Current Research Supported By The Woods Hole Oceanographic Institution Sea Grant Program

The Boston Harbor Cleanup Project: Background

The Massachusetts Water Resources Authority (MWRA) was created in 1985 to modernize water and sewer services in the metropolitan Boston area and to spearhead the cleanup of the harbor. Parts of this program have been ordered by a Federal court which found the MWRA and its predecessor agency in violation of both state and federal clean water laws. At a cost estimated at $6 billion, the Boston Harbor Project includes new primary and secondary sewage treatment plants to be built according to a court-mandated schedule, along with a 9.5 mile, 24-foot diameter tunnel that will discharge treated effluent into Massachusetts Bay. The objective is to replace the inadequate and antiquated facilities on Deer and Nut Islands which discharge sludge and primary-treated effluent directly into Boston Harbor with a program of sludge processing and disposal on land and the discharge of cleaner effluent to the deeper waters of Massachusetts Bay.

The cleanup of Boston Harbor is a daunting undertaking. Five hundred million gallons of sewage flow into the harbor each day. Waste from 2 million people and 5,500 businesses and industries from 43 communities surrounding Boston is sent to Boston Harbor. The existing system has over 5,000 miles of pipes, some more than a century old. Aging pipes allow groundwater to leak in, further increasing the load sent to the harbor, which is known as the dirtiest harbor in the United States. Toxic chemicals from industries and households contaminate the water, posing serious threats to fisheries and wildlife. The oldest pipes, called combined sewers, carry street runoff as well as sewage. Heavy rains flood these sewers, causing untreated waste to overflow from pipes along the shoreline onto beaches and into the harbor and rivers. These are called combined sewer overflows, or CSOs.

New facilities, scheduled for primary operation in 1995, include the 9.5 mile tunnel that will be 250 feet below the surface of the water. This tunnel will discharge up to 1.2 billion gallons of liquid effluent daily and treated sewage will be discharged into approximately 110 feet of water through a series of 55 diffusers, rising from the tunnel to about 14 feet above the bay floor. A second rock tunnel under the harbor, scheduled for completion in 1999, will carry sewage five miles from Nut Island to Deer Island for treatment. Sludge will be barged off Deer Island for processing. Once the project is completed, effluent discharged from the tunnel is expected to be cleansed of 90 percent of solids and 85 percent of toxins.

The WHOI Sea Grant Program, recognizing the importance of the issues and concerns expressed by both opponents of the Boston Harbor outfall as well as proponents, will provide support for three separate but related research projects to be conducted over the 1992-1994 funding period:

Toxic Red Tides in Massachusetts and Cape Cod Bays

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Toxic or harmful algal blooms, commonly called "**red tides,**" are a serious economic and public health problem throughout the United States and the world. In the New England region, the most serious problem in this context is that of paralytic shellfish poisoning (PSP), a potentially fatal neurological disorder caused by human ingestion of shellfish that accumulate toxins as they feed on dinoflagellates of the genus *Alexandrium*. Twenty years ago, PSP was virtually unknown in New England, yet now, significant portions of the region's intertidal shellfish resources are closed annually due to toxicity, and the vast resources of Georges Bank and Nantucket Shoals have also recently been shown to contain dangerous toxin levels.

Our understanding of *Alexandrium* bloom dynamics and transport within Massachusetts and Cape Cod Bays is too limited at present to support an estimate of possible impact. Investigators know that a buoyant plume of water originating in rivers from New Hampshire and Maine enters Massachusetts Bay from the north near Cape Ann carrying toxic *Alexandrium* cells, but the fate of the cells within the bay is not known. It is also known that outbreaks of PSP on the southwestern shore of Massachusetts Bay (the "south shore") are more sporadic than those on Cape Ann and the northern coast of Massachusetts (the "north shore"), occurring every few years rather than annually. Investigators now believe that the same blooms that cause toxicity along the north shore traverse the Bay and cause south shore toxicity as well — in effect, that the buoyant plume and its associated cells enter the Bay from the north and in some years, proceed directly south to intercept the south shore at Scituate, Massachusetts.

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This Sea Grant-supported study will seek to develop an understanding of the bloom dynamics of *Alexandrium tamarense* within the bay, as well as the nutrient status of the population in the vicinity of the outfall site. These investigators will provide some of the necessary information needed for a realistic evaluation of the potential impact of the outfall.

Benthic Processing of SewageAdditions: Role in Anoxia and Nitrogen Cycling

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Coastal communities are facing ever-increasing demands to increase their level of sewage treatment prior to discharging into harbors and bays. To meet judicial mandates for improved sewage disposal and treatment in the Boston area, the Massachusetts Water Resources Authority (MWRA) has begun the construction of a new sewage treatment plant and a new outfall to be located at the bottom of Massachusetts Bay in water 32 m deep. Improved sewage treatment, cessation of sludge discharge, prevention of combined sewer overflow (CSO), and moving the wastewater discharge from within the confines of Boston Harbor are expected to result in significant improvement in the water and sediment quality within the Boston Harbor area.

Injecting sewage into the deep waters of Massachusetts Bay, which are stratified for at least half the year, represents a significant departure from current practice, where injection is into a shallow, well-mixed water column. As a result of the seasonal stratification, two major concerns arise from the proposed deep-water discharge of sewage: (1) Increased oxygen demand and potential lack of oxygen in bottom waters, and (2) Greatly increased concentrations of dissolved inorganic nitrogen in bottom waters which may lead to blooms in remote locations such as Cape Cod Bay

This study will provide critical information on the benthic response to organic and inorganic nitrogen inputs and an ability to trace Boston sewage nitrogen inputs so as to be able to "fingerprint" the nutrients responsible for blooms in the far-field (Cape Cod Bay, for example). This study will also enable researchers to collect baseline data in the Boston Harbor and Massachusetts Bay area **before** the current outfall is moved and to develop models that will help to **predict** the effects of sewage diversion throughout Massachusetts and Cape Cod Bays.

Vertical Mixing Processes in Massachusetts Bay

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Vertical mixing across the thermocline is a physical process of great importance to the ecology of coastal waters, since it often determines the rate at which nutrients are delivered to the euphotic zone, thus controlling the rate of primary production. Like many deep bays, Massachusetts Bay has a strong thermocline that acts as a partial barrier to the vertical transport of nutrients, as evidenced by very strong gradients of nutrients across the thermocline (Townsend, et al. 1991), and virtually no inorganic nitrogen in the surface mixed layer during the period of strong stratification. **The extent to which nutrients from the deep water support phytoplankton growth depends sensitively on the rate of vertical mixing, since it controls the transport of nutrients into the euphotic zone.**

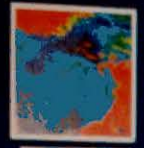
This Sea Grant study addresses the rate of vertical mixing in Massachusetts Bay with the implementation of a dye study. Rhodamine, a fluorescent dye, will be injected in a thin layer in a position within the thermocline that has the strongest nutrient gradients (Townsend et al 1991), hence the vertical mixing at this level has the most pronounced influence on nutrