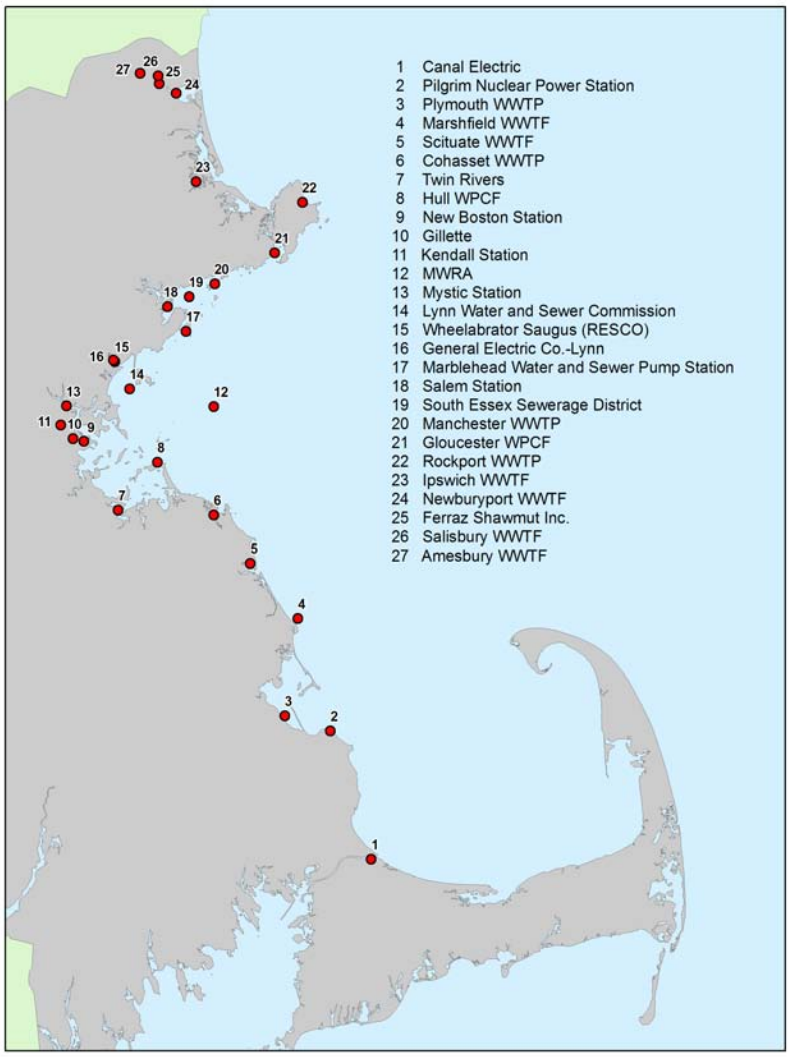


Figure 7.1. Locations of large point source pollution sources (>1 MGD) permitted under the National Pollution Discharge Elimination System program, as of 2008, in the Massachusetts Bays Program region. Location data provided by CZM.

Sewage Treatment Plants

In 2003, there were 18 POTWs that discharged 553 million gallons per day (MGD) of sewage and other pollutants to the bays, of which the Massachusetts Water Resources Authority (MWRA) facility contributed over half (See Question 1, Municipal Wastewater in Boston Harbor). In 2008, the number of POTWs remained the same, but the amount of discharge decreased by 7% to 513 MGD. The decrease in POTW discharge is striking given that significant areas along the Massachusetts Bays coastline have been serviced by sewers since 2003. The decrease in POTW discharge is likely due to the replacement of old, leaky sewer infrastructure that experienced significant stormwater and groundwater surcharging. All plants except for Gloucester are equipped with at least secondary sewage treatment, where much of the effluent material is digested by microbes and the less soluble material is collected and removed as solids. The Gloucester POTW operates under a Clean Water Act 301(h) waiver that allows it to use only primary treatment as long as its discharge meets stringent water quality requirements through the enhanced dilution and dispersion provided by the deep ocean waters, strong tidal mixing, and substantial currents characteristic of the outfall location. Two POTWs, located in Cohasset and Plymouth, have initiated or are taking steps toward the implementation of tertiary treatment, which employs technology to remove additional nitrogen or phosphorus from their effluents.

Industrial Discharge

In 2003, the number of non-power plant industrial permittees was four, discharging 32.5 MGD. There were only two non-power plant industrial facilities in 2008 (Gillette, and a new discharger: Twin Rivers Technologies), since Ferraz Shawmut tied into a POTW and Lucent Technologies eliminated its outfall. In the current assessment, the volume of industrial discharge appears to have increased slightly to 35.6 MGD because of the increased flow from Twin Rivers Technologies.

