Boston Harbor Water Quality
1994-2014

Massachusetts Water Resources Authority
Environmental Quality Department
Report 2015-05

Citation

Taylor DI. 2015. **Boston Harbor Water Quality 1994-2014**. Boston: Massachusetts Water Resources Authority. Report 2015-05. 11 pp.

BOSTON HARBOR WATER QUALITY

(1994-2014)

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June 2015

Technical Report No. 2015-05

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EXECUTIVE SUMMARY

Water quality in Boston Harbor is affected by a large number of factors, among them infrastructure projects that have been and continue to be implemented by the MWRA. In support of these projects, MWRA monitors water quality in the harbor. This report documents 2014 water quality, and compares it with water quality during the past 20 years. The report addresses issues associated with over-enrichment (algae, concentrations of N and P, transparency and dissolved oxygen) and microbial contamination of the harbor (pathogen indicator counts). It focuses on the main body of the harbor, the region that best integrates the effects of all upstream infrastructure projects. Important findings from this report include:

- Boston Harbor water quality has improved substantially during the past 20 years, and the improvements were sustained during 2014. 2014 was a relatively dry year, with river inflows to the harbor the second lowest since 1990.

- 2014 nitrogen (N) and phosphorus (P) concentrations were again much lower than during the years the harbor received Deer Island and Nut Island plant discharges. N concentrations were the fourth lowest since the discharges ended; P concentrations were the lowest since monitoring began in 1995. N:P concentration ratios were higher than other years since the discharges were discontinued.

- Phytoplankton or microalgae biomass during this dry year was lower than during years the treatment facilities discharged to the harbor, but the third highest since the discharges to the harbor were discontinued.

- Total suspended solids (TSS) concentrations were the highest, and transparency among the poorest, since the discharges to the harbor were discontinued. Shoreline and salt marsh erosion known to be a problem in the south harbor may have been responsible for the solids increase.

- Bottom-water dissolved oxygen (DO) concentrations, which have also improved since 1994, easily met the State Standard in 2014 (6 mg l^{-1}). Bottom-water DO concentrations have been consistently high since 2009.

- 2014 *Enterococcus* counts were among the lowest observed since 1996, and easily met the State swimming standard. *Enterococcus* counts too have declined during the past 20 years.

- Water quality in the main body of the harbor continues to be much improved.

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1.0 INTRODUCTION

During the past 25 years the MWRA has undertaken a series of engineering projects to better collect, treat and dispose of the wastewater discharged from the City of Boston and surrounding communities to the harbor and its tributary rivers. These projects have included the Boston Harbor Project (Fig. 1, Taylor 2010), the combined sewer overflow Control Plan (MWRA 2014), the TRAC pretreatment program, and programs to decrease infiltration into the sewer system.

Fig. 1. Deer Island wastewater treatment facility with City of Boston in background.

Over the same period, in support of the engineering projects, MWRA has monitored water quality in Boston Harbor. In this report we document the harbor water quality during 2014. The report focuses on the main body of the harbor, because water quality in this region integrates the impacts of pollutant inputs from all sources. Water quality data from the tributary rivers are reported in MWRA (2014).

This report addresses three water quality issues: the over-enrichment of the harbor (measured as amounts of algae, nutrient concentrations and bottom-water dissolved oxygen concentrations), water transparency (measured as total suspended solids concentrations and attenuation coefficients) and pathogen indicator counts (measured as *Enterococcus*).

This report presents data collected by MWRA at 12 harbor locations (Fig. 2). The data were collected as part of MWRA's Boston Harbor Water Quality Monitoring (BHWQM) project. Most of the 12 locations have been sampled weekly or every two weeks since 1994. The sampling and analytical procedures used are described in detail in Rex and Taylor (2000). All water samples were collected from MWRA's sampling vessel, the *Merganser* (Fig. 3, 4).

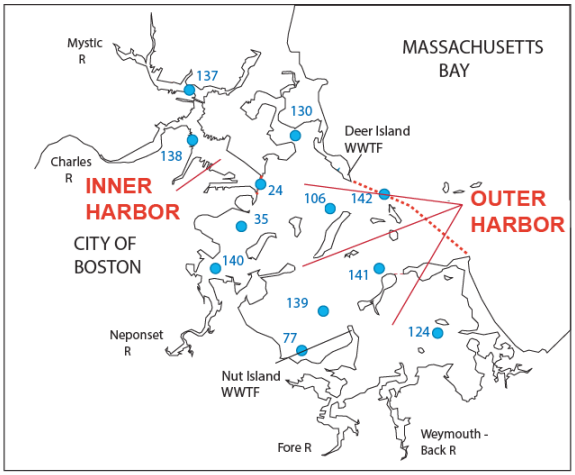

Fig. 2. Boston Harbor showing the 12 sampling locations, and the Inner (IH) and Outer Harbor (OH) regions of the harbor.

All data in the report are averaged for either the harbor as a whole, or for particular regions of the harbor. Stations 137, 138 and 24 were located in the Inner Harbor (IH), and stations 106, 124, 139, 140, 141 and 142 in the Outer Harbor (OH). The horizontal bar at the top of each Figure shows the 14 years since the

wastewater treatment facility discharges to the harbor were discontinued in September 2000.

