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# Predicting the Impact of Relocating Boston's Sewage Outfall—Effluent Dilution Simulations in Massachusetts Bay

## Introduction

For nearly 300 years, Boston Harbor has been the disposal site for regional sewage. Today, Boston is approaching completion of a $3.5 billion court-ordered cleanup project that includes elimination of sludge discharge, treatment of secondary sewage, and containment of combined sewer overflows. One aspect of the project, however, has created substantial controversy—the relocation of the sewage outfall from the mouth of Boston Harbor to a new site 15 km offshore in Massachusetts Bay (fig. 1). There is concern that the new outfall, scheduled to begin discharge in October 1998, might turn Massachusetts Bay into the next Boston Harbor and that whales and other species in the region (which includes the Stellwagen Bank National Marine Sanctuary) might be endangered.

Computer simulations conducted by the U.S. Geological Survey (USGS) of sewage effluent dilution indicate that, while elevated effluent levels will be found within a few kilometers of the new outfall, effluent levels will remain low throughout most of Massachusetts Bay and will dramatically decrease in Boston Harbor. The new outfall site in western Massachusetts Bay has the important advantage of being in deeper water. This location allows greater dilution of effluent when compared with that in the shallow, confined waters of Boston Harbor. As a result, the areal extent of relatively high effluent levels will be reduced.

## Simulation Models

In recent years, there has been significant progress in the development of numerical circulation models that are able to simulate and predict the transport processes that operate in coastal areas. Such models, when properly configured and validated with observational data, are often the best tool for evaluating management scenarios in the coastal ocean. Because of the complexity of driving forces and topography in Boston Harbor and Massachusetts Bay, computer models have played a critical role in predicting how sewage effluent released from the new outfall will be transported and diluted.

The Estuarine and Coastal Ocean Model (ECOM) was used to study the new Massachusetts Bay outfall site; this model was originally developed by George Mellor and Alan Blumberg at Princeton University and has been further refined by the oceanographic community over the past 10 years. It has been used in more than 40 studies in coastal waters worldwide. The model simulates currents and water properties in three dimensions (and time), driven by wind, river runoff, offshore discharges of freshwater, surface heating and cooling, tides, and sea-level fluctuations in the open ocean. In Massachusetts Bay, the model has been used to study the flushing characteristics of Boston Harbor, to provide input for a

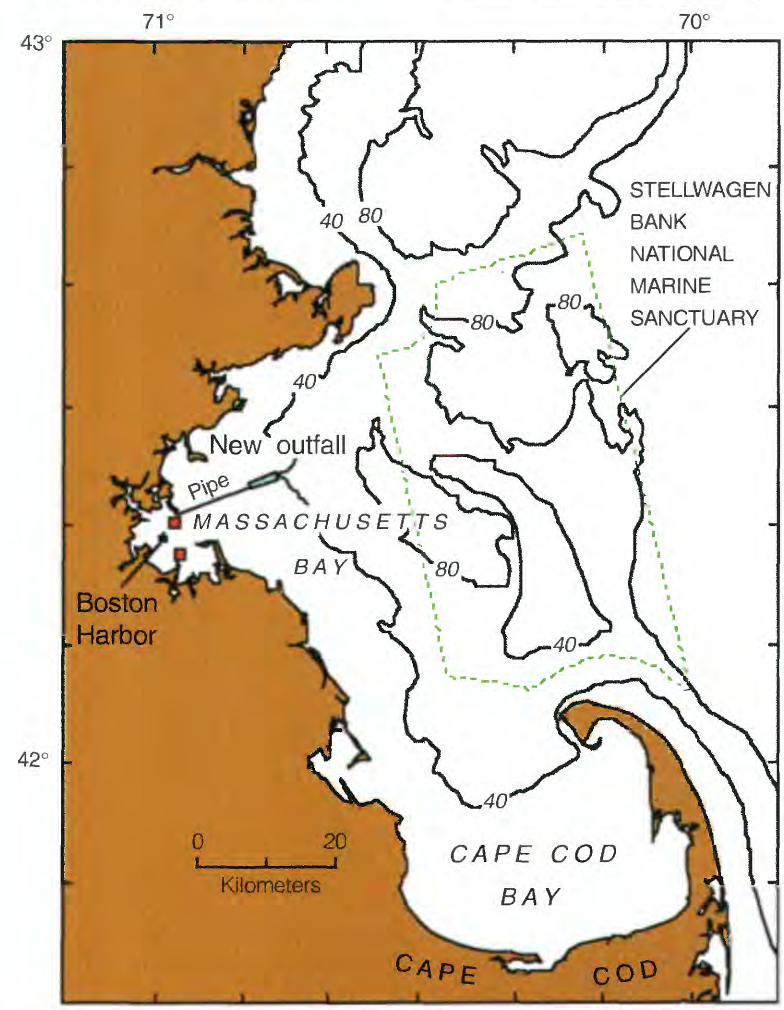


**Figure 1.** Massachusetts and Cape Cod Bays, present sewage outfalls in Boston Harbor (red squares), location of new ocean outfall (blue rectangle) for treated Boston sewage in western Massachusetts Bay, and the location of the Stellwagen Bank National Marine Sanctuary. The 40- and 80-m depth contours are also shown.

baywide water-quality model, and to assess the impact of possible chlorination failure at the new outfall location, as well as to predict effluent dilution.

