

2300 Days at Sea: Monitoring the Impacts of the Outfall on Massachusetts Bay

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Atlantic Wharf
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Executive Summary of the Outfall Monitoring Science Advisory Panel Workshop

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The Massachusetts Water Resources Authority was required to conduct a monitoring program to assess whether moving the outfall discharge from Boston Harbor to Massachusetts Bay would not adversely affect the environment. Although there have been revisions to the monitoring plan over the past 25+ years, the Outfall Monitoring Science Advisory Panel (OMSAP) that advises the U.S. Environmental Protection Agency (EPA) and Massachusetts Department of Environmental Protection (MassDEP) convened a workshop to review past and current monitoring activities and identify emerging issues. This document summarizes the presentations from speakers and input from stakeholders (scientists, regulators, non-government organizations, and the concerned public) who attended the November 2018 workshop.

Summary of Issues and Recommendations

1. MONITORING HIGHLIGHTS

- **After 25+ years of monitoring, the data show that the MWRA outfall has not adversely affected Massachusetts Bay. Many parameters that are monitored show either no change or decreases in concentrations in effluent, sediments or biological tissue.**
 - **Effluent concentrations of legacy contaminants have decreased**
 - **Contaminant levels in sediments and biota have decreased**
 - **Sediment oxic layer increased**
 - **Benthic diversity increased**
 - **Nuisance/toxic algal blooms have not intensified around the outfall**
 - **Outfall diffusers are surrounded by a vibrant community of organisms**

2. EMERGING CONTAMINANTS

- **Of growing concern are emerging contaminants and microplastics. Understanding their presence in the environment, sources, and potential adverse environmental impacts are of interest for future monitoring and understanding.**

- Per- and polyfluoroalkyl Substances (PFAS) are endocrine disruptors and increase the risk of cancer – found in many products including fire retardants, food packages
- Microplastics – microbeads (banned in MA), lint from polyester clothes, breakdown of plastics, attract contaminants
- Endocrine disruptors found in pharmaceuticals and personal care products

3. CLIMATE CHANGE

- Climate change is having an effect on the ecosystem and the region and should be monitored regionally, including use of remote sensing and collaboration of other dischargers. Designing monitoring that can distinguish impacts of climate change from outfall effects is challenging.
 - Species ranges are changing
 - New species may need to be monitored

4. SPECIAL STUDIES AND COLLABORATIVE EFFORTS

- Special studies are effective in identifying sources and contaminants of concern for Mass Bay
- Collaborative efforts with other dischargers, agencies, and universities can address regional issues such as climate change impacts
 - Nutrients
 - Water chemistry
 - Biota
 - Physical parameters

5. OTHER ISSUES

- Concern for endangered species and the biota remains an issue and will require some monitoring
- Application of technology to address issues was raised as potentially efficient options to current approaches
- Role of models to enhance monitoring program
- Lessons to be learned from national and regional wastewater treatment plants

6. GOVERNANCE AND EFFICIENCIES

- MWRA is the largest discharger to Mass Bay for about half of the coastal population
- In Mass Bay, it is estimated that there are 26 dischargers and other sources that serve the remaining population.
- Currently, there is no coordinated or long-term monitoring by other major dischargers
- MWRA increases efficiencies by collaborating with others and integrating data from various sources, but these are usually not long-term monitoring activities.

Background

In the late 1980s, Boston Harbor was dubbed the dirtiest harbor in the nation. It took a lawsuit and legal oversight to force the Commonwealth to stop polluting Boston Harbor. The Massachusetts Water Resources Authority (MWRA) was established to oversee the upgrade of Boston's wastewater system. That upgrade included eliminating sludge discharges, improving the wastewater treatment facility, and relocating the outfall 9.5 miles offshore into Massachusetts Bay. At the time, the public and regulators were concerned that the new outfall would transfer environmental degradation from Boston Harbor to the cleaner waters of Massachusetts Bay. To address these concerns, scientists, regulators, and non-government organizations oversaw the development of a monitoring program that was designed to evaluate the outfall's impacts on human health, seafood safety, aesthetics, and ecosystem health. Following the guidelines of the National Research Council, an Ambient Monitoring Plan was designed. To maximize protections for humans, endangered species, and other ecosystem components, a Contingency Plan was adopted, with thresholds (caution and warning levels) to trigger further examination or action. Twenty-five plus years later (and 2300 days at sea), the monitoring program has documented that impacts from the outfall are minor and within pre-monitoring projections.