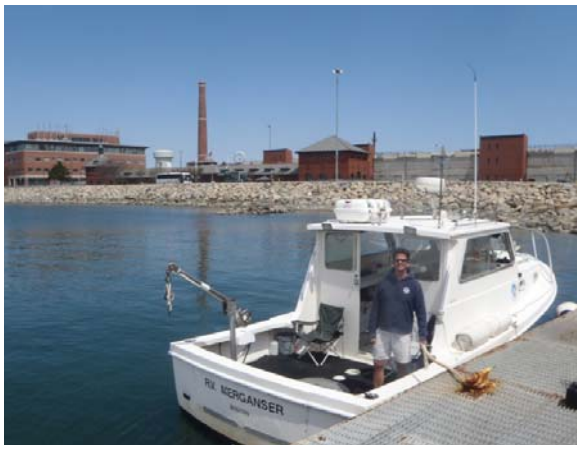

Fig. 3. MWRA's sampling vessel, the *Merganser*.

Fig. 4. Water sample collection using a Niskin bottle.

2.0 RESULTS

2.1. WATER QUALITY

2.1.1. Amounts and types of nutrients

The harbor's total N (N) concentrations in 2014 (20.6 µmol l^{-1}), were higher than certain years since the Deer Island and Nut Island discharges to the harbor were discontinued, but lower than during the six final years the harbor received the discharges (Fig. 5). This applied for all nine locations shown in Figure 6. 2014 total P (TP) concentrations (1.2 µmol l^{-1}) were the lowest since 1995. Total N: total P concentration ratios, which measure the amount of N relative P, and can determine whether algae build up in coastal systems or not, were the highest since 2000, the year the discharges were diverted offshore.

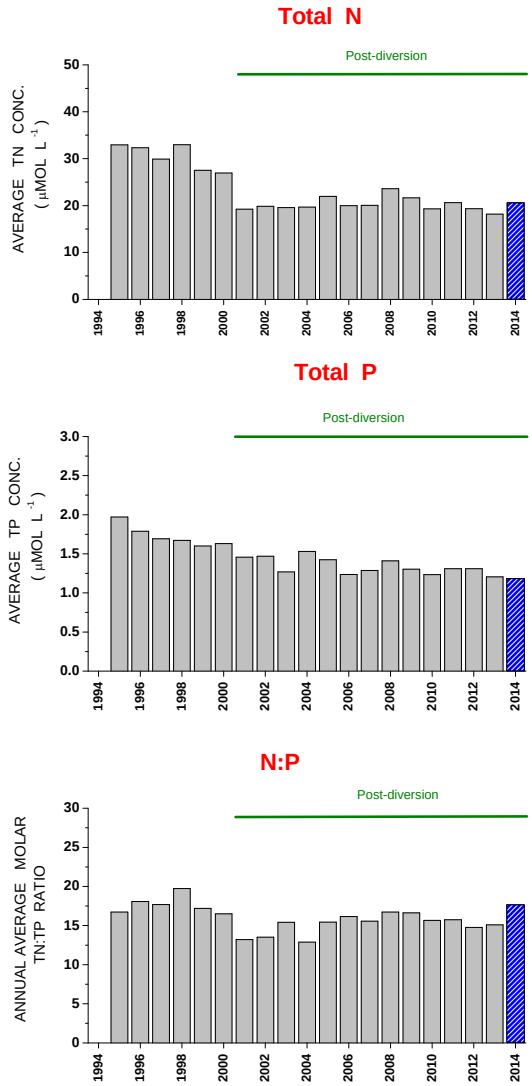

Fig. 5. Annual average total N and total P concentrations and total N:total P concentration ratios, 1995-2014.

