The MWRA Monitoring Program in Boston Harbor and Massachusetts Bay

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Background

The Massachusetts Water Resources Authority (MWRA) was formed in 1984 to provide water and sewage services to member communities in metropolitan Boston, and to clean up a polluted Boston Harbor by improving wastewater treatment. The Boston Harbor Project involved moving Boston-area wastewater discharge 9.5 miles from Deer Island into Massachusetts Bay to improve conditions in the Harbor (which until then had been receiving the treated sewage) and the addition of secondary treatment at the Deer Island Treatment Plant. The new outfall became active in 2000. Regulators and concerned citizens wanted to ensure the continued health of the ecosystems of Massachusetts and Cape Cod Bays, so MWRA was required to measure any potential effects of the Bay outfall through an extensive monitoring plan (Fig. 1, Fig. 2). MWRA monitoring of the water column and sea floor has not revealed any adverse impacts of the discharge within Massachusetts Bay.

Methods

Sampling by MWRA and its consultants has been conducted in Boston Harbor and Massachusetts and Cape Cod Bays since 1992, decreasingly slightly in frequency as initial concerns were allayed. Today, crews on ships conduct nine water quality surveys annually (Fig. 2). Monitoring of the sea floor and fish/shellfish occurs less frequently through fishing, sea floor sediment grab samples, and underwater cameras. Sampling analysis and results are compiled in technical reports for the Environmental Protection Agency, the state Department of Environmental Protection, the broader scientific community, and the public.

Sampling Locations and Survey Schedule

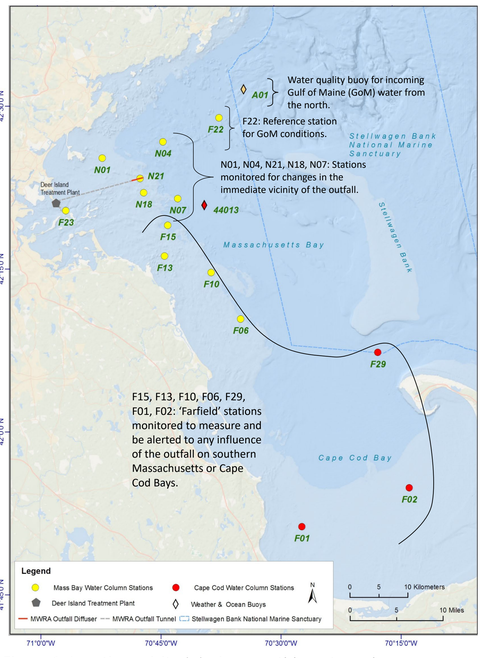

Figure 1: Locations visited during monthly water column surveys

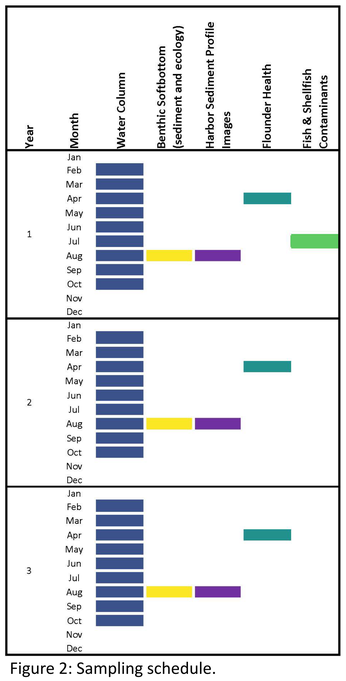

Figure 2: Sampling schedule.

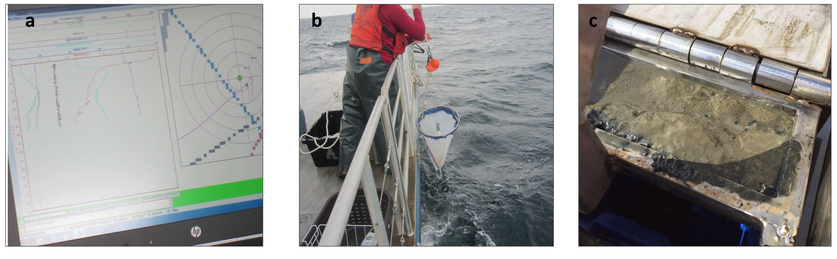

Figure 3: Photos of field monitoring methods and results (left to right): Monitoring water column profile data during survey (a); retrieving zooplankton net tow (b); benthic (sea floor) grab sample (c).