Brief History of Outfall Monitoring Program

The Ambient Monitoring Program began in 1991, was conducted for 9 years prior to the outfall relocation, and was modified twice after the new outfall came online (April 2003 and October 2009) to reflect changes based on results that modified questions and parameters to be sampled. Although the four primary concerns still drive the monitoring program, much has changed in the past couple of decades. An Outfall Monitoring Science Advisory Panel (OMSAP) provides scientific advice to MWRA on the results from the monitoring program and makes recommendations to the U.S Environmental Protection Agency (EPA) and Massachusetts Department of Environmental Protection (MADEP) on modifications to the plan.

The nine years of pre-outfall monitoring are considered reference data, but much has changed in the nearly 18 years of post-discharge data. With climate change, we have seen rapid changes in sea surface temperatures (especially in the Northeast), rising sea levels, increased storm intensity and precipitation, and increased acidification. These and other climate-change effects are altering the chemical, physical, and biological ecosystem, independent of the outfall. In addition, new questions are arising about the presence and environmental impacts of emerging contaminants, microplastics, nanoparticles, and microbeads. After 25+ years of monitoring, it is time to review the initial questions, to evaluate results, to identify emerging issues of concern, and to examine how climate change effects can be distinguished from outfall impacts.

MWRA, EPA, OMSAP, and PIAC held a workshop in November 2018 to review past and current monitoring activities, to discuss whether the monitoring questions have been sufficiently answered, and to begin addressing climate-change impacts and emerging contaminants of concern. This document summarizes the presentations from speakers and input from stakeholders (scientists, regulators, non-government organizations, and the concerned public) who attended the workshop.

Workshop Goals

The goal of the workshop was to examine the questions asked in the monitoring plan, identify remaining issues to be addressed, and suggest emerging issues and contaminants of concern. Presenters were asked to (1) provide background information on the monitoring program, (2) address the extent to which monitoring questions have been answered sufficiently, (3) introduce climate change and how it might interact with the outfall and its effects, (4) summarize new concerns about emerging contaminants and microplastics, and (5) discuss how other wastewater treatment systems address concerns about pollutants and contaminants. The workshop was an opportunity to garner input from the public on their concerns during question-and-answer periods and breakout sessions. We have briefly summarized the talks and input from the public here; a full transcript is available at <https://seagrant.mit.edu/>.

Highlights of the Workshop

Monitoring the Outfall and Questions Asked and Answered

The long-term Ambient Monitoring Plan provides a basis for following changes over time and has provided a wealth of scientific information about the physical, chemical, and biological systems in Massachusetts Bay. The initial four questions, on which the Ambient Monitoring Plan is based, are:

- *Is it safe to eat fish and shellfish?*
- *Is it safe to swim?*
- *Are aesthetics being maintained?*
- *Are natural/living resources protected?*

The monitoring program includes sampling the effluent, water column, benthic organisms, fish, and sediments and addressing regulatory requirements for bacteria, contaminants in seafood, and aesthetics. Of the 33 monitoring questions, the majority are focused on ensuring that the ecosystem is not impacted. The pre-discharge monitoring provided a reference for ambient levels of contaminants in fish, shellfish, and sediments, occurrence of lesions in winter flounder, and measurements of several parameters that indicate health of the plankton and benthic communities. As Ken Keay (MWRA) noted, the list of constituents includes nutrients, toxic contaminants (e.g., 1990 EPA priority list of metals), polychlorinated biphenyls (PCB) and other organic compounds, indicators of human pathogens, and suspended solids that continue to be monitored, but as Betsy Reilly (MWRA) noted – contaminant levels measured in the effluent have been 100% in compliance with permit limits for the past 11 years. Overall there have been decreases in 22 of 26 contaminants, with four remaining about the same. In addition to the ongoing monitoring program, several special studies have been conducted, e.g., sediment metabolism, nutrient effluent, and acidification. To maximize efficiencies, MWRA collaborates with agencies and regional organizations to increase their information gathering.