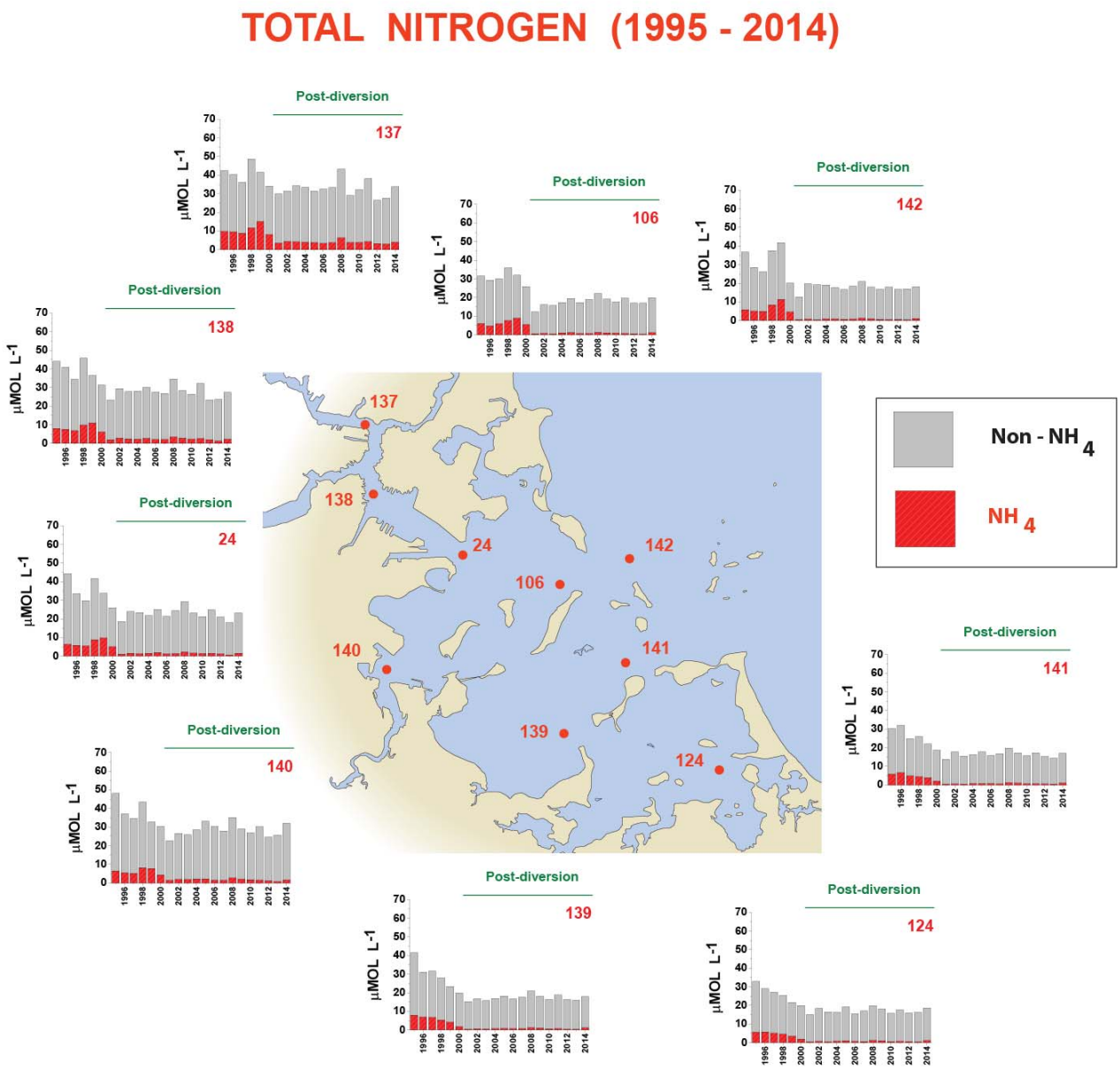

Fig. 6. Annual average total N concentrations partitioned into the ammonium (NH_4) and non-ammonium fractions at nine locations, 1995-2014.

For all four fractions making up the total N, 2014 concentrations fell within the range seen since 2000 (Fig. 7). Total N concentrations in the OH were again lower than in the IH, and in both regions were much lower than during years the harbor received the discharges (Fig. 8). N:P concentration ratios were the highest since 2000. Total N refers to dissolved inorganic N (DIN)

+ particulate nitrogen (PN) + dissolved organic N (DON), and DIN refers to NH_4 + NO_{3+2}.

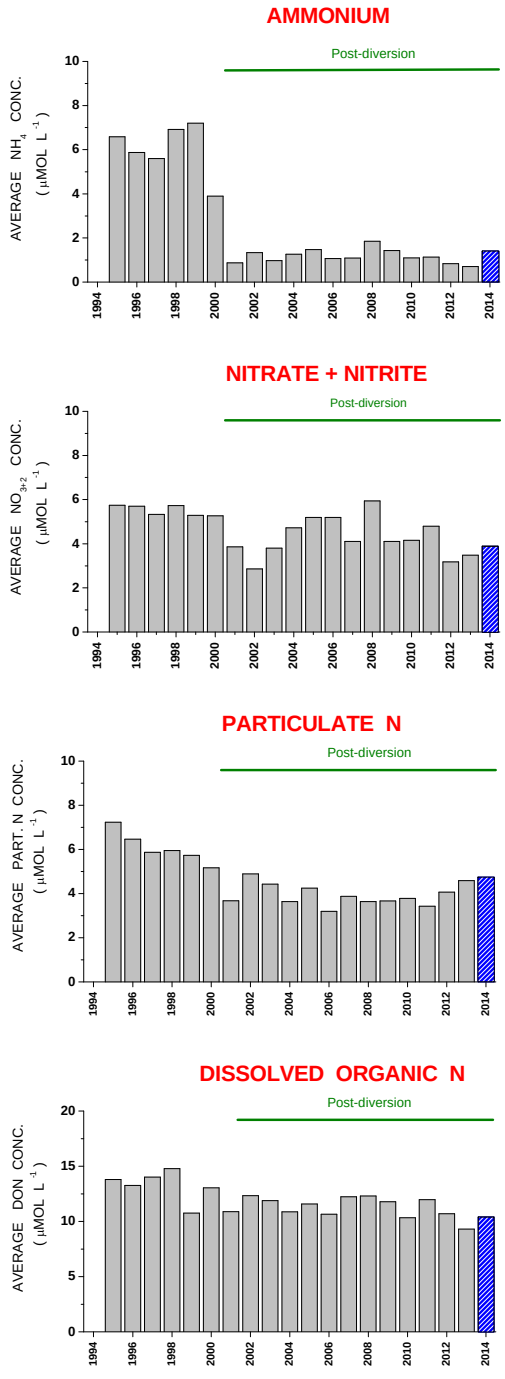

Fig. 7. Annual average concentrations of the four fractions making up total N (N), 1995-2014.