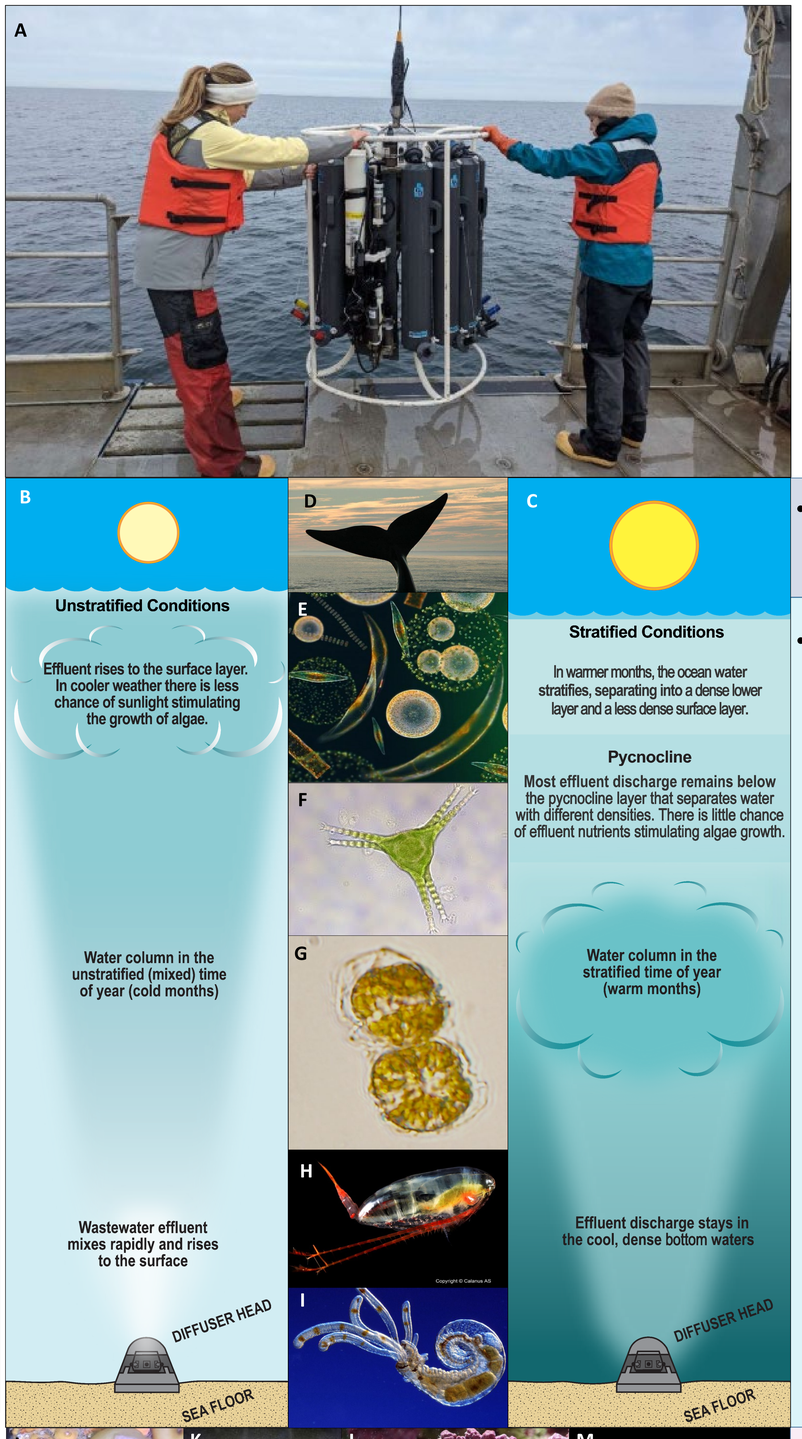

Figure 4: (**A**) Crews deploying a sampling device called a rosette into the water column to collect water samples and measure water quality parameters. Figures below show water column in the winter – well mixed conditions (**B**), and summer - stratified conditions (**C**). We report any marine mammal sightings (**D**). Photos show the various organisms or characteristics that we measure within the water column or sea floor including phyto (**E-G**)- and zooplankton (**H-I**) in the water column , and anemones (**J**), sediment type (**K**), algae (**L**), and flounder (**M**) along the sea floor.

What is monitored and why?

MWRA and regulators designed the monitoring plan to address 33 questions with four main themes:

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

To address these questions, we monitor for **direct** and **indirect** impacts that nutrients and other parameters can have on the ecosystem. Direct impacts include toxicity from contaminants in the effluent, which an organism would interact with immediately. Indirect impacts occur if the effluent triggers changes that impact biological or ecological functioning and could cause harm, such as eutrophication, or disruption of the food web. The following parameters that we measure through monitoring are throughout the water column in the sea surface layer, the water column, which can be well mixed or stratified (layered) depending on the time of year, and the sea floor.

- **Water surface** observations are important for aesthetics and can signal a problem with the wastewater treatment process. We look for:
  - Oil, grease, and visible debris

- **Water column** measurements can signal water quality impacts from the discharge. We are most concerned with eutrophication, which occurs when phytoplankton populations grow rapidly. When the phytoplankton cells die and sink, bacteria degrade the organic matter, consuming dissolved oxygen in the process. This can ultimately reduce dissolved oxygen in the water that organisms depend on, harming marine life. To monitor for signs of eutrophication, we measure:
  - Physical and chemical properties:
    - Dissolved oxygen/Temperature/pH/Salinity/Density;
    - Stratification/Seasonality (which controls phytoplankton distribution within the water column).
  - Nutrients: Ammonia*, Nitrate+Nitrite, Silicate, Phosphate, Total Dissolved Nitrogen, Total Dissolved Phosphorus, Particulate Organic Nutrients.
    - Monitored at multiple depths of the water column for the potential to overstimulate phytoplankton growth.

    *Ammonia provides the best indicator for the presence of effluent in the environment.
  - Biological parameters: phytoplankton+ and zooplankton abundance, species identification, and in some cases, life cycle stage.
    - Their abundance characterizes ecosystem productivity, which serves as the base of food webs for fish and marine mammals.
    - Phytoplankton utilize nutrients and sunlight to produce oxygen. When overly abundant, their decomposition can lead to low dissolved oxygen levels (eutrophication).
    - Zooplankton graze (eat) the phytoplankton and are an important food source for many marine organisms, from small fishes to large whales!

    + Including potentially harmful species of phytoplankton.

- **Ocean Floor** measurements assess species composition and sediment conditions. Is the seafloor near the outfall impacted relative to other parts of Massachusetts Bay considering debris, toxicity, and sediment oxygen?
  - Toxicology measurements: Fish/shellfish tissue, flounder health (Fig. 4 panel M)
  - Ecological measurements: Species occurrence and diversity (e.g., sponges, anemones, and algae (Fig 4 panels J and L)
  - Seafloor sediment characteristics (Fig. 4 panel K)

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