In studies by the USGS, the ECOM model was configured to encompass all of Massachusetts and Cape Cod Bays, with a resolution that varied from approximately 1 km in western Massachusetts Bay to about 6 km in the open ocean outside Massachusetts Bay. Simulations were performed over an 18-month period from January 1990 to July 1991, a time of particularly intense oceanographic data collection by the Massachusetts Bays Estuary Program, a program funded by the U.S. Environmental Protection Agency.

## Utility of the ECOM Model

Comparing the model to the observational data gathered showed that the model reproduced the development of seasonal stratification in the bay and the statistics for currents responsible for effluent transport in western Massachusetts Bay. The model was therefore judged to be appropriate for use in simulating effluent fields produced by continuous discharge in this region. Comparative dilution simulations for the existing outfalls and for the new outfall (figs. 2 and 3) projected that effluent concentrations in Boston Harbor will be greatly reduced by using the new outfall site, without significantly increasing concentrations in most of Massachusetts Bay. Thus, the model-simulations supported the use of the new outfall.

## The Future

While these effluent-concentration simulations are encouraging, dilution alone will not solve the pollution problem in this area. Although dilution can decrease the impact of pollutant effects in the water column, pollutants that settle into the sediments can accumulate in the ecosystem, and for some contaminants, source reduction is the only viable long-term solution. For this reason, the ocean outfall site will be complemented by a new secondary sewage treatment plant that will greatly reduce the levels of solid sewage and toxic substances entering the ecosystem.

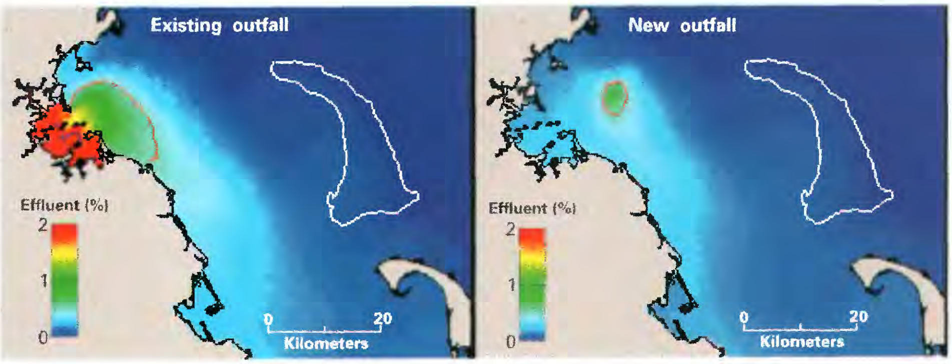


**Figure 2.** Model comparison of winter near-surface (2-m depth) effluent concentrations at the existing sewage outfalls and at the new outfall. The red line indicates a concentration of 0.5 percent (200-fold dilution of effluent), which is approximately the level at which nutrient levels released in the effluent are comparable to background variability. With the existing outfall locations, high effluent concentrations are found within Boston Harbor and along the coastline immediately south. With the new outfall location, high concentrations are found only within a few kilometers of the outfall, concentrations are dramatically lower in Boston Harbor, and concentrations in most of Massachusetts Bay (including the region near Stellwagen Bank) are not significantly changed from their existing low levels. The white outline indicates the location of Stellwagen Bank.

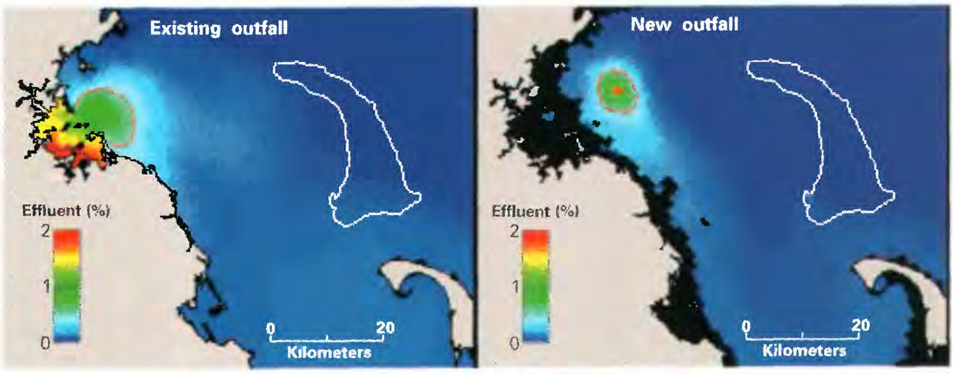


**Figure 3.** Model comparison of summer near-surface (2-m depth) effluent concentrations at the existing sewage outfalls and of summer middepth (16-m depth) concentrations at the new outfall. At the new outfall location, effluent is trapped at middepth during the summer beneath the warm surface layer, while effluent from the existing outfalls remains near the surface. The areal extent of high effluent concentration at the new outfall is smaller, as in winter (see fig. 2), than at the existing outfalls. In addition, because nutrients from the new outfall are trapped in waters that are already nutrient rich, the impact of sewage-borne nutrients is decreased.

Models provide our best estimate of what will happen, but they are based on projections, not certainties. Unforeseen events such as pipeline leaks or the failure of chlorination at the new location can occur. In the baywide monitoring program currently underway in Massachusetts Bay, trigger levels have been set and contingency plans developed to ensure that such events will be detected and corrective action taken, once the new outfall is activated.

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