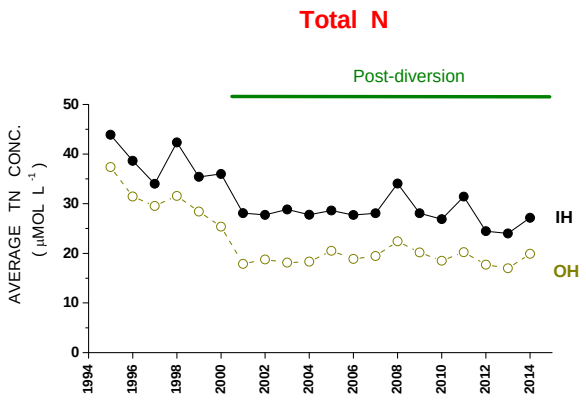

Fig. 8. Annual average total N concentrations in the Inner Harbor and Outer harbor, 1995-2014.

2.1.2. Amounts of phytoplankton

2014 summer phytoplankton biomass (measured as chlorophyll a) at all locations combined averaged 4.9 µg l^{-1} (Fig. 9). 2014 concentrations were slightly lower than in 2013, but the third highest since the discharges to the harbor were discontinued. The slightly elevated chl-a concentrations during 2014 were observed at all locations, and especially at the locations in the IH (Fig. 10).

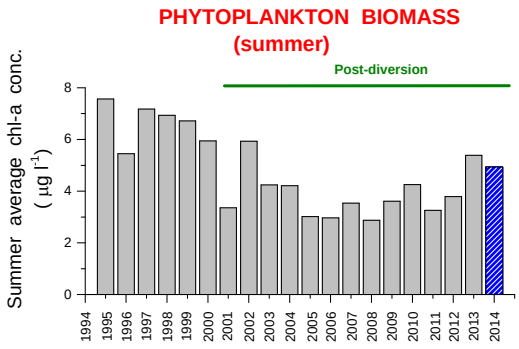

Fig. 9. Summer average phytoplankton biomass measured as chl-a, 1995-2014. Summer = Jun, Jul, Aug, Sept.