Box Note: Summary of changes in discharges since 2003:

Discharges Discontinued

- The discharges from Ferraz Shawmut (NPDES # MA00002816) and Lucent Technologies (NPDES # MA0001261) on the Merrimack River were discontinued
- Sithe New Boston station discharge was discontinued as the site was closed down
- The Exxon Island End Terminal (NPDES # MA0000833) reduced its discharge to less than 1 MGD, so it is no longer part of this evaluation

New Discharges

- The Twin Rivers Technologies thermal discharge (NPDES # MA0004073) to the Weymouth Fore Harbor was not on the 1991 or 2003 lists

Facilities Renamed

- U.S. Gen New England, Inc. Salem Station (NPDES # MA0005096) was renamed

SPECIAL TOPIC

No Discharge Areas

Contributor: Jo Ann Muramoto, Massachusetts Bays Program Cape Cod Regional Coordinator

Nonpoint sources of pollution to coastal waters can come from a variety of sources including stormwater runoff, failing septic systems, lawn care products (e.g., pesticides and fertilizers), and many others. Wastewater from commercial and recreational boats can also lead to significant water quality impairment. As a result, the discharge of untreated sewage within navigable U.S. waters is prohibited under federal law. However, vessels can still discharge treated sewage from Type I and Type II Marine Sanitation Devices (MSDs), which provide limited onboard treatment of wastewater – unless the water body is designated as a No Discharge Area (NDA). Treated boat sewage often contains nutrients, toxic chemicals, and harmful bacteria at levels that can be up to 70 times higher than state water quality standards allow (Figure NDA.1).

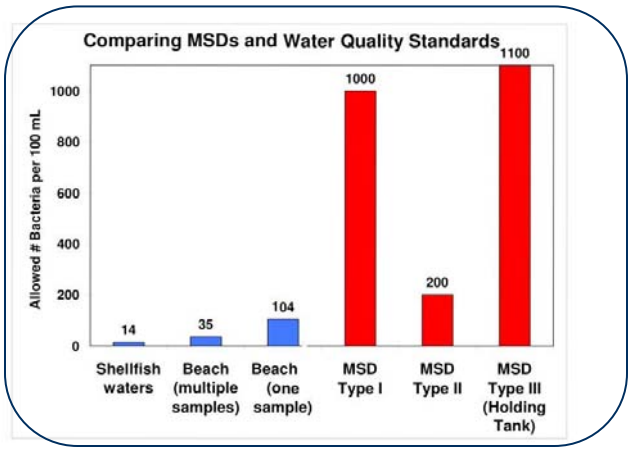


Figure NDA.1. Comparison of bacteria treatment standards for Marine Sanitation Devices (MSDs, red columns) and water quality standards for harmful bacteria in shellfishing waters and bathing beaches (blue columns). MSD standards and shellfishing standards are based on fecal coliform colonies per 100 milliliters (mL), while beach water quality standards are based on *Enterococcus* colonies per 100 mL.

Under Section 312 of the federal Clean Water Act, states can designate a body of water as an NDA and petition for approval by the U.S. Environmental Protection Agency. An NDA is an area in which the discharge of treated and untreated boat sewage is prohibited. A body of water may be designated as an NDA if it is demonstrated that the area's ecological and recreational values warrant this protection. Within an NDA, treated and untreated boat sewage must be discharged to a boat waste pumpout facility, and the sewage is then taken to an approved wastewater treatment facility. T he purpose of NDAs is to improve water quality and support the protection of public health, aquatic ecosystems, and local economies that rely on clean water for safe swimming, boating, shellfishing, fishing, and aesthetic appeal.

Nationwide, there are 26 states with NDAs, and many Massachusetts marine water bodies have recently been designated as well (Figure NDA.2). All of Massachusetts and Cape Cod Bays are designated as NDAs. To complete coverage of the entire Massachusetts coastline, efforts are underway to secure designations for NDAs on Mount Hope Bay and