One of the expectations of the monitoring program was to use observed changes as a means of evaluating impacts. Questions that have been answered, i.e., where monitoring did not show adverse impacts, include floatables, phytoplankton, and sediment metabolism/nutrient flux. In addition, the monitoring program was designed to test the assumptions, or the predictions, of the

modeling used for the design and relocation of the outfall. Studies to measure dilution and track the outfall plume were consistent with predictions from pre-outfall models. There are other questions that may also be considered as answered. Flounder no longer have tumors and the incidence of tumor precursors is down, contaminants in fish and shellfish are low, harmful algal blooms (which are unpredictable) have not been shown to be associated with the outfall discharge. Several other parameters are at the same or slightly higher levels, but none have exceeded the caution or warning levels. Dissolved oxygen (which is decreasing slightly as expected with increasing temperatures) is a measure of water quality and remains healthy for marine biota. The increase in the oxic layer of the sediments is an indication that organic material is not accumulating on the sediments. Benthic populations are variable over time, but diversity has been increasing. Contaminants are slightly higher in mussels, and ammonia is slightly higher around the outfall but not throughout Massachusetts Bay.

The last revision of the monitoring plan was 10 years ago, with some minor changes since then, but many “answered questions” continue to be monitored. MWRA has expressed concern about the time it takes to make changes to the monitoring plan under the permit process outlined in the National Pollutant Discharge Elimination System permit, and also that the Contingency Plan’s caution and warning levels restrict the ability to revise the monitoring plan. In addition, newer issues such as emerging contaminants are not part of the monitoring program.

Comments from the public appreciated the long-term value of the monitoring program but also recognized that there are questions not asked that should be included in the plan, e.g., questions about emerging contaminants, microplastics, and climate change impacts. There were questions about temperature (it is increasing), variability of benthos (increasing diversity is perceived as a positive outcome), changes in phyto- and zooplankton (basically no change detected), and comparison of differences between the pre- and post-outfall monitoring. Two comments addressed were how to evaluate large-scale changes that may have local impacts. One commenter raised issues about the “underwater fresh river” created by the outfall and its impact, although it was noted that the organisms growing on the diffusers remain consistent since pre-outfall discharge. Another commenter discussed the long-term Atlantic Multidecadal Oscillation that every forty years brings colder waters into the Bay and may decrease benthic diversity in coming years. Other comments suggested reduction of contaminants in the effluent should be taken into account when considering changes, consider using carbon build-up in sediments as a signature for pollution, and explore using other sentinel organisms. MWRA was credited with collaborations with other agencies, non-government organizations, and researchers – highlighting the value of special studies to investigate potential contaminants of concern as a precursor to monitoring.

Climate Change and the Outfall

Environmental conditions are variable, dynamic, and impacted by climate change. The Gulf of Maine has warmed by $>1^{\circ}\text{C}$ over the past 30 years. While this does not sound like much of an increase, fish such as black seabass, tautog, and scup, as well as blue crabs, are found farther north and in greater numbers than in the past. Juveniles of many species may be more susceptible to warming temperatures than adults. Lobsters are virtually gone from areas south of Cape Cod. But increasing temperature is not the only change we are observing. As Juliet Simpson (MIT)

noted, while precipitation is not increasing overall, it occurs in more intense events, causing flooding, changing runoff and water movement, and bringing contaminants to the ocean. Another concern is that acidification affects organisms that build shells (such as mollusks), but also those that do not, for example, fish otoliths can be affected. The challenge is to distinguish impacts that may be attributed to the outfall from those related to climate change, and also to adapt monitoring to conditions brought on by climate change (e.g., monitoring new species).

Breakout discussions highlighted challenges associated with climate change effects that are regional in scope—requiring collaborative efforts to monitor and report impacts. While MWRA collaborates with others such as the Northeastern Regional Association for Coastal and Ocean Observing System that maintains buoys throughout the Gulf of Maine, there are no equivalent monitoring programs to the one MWRA maintains. Concern about the longevity of the Deer Island wastewater treatment plant (and Boston) with rising sea levels was raised as an issue. Given the spatial scale, others recommended remote sensing both above and below the water, along with biological sampling, which may reduce the number of stations and still provide the necessary data. Others supported using models to predict outcomes (although models need data for validation), evaluating the contribution of stormwater, and including other sources of pollution. The role of Contingency Plan values and baseline or reference sites, and the complications associated with changing conditions, are challenging for separating outfall impacts from climate change-related impacts. Time scales and changes spatially over time are relevant but require monitoring. Others suggested using eDNA for assessing changes in plankton, evaluating stormwater, and identifying other polluters.