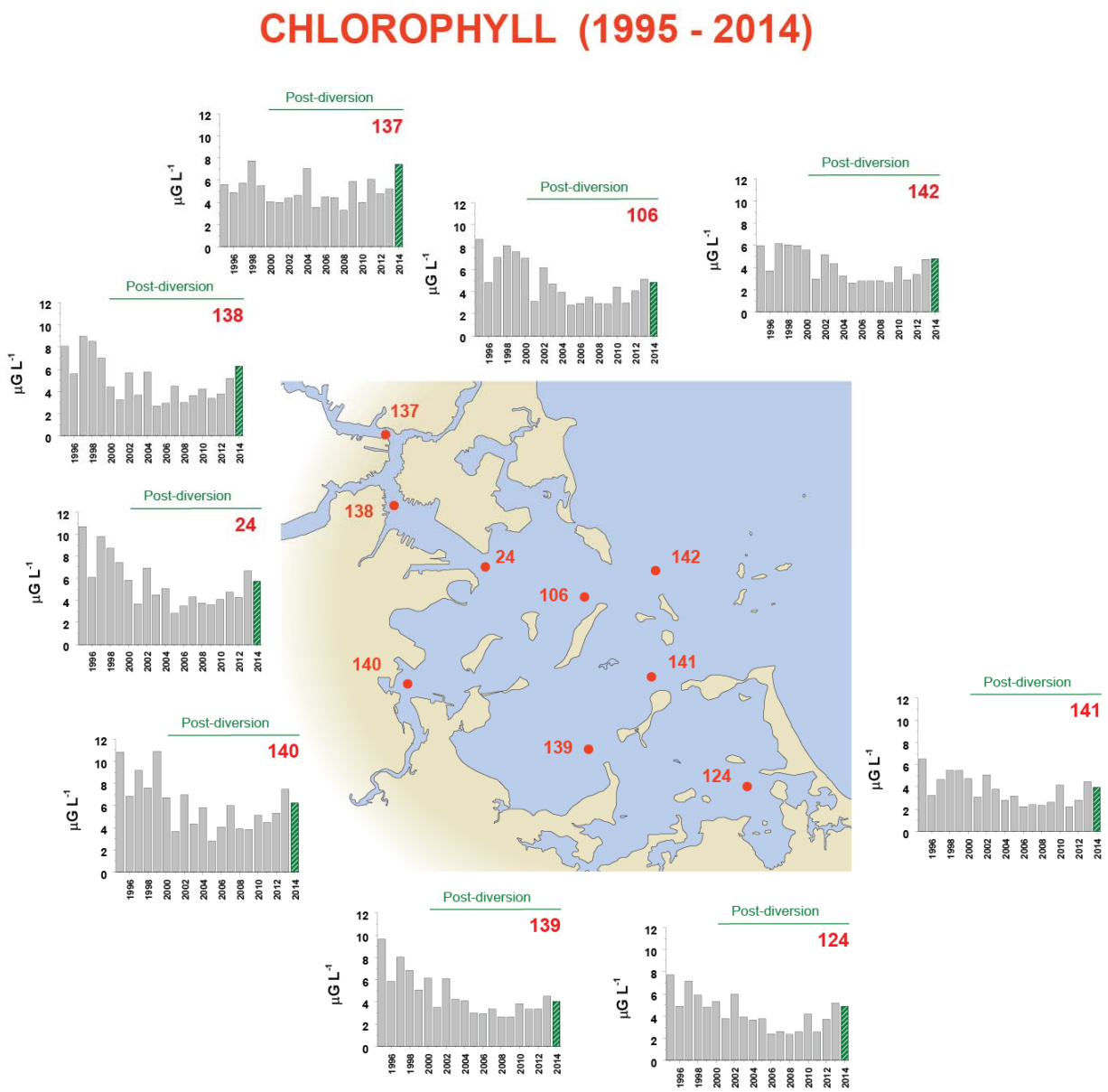

Fig. 10. Summer average chl-a, 1995-2014.

2.1.3. Suspended particulate material

2014 TSS concentrations were by far the highest observed since 1996 (Fig. 11). TSS increases in the OH, and especially Stations 140, 139 and 124 were responsible for the increases (Fig. 12).

Particulate organic C (PC), a measure of the organic content of the TSS, was also elevated in 2014, but not to the same extent as TSS. 2014 PC concentrations were the highest since 2000, but lower than during years the harbor received wastewater discharges. PC expressed as percent TSS was the lowest since 1996.

TSS was the lowest since 1996

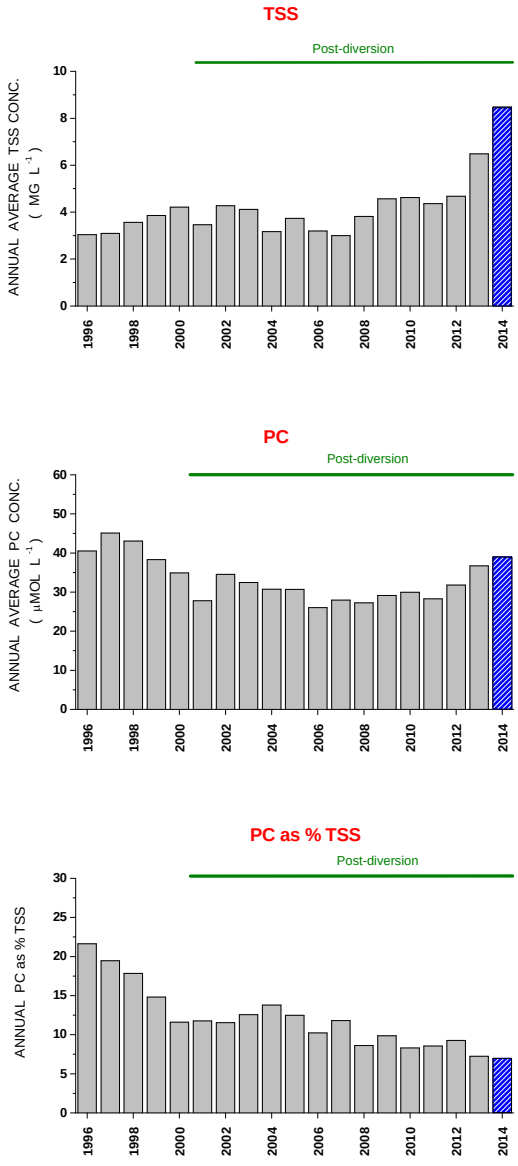

Fig. 11. TSS, PC and PC as % TSS, 1996-2014.

2.1.4. Transparency

Consistent with the harbor's elevated TSS, water transparency during 2014 was the poorest since 1996 (the first year for which harbor-wide attenuation coefficient data were available (Fig. 13). Harbor attenuation coefficients in 2014 averaged 0.63 m^{-1}. Note, the attenuation coefficients, as reported, are reciprocal values, so the higher the value, the more rapid light attenuation is, and the poorer the transparency.

2.1.5. Bottom-water DO

Minimum monthly average bottom-water DO concentrations in 2014 (7.6 mg l^{-1}) were among the highest since 1994 (Fig. 14). Bottom-water DO has increased since 1994, and the elevated 2014 concentrations were a continuation of this trend. Both in the IH and the OH, the minimum monthly DO concentrations easily met the State Std of 6 mg l^{-1} (Fig. 15). DO was measured by lowering YSI or Hydrolab sondes from the sampling vessel into the water (Fig. 16).

2.1.6. Pathogen indicator counts

Recreational use of the harbor requires monitoring for pathogen indicator bacteria. *Enterococcus* counts in 2014 were low and averaged 3 colony forming units 100 ml^{-1} (Fig. 17). Counts in the IH were higher than in the OH, as has been the case in all years since 1995. Counts in both regions easily met State Standards, and in the IH the 2014 counts were the lowest since monitoring was started in 1995 (Fig. 18, 19).