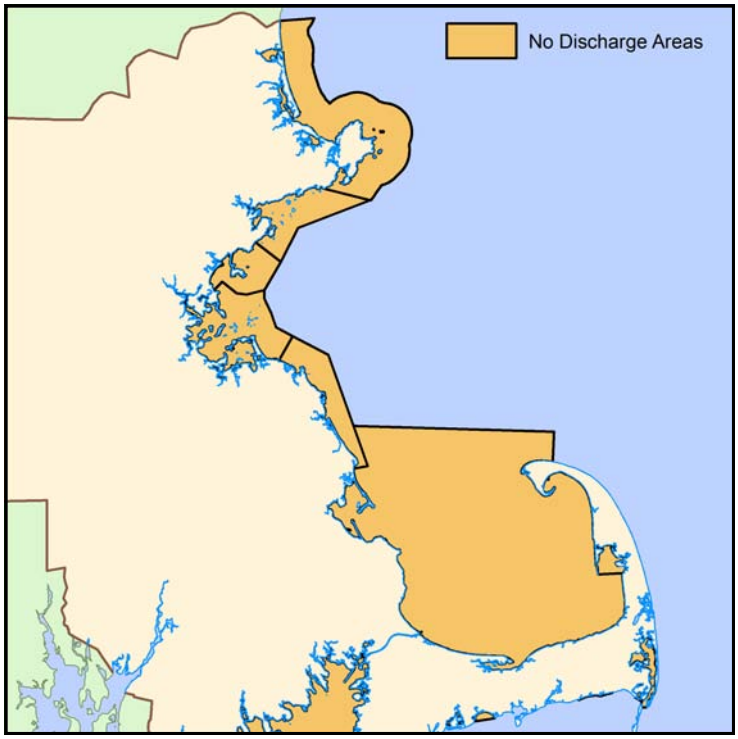


Figure NDA.2. NDAs in Massachusetts, 2010.

the waters south and east of Cape Cod. There are currently over 120 pumpout facilities along the Massachusetts coast that are available to almost 50,000 vessels, about a third of which are thought to have some form of MSD aboard.

Because NDA designation requires sufficient pumpouts (see Figure NDA.3) to serve the existing population of boats, vessel inventory is an important part of the NDA application. The data are used to estimate the numbers of MSDs that need to be pumped, which are then used to determine if additional pumpouts are needed in the area before designation can occur. For NDA designation, a general goal for the ratio of MSDs to pumpouts is about 300 to 400 MSDs per pumpout depending on vessel size, category, and type of harbor. If sufficient pumpouts do not exist in the area being considered for NDA designation, additional pumpouts must be installed before the NDA application is accepted.

Figure NDA.3. Boat waste pumpout station

Following designation, discharge of any boat sewage is a violation of state and federal law. In late 2008, state legislation was passed which gives local and state environmental law enforcement officials, including Harbormasters, as well as their state counterparts, the express authority to enforce NDA provisions and to impose a $2,000 fine for each offense. Generally, however, the most effective enforcement is to provide effective outreach to the boating community.

With New England currently leading the country in the percentage of area covered by NDAs, it is hoped that area boaters will embrace the new regulations and that the collective response will benefit the region's water quality in years to come.

SPECIAL TOPIC

National Coastal Condition Assessment

Contributor: Christian Krahforst, Massachusetts Bays Program

Understanding the conditions that affect the health and well being of our coastal ecosystems is critical for sound resource management. In an effort to gain a greater understanding of the status of the marine and estuarine waters of Massachusetts, the Commonwealth began participating in the National Coastal Assessment (NCA) in 2000. Led by the U.S. Environmental Protection Agency (EPA), the NCA was developed to evaluate and report on the condition of the nation's coastal resources. In Massachusetts, the Massachusetts Bays Program (MBP), Office of Coastal Zone Management, Department of Environmental Protection, Division of Marine Fisheries (*MarineFisheries*), and the University of Massachusetts collaborated to collect biological, sediment, and water samples at 99 stations in the Massachusetts Bays region from 1999 to 2006 (Figure NCA.1). In addition, *MarineFisheries* provided data from their annual trawl surveys, which were used to evaluate contaminant levels in fish populations.

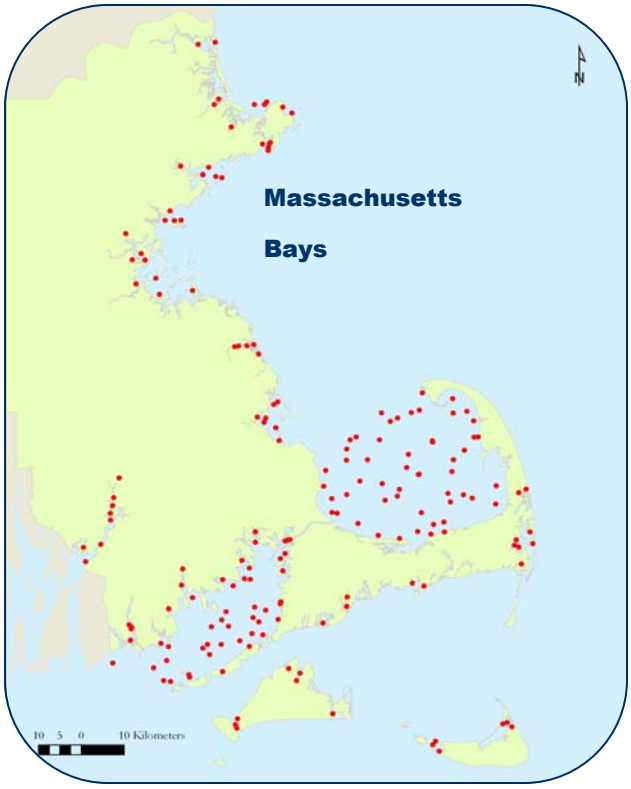


Figure NCA.1. The location of 186 National Coastal Condition Assessment stations in Massachusetts coastal waters sampled during 2000—2006. Of these, 99 stations were located in the Massachusetts Bays region.

