Sea Grant
Woods Hole
Focal Points
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The Massachusetts Bay Outfall

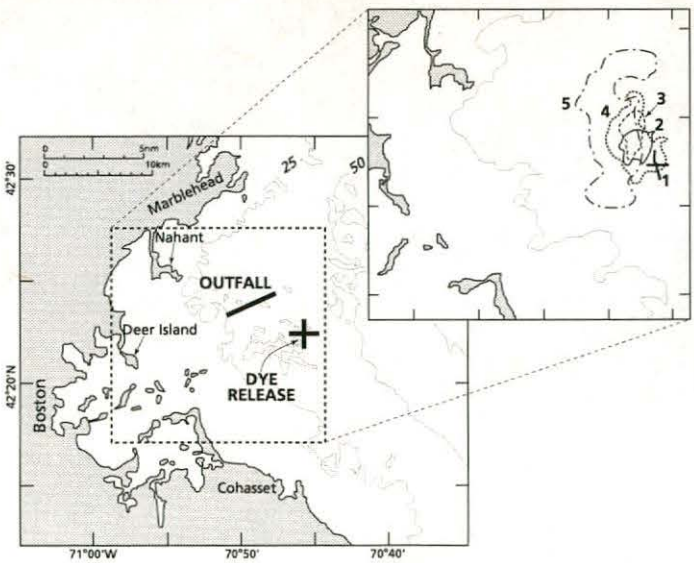
Introduction

Since the time of the Boston Tea Party during the American Revolution, Boston Harbor has received a wide range of society's wastes. This history culminated in political debates during the 1988 presidential campaign designating Boston Harbor as the "Harbor of Shame" and the dirtiest harbor in the country. Decades of debate on the best approaches to clean up Boston Harbor resulted in decades of inactivity in solving the emerging water quality and sediment quality problems. In 1985 the Massachusetts Water Resources Authority (MWRA) was created to modernize water and sewer services in the metropolitan Boston area and to spearhead the cleanup of the harbor. Forty-three communities are served by the MWRA sewage treatment facilities. To bring Boston's waste treatment facility into compliance with the Federal Clean Water Act, a court order was issued that mandated specific milestones for the construction of new wastewater treatment facilities. At a cost estimated at $3.5 billion, the Boston Harbor Project includes new primary and secondary sewage treatment plants and a 9.5-mile, 24-foot diameter tunnel that will discharge treated effluent into Massachusetts Bay. Construction of new treatment facilities began in 1989 and will be completed in 1999. Improvements in water quality have already been noted in Boston Harbor, especially with the cessation of sludge dumping in the inner harbor. Some examples of improved conditions include lower levels of contaminants discharged to the harbor, beaches open for swimming, and a more diverse benthic community.

The new outfall will be completed in the fall of 1998 and effluent will then be discharged at the Massachusetts Bay site. When the offshore outfall was initially proposed, many questions were raised by local communities on the potential impacts of effluent discharge in the relatively pristine waters of outer Massachusetts Bay and Cape Cod Bay. Some of these concerns included potential for eutrophication and harmful algal blooms, altering food chain dynamics—especially in feeding grounds for the endangered right whale—and relocating contaminants from Boston Harbor to the shores of Cape Cod.

Sea Grant Funds Baseline Data Collection

To address the concerns identified above, WHOI Sea Grant supported several investigations, beginning in 1992, directed at a better understanding of the poten-



Rhodamine dye was released into Massachusetts Bay in the shape of a '+' in August, 1993. The vertical and horizontal spreading of the dye was monitored for the next 4 days. Horizontal spreading of the dye is depicted in the inset (numbers correspond to days, 1 being the deployment day). The spreading of the dye patch allows the mixing rates of the Bay to be quantified, which will lead to more accurate estimates of the dilution and transport of the sewage effluent.

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tial effects that discharges from the new outfall may have on Massachusetts and Cape Cod Bays:

Circulation Studies

Multidisciplinary studies focusing on the circulation in Massachusetts Bay began in 1993. Circulation in the Bay influences the transport of nutrients and other contaminants across the thermocline, the boundary that separates a warm water layer from a cold water layer. Using dye tracer studies to examine the movement of water masses and quantify dilution rates, the vertical mixing of the water column in the vicinity of the outfall site was examined under different environmental conditions.

Results of the first vertical mixing study in Massachusetts Bay revealed a much lower estimate of vertical mixing across the thermocline than was anticipated by the researchers, based on seasonally averaged mixing rates in the bay. This lower rate was determined to be indicative of the pronounced stabilizing influence of stratification, or layering of the water, even in the presence of strong internal tidal motions.

These data were then incorporated into numerical models of the Bay to gain a better understanding of the nutrient dynamics of the Bay and to predict the fate of the effluent, which will be discharged below the thermocline and may be mixed into the upper layer, where it could contribute to excessive phytoplankton production. This study suggested that the rate of transfer is small enough that there should not be excessive vertical exchange.