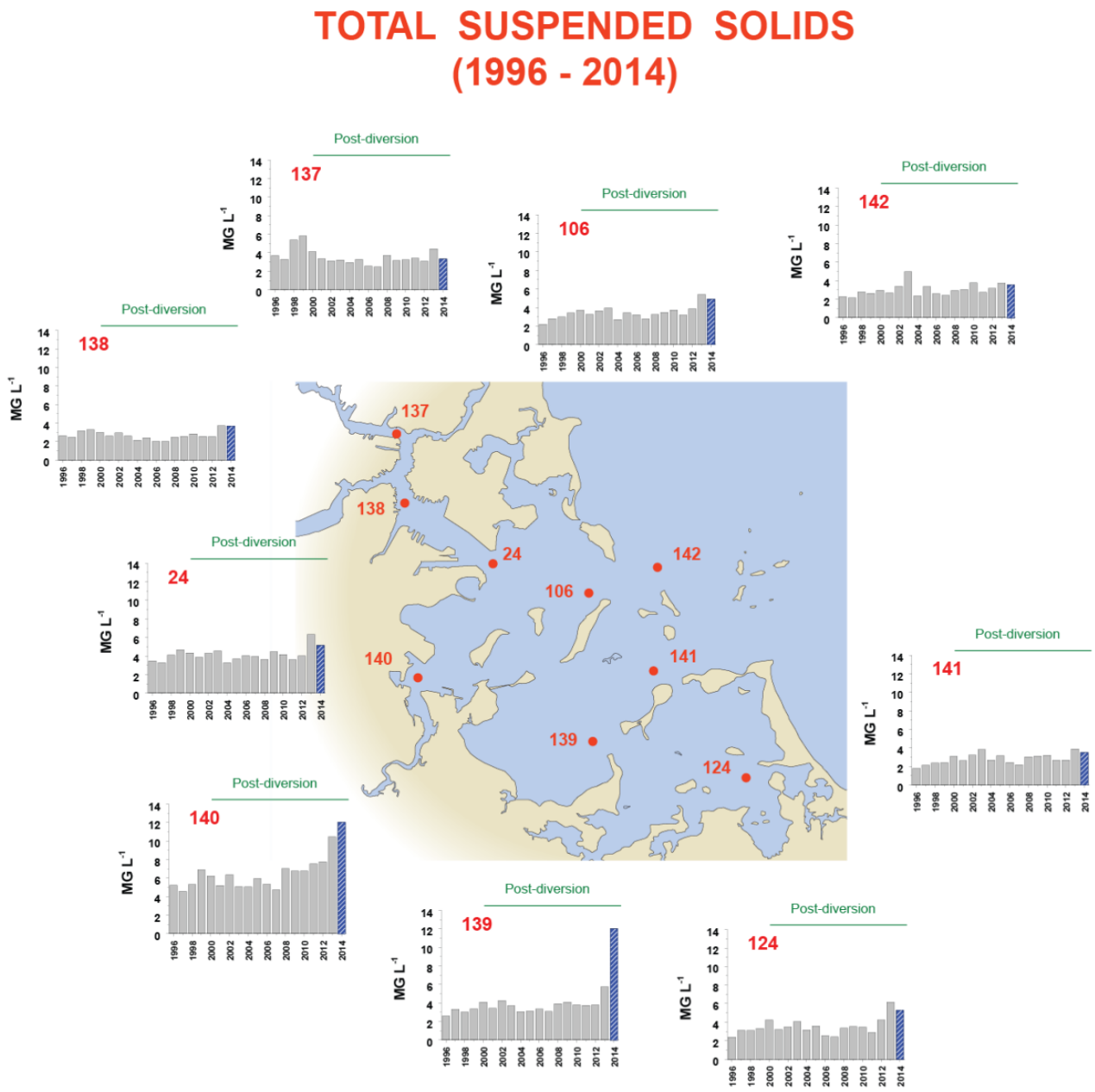

Fig. 12. Annual average TSS concentrations, 1996-2014.

2.2. PHYSICAL CONDITIONS

2.2.1 River inflows, salinity and water temperature

2014 river flows averaged 1.34 x10^6 m^3 d^{-1}, the second lowest since 1990 (Fig. 20). Accordingly, salinity both in the IH and the OH were greater than in most years (Fig. 21). Water

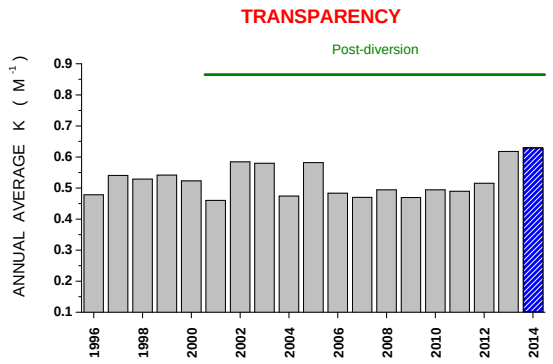

Fig. 13. Annual average attenuation coefficients, 1997-2014

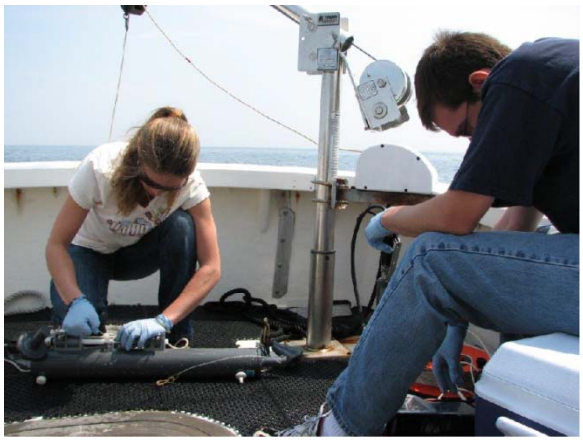

Fig. 16. Sampling equipment preparation onboard the *Merganser*.