Emerging Contaminants of Concern

The definition of emerging contaminants is not universally agreed upon. As Mark Smith noted, the number of chemical compounds is huge and substances are added daily, making it difficult to review chemicals for their toxicity. MADEP lists about 1200 chemicals within their hazardous waste program. MADEP has developed a process for identifying emerging contaminants of particular concern in Massachusetts. Currently, ten compounds have been identified as priorities, some of which are currently regulated, and several are under review. There are other emerging compounds that are just beginning to be addressed, including per- and polyfluoroalkyl substances (PFAS), by-products of polychlorinated biphenyls, and microplastics and microbeads. The approach is to research potential health impact and develop standards for wastes and drinking water. The PFAS chemicals are a rapidly growing concern—over 3000 different compounds, very long-lasting, widely used (e.g., fire retardants, food containers, ski wax, waterproofing), and some very toxic with endocrine-disruptive and immunosuppressive effects.

The comments from the public included concern about impacts of pharmaceuticals and personal-care products, endocrine disrupters, and microplastics, but with the caveat that the primary source is unknown, as are the impacts. Emerging contaminants represent a typical “Catch-22” dilemma – data are needed on contaminants of concern to show impacts and presence in the water, but getting those data is limited by adequate resources and time, thus no standards are set nor are sources identified. Hence, emerging contaminants continued to be used and have not been reduced as happened with metals (by regulating metal industries), PCBs (by eliminating their use), and other priority pollutants. In addition, many other contaminants are also removed

from the effluent. Microplastics have multiple sources; one is washing machines where fibers come off clothes (e.g., polyester fleece) and are discharged into the waste stream. Wastewater treatment plants probably remove larger pieces, but those that get through may have other contaminants adhered to them and many are found in the guts of plankton. While it is not possible to monitor all contaminants, it is also not only MWRA's responsibility. Ideally, collaborative efforts are needed. There was consensus that the sources should be identified, that levels of contaminants in effluent should be compared to ambient levels, and that special studies should be conducted first rather than immediately monitoring for emerging contaminants.

Managing Wastewater in San Francisco Bay

Major differences between MWRA and wastewater treatment facilities in California are the governance structure and the approach to monitoring pollutants and contaminants of concern. The MWRA is responsible for the monitoring program, reports to EPA and MassDEP, and is funded by ratepayers. The agency collaborates with others for efficiency and to conduct special studies to enhance the monitoring program. The governance structure of San Francisco Bay (SF Bay) is regional with participation of other wastewater treatment plants, whereas in Massachusetts, only MWRA is required to monitor and demonstrate they are not causing harm. The approach to determining what to monitor is also different. Total Maximum Daily Loads are set for the SF Bay for a variety of pollutants and contaminants and are used to measure how well the plants are performing. Contaminants of concern such as polybrominated diphenyl ethers, PCBs, PFAS, and other emerging contaminants are addressed throughout the system with each wastewater treatment plant developing their own approach. Funding is provided by assessments to the permits and managed by the San Francisco Bay Regional Water Quality Board, a regional governing body.

Mike Connor (Retired General Manager, East Bay Dischargers Authority) compared the outcomes of SF Bay approach to the MWRA approach, which were basically similar, but with better efficiency of nutrient removal and more flexibility in the SF Bay approach. While both achieve their goals, the burden of the monitoring in Massachusetts Bay resides primarily with MWRA. As a former director of the MWRA Environmental Quality Department, he noted that MWRA is currently monitoring parameters, such as "priority" pollutants that no longer considered priority (except for mercury and few others) and many others that were thought to be an issue when the monitoring began. He stressed the value of reducing monitoring of pollutants that have decreased or remained the same and instead focusing on special studies to address specific issues, and using these to focus on broader issues that support ecosystem health. With a strong governance structure, MWRA has four elements of good monitoring programs – stable funding, good science, public involvement, and flexibility.

Looking Forward

The data and science of the current Ambient Monitoring Plan are valuable resources that have demonstrated that Mass Bay has not been adversely affected by the outfall. Nonetheless, after 25+ years of monitoring, the questions and approach to answering questions of the Ambient Monitoring Program deserve review and revision to address current and trending issues of environmental concern associated with the outfall discharge as we look toward the future.

Ecosystem protection remains a high priority and the goal will be to develop a monitoring program that reflects the outfall contribution relative to climate change impacts, contaminants of concern, and contributions of other dischargers. Continued collaboration, incorporation of new technologies, wise use of models, and commitments to good science will continue to drive the revisions.