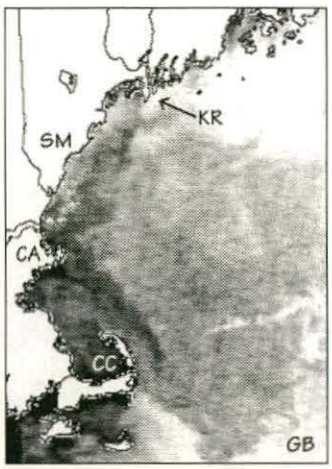
The first study of mixing in the middle of the Bay prompted a second dye study to look at mixing along the boundary region of Massachusetts Bay. This study yielded important information about the predominant water movement in summer conditions—and thus the fate of pollutants introduced at the outfall—a concern to many residents of the South Shore and Cape regions. Results of this study indicate that there is not a dramatic increase in mixing in the near-shore region, but the mixing is enhanced enough that boundary mixing makes a significant contribution to the bay-wide exchange. These results are good news for communities southeast of the outfall, where residents expressed concerns about increased pollutants from the outfall.

These Sea Grant studies complement ongoing activities by the MWRA and the U.S. Geological Survey to provide an independent assessment of environmental concerns.

Nutrient Studies

Nutrient enrichment in the offshore environment of Massachusetts Bay and Cape Cod Bay raises concerns for the long-term effects of the effluents on the ecological conditions of these waters including the potential for the increased frequency of harfmul algal blooms and altered food chain dynamics.

Ongoing efforts supported by WHOI Sea Grant are focused on understanding the dynamics of toxic dinoflagellate blooms in Massachusetts Bay. Recurrent episodes of Paralytic Shellfish



NOAA Coastwatch satellite image of sea surface temperature, on May 23, 1992, at 3 a.m. A warmer (darker) coastal current or plume formed principally from spring runoff from the Kennebec River (KR) in southern Maine (SM) and the Merrimack River near Cape Ann (CA) in Massachusetts was detectable in the imagery. The toxic dinoflagellate *Alexandrium sp.* has been shown to be associated with the less-saline, warmer (darker) surface waters of the plume. The plume extends several hundred kilometers along the coast from the Kennebec River (KR) in Maine to the east of Cape Cod (CC) affecting nearshore shellfish and may also potentially impact shellfish resources on Georges Bank (GB) as it travels south and further offshore.

Poisoning (PSP) caused by blooms of the dinoflagellate *Alexandrium* have been reported for this area and pose serious human health, ecological and economic concerns for the region. The PSP toxin can be passed along the food chain and present serious problems for high level consumers including humans and marine mammals. Intensive field efforts are being conducted now to establish baseline conditions before the outfall is "on-line." Once the outfall goes on-line, field sampling will continue to examine nutrient conditions, bloom frequency, and the transfer of PSP toxins through the food chain. In addition, a comparative analysis of twenty-five years of monitoring data for PSP in shellfish populations from coastal embayments will be conducted to develop a statistical model of pre-outfall variability in shellfish toxicity.

Additional studies are directed at examining the benthic processing of sewage inputs into Boston Harbor and offshore waters in Massachusetts Bay. One study confirmed that sewage material does enter marine food webs and that stable isotopes can be used to trace the input of sewage. The study used a dual tracer approach—nitrogen and sulfur stable isotopes—which proved to be especially valuable in Boston Harbor, where both inorganic nutrients and sewage particulates are released.

Another study gathered baseline data for Boston Harbor and Massachusetts Bay with regard to benthic oxygen consumption, nutrient release, and denitrification. The cold, deeper waters of Massachusetts Bay tend to stratify, or form layers, thus presenting an environment that may handle sewage-derived nutrients differently than other, previously studied environments. Results from that study revealed that Massachusetts Bay sediments may play a significant role in the nitrogen budget of the bay, removing 25% of the anthropogenic nitrogen entering the bay. The absolute rates of denitrification in Boston Harbor were higher

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than in the bay, but only remove about 12% of the anthropogenic nitrogen inputs to the harbor because of the much higher nitrogen loading to the harbor. These results could be of use to many coastal communities involved in developing nutrient loading bylaws.

Future Research Studies

When effluents are discharged from the offshore outfall beginning in the fall of 1998, citizen groups will carefully review the results of monitoring programs to ensure that effluents are adequately diluted and adverse conditions do not occur. The MWRA has developed an action plan that identifies key environmental parameters and threshold values that, if exceeded, will require remedial action by MWRA. WHOI Sea Grant will continue to support investigations on fundamental processes in the offshore habitats of Massachusetts and Cape Cod Bays that may explain the natural variability in ecosystem parameters and help explain the trigger points of post-outfall effects.

For more information about the research or outreach projects profiled in *Focal Points*, contact WHOI Sea Grant at the address listed above.