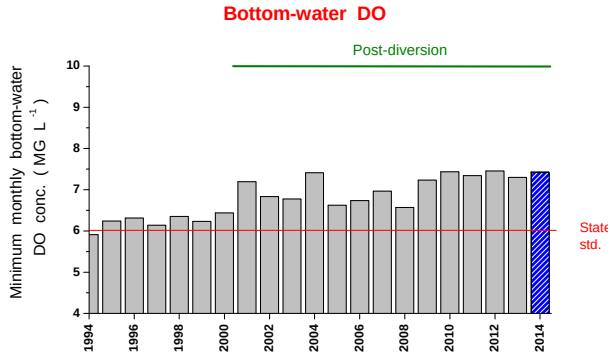

Fig. 14. Minimum monthly harbor-wide average bottom-water DO concentrations observed each year, 1994-2014

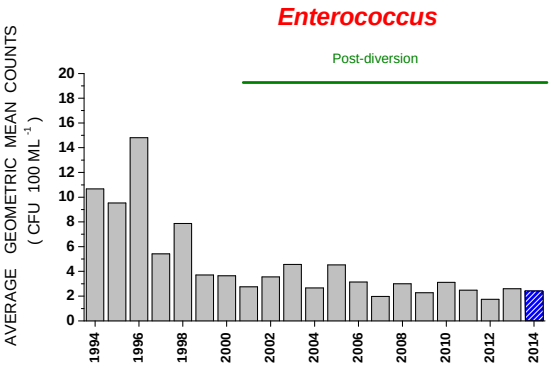

Fig. 17. Average *Enterococcus* counts by year, 1994-2014.

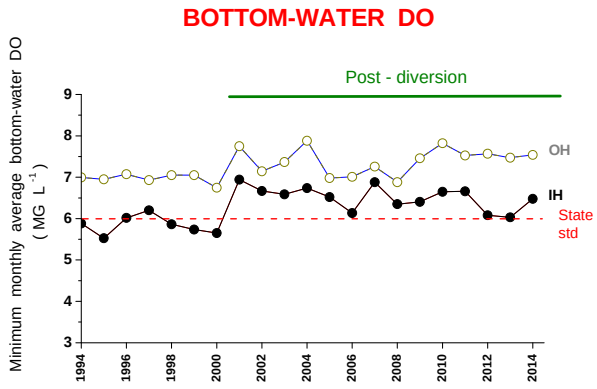

Fig. 15. Minimum monthly average bottom-water DO concentrations in IH and OH.

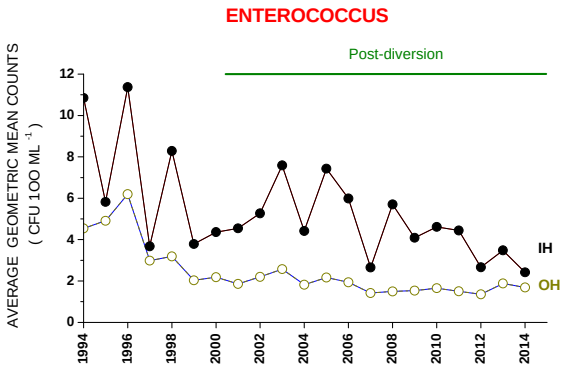

Fig. 18. Average geometric mean *Enterococcus* counts in the IH and OH, 1994-2014.