To evaluate the data, the U.S. EPA Office of Research and Development created a rating system based on five indices of ecological condition: water quality, sediment quality, benthic quality, coastal habitat, and fish tissue contaminants. The most recent National Coastal Condition Report, published in 2008, states that the overall condition of the nation's coastal waters is "fair." while the Northeast region, which includes the MBP planning area, was found to be "fair -to-poor." The rating was generally due to indicators related to sediment quality, benthic community structure, and contaminants in fish tissue. The report can be accessed at: http://www.epa.gov/owow/oceans/nccr3/downloads.html.

Additionally, EPA issued the National Estuary Program Coastal Condition Report (NEPCCR) in June 2007. For this report, NCA results were supplemented with data collected by the National Estuary Programs (NEPs) in partnership with state environmental agencies, universities, and volunteer monitoring groups. In the Northeast, this report stated that 43% of the estuaries (12 of 28) served by NEPs were generally in "poor" condition. The MBP NEP received an overall rating as "fair." For individual indices, the MBP region rated "good" for water quality, "fair" for fish tissue contaminants, and "poor" for sediment quality and benthic community structure. Tissue contaminant levels in fish and lobster collected from Massachusetts and Cape Cod Bays were significantly below average for the Northeast region. The NEPCCR can be downloaded from http://www.epa.gov/owow/oceans/nepccr/index.html.

It is important to note that the NCA was designed to assess large scale, national water quality characteristics and trends. Because NCA sampling stations are distributed over a large area within Massachusetts and Cape Cod Bay, and because data are collected only once at each station, specific conclusions about the water quality of coastal Massachusetts, which may change quickly, can be difficult to draw. However, NCA data can be useful to document the condition of sediment and associated indicators that tend to be more stable over time. NCA data have further value in that they can supplement local analyses that have been developed to monitor water quality and sediment condition within Massachusetts and Cape Cod Bays.

NCA data are clearly contributing to a better understanding of ecological conditions and revealing processes that may help us better manage water, sediment, and biotic quality. For example, preliminary analysis of surface sediment of Cape Cod Bay show the amount of certain contaminants to be closely related to the amount of organic carbon. Sediments rich in organic content in Cape Cod Bay may be an important "trap" for these contaminants. Chemical databases for sediments often contain organic carbon information and are useful in guiding management efforts that require an understanding of where pollutants may accumulate and developing strategies for protecting and improving benthic habitat quality. The concentration of organic carbon increases in the central region of Cape Cod Bay (Figure NCA.2).

The NCA program continues to be a priority for EPA, and, under a redesigned program, sampling is scheduled to occur every five years. Sampling for the 2010 Assessment began in July 2010 and concluded in September 2010. Data analysis is ongoing.

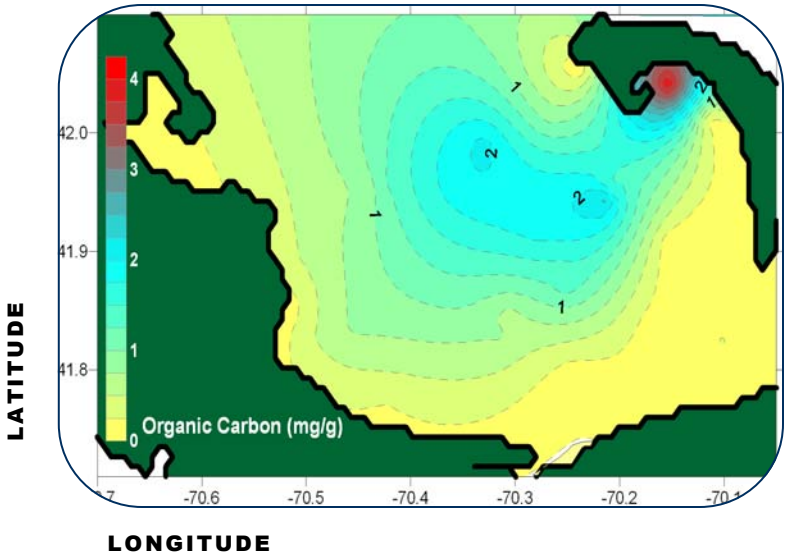


Figure NCA.2. Organic carbon gradient in surface sediment (0-2 cm) in Cape Cod Bay. Based on NCA assessment data, 2000—2006.