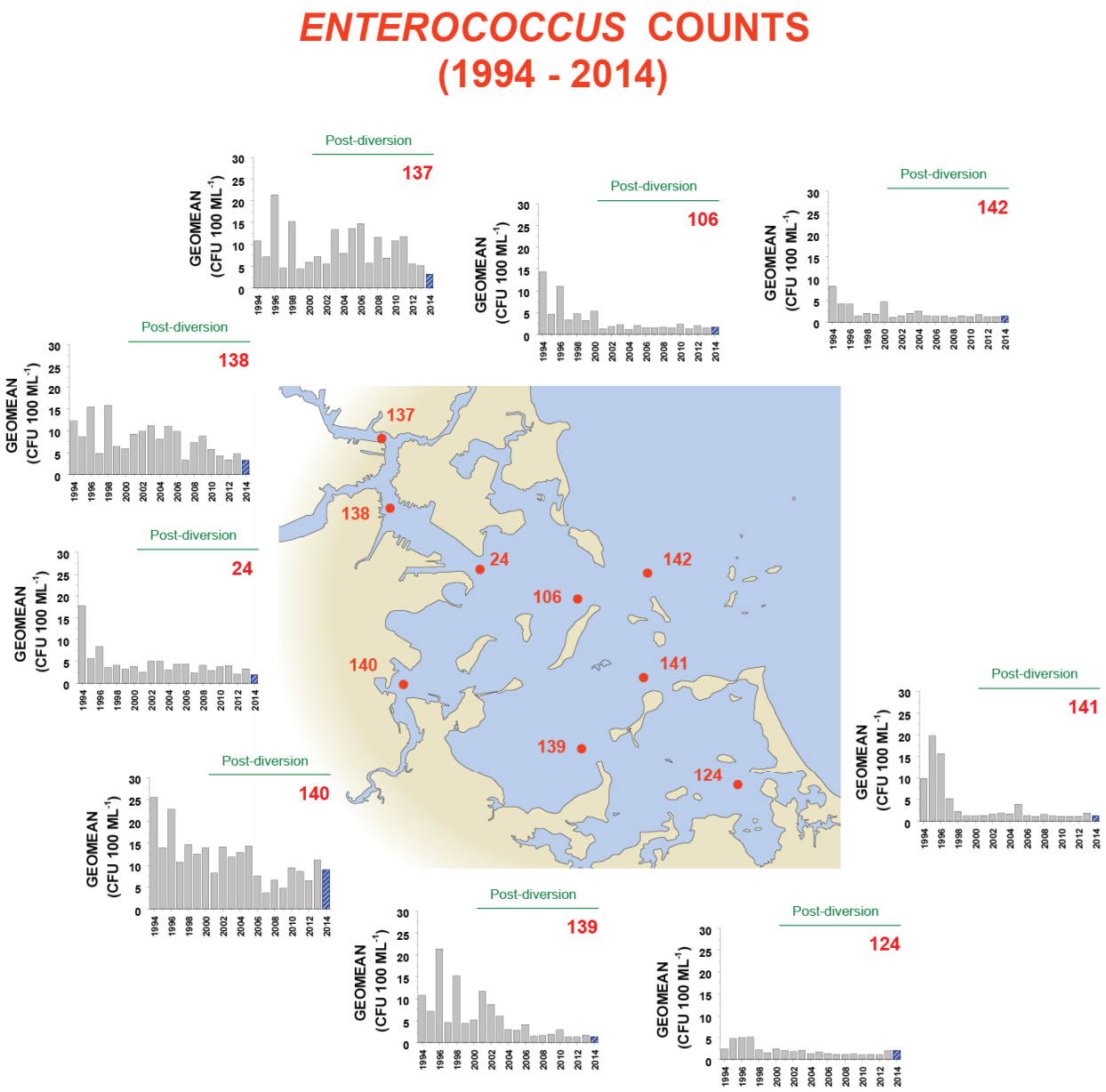

Fig. 19. Annual geomean *Enterococcus* counts, 1994-2014.

temperatures during late winter/early spring 2014 were lower than average, but the opposite applied during June and from August through October (Fig. 22).

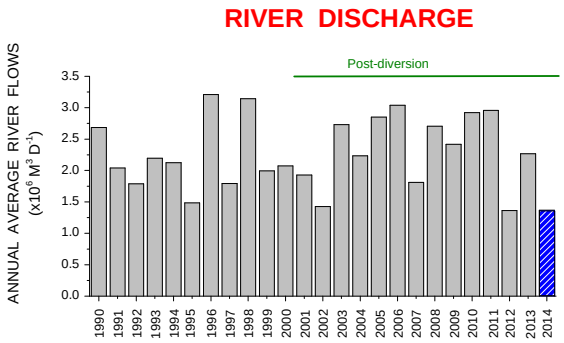

Fig. 20. Annual average river inflows into Boston Harbor. Data are sum of discharges from Charles, Mystic, Neponset and Weymouth- Weir rivers (data from USGS).

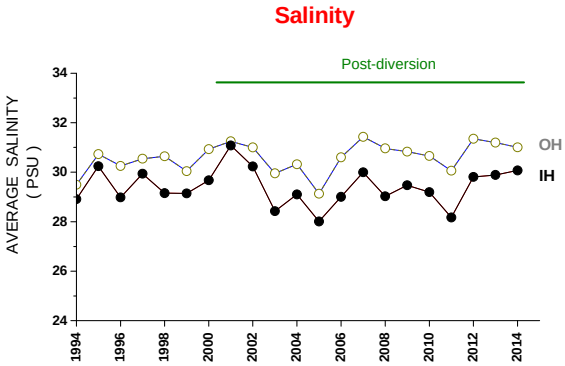

Fig. 21. Comparison of annual average salinity in the IH and OH, 1994-2014.

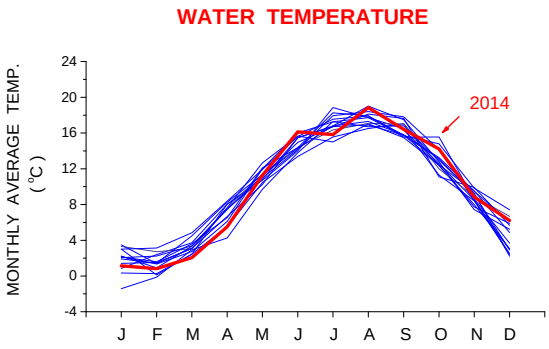

Fig. 22. Average water temperatures by month. Blues lines show data for 2001-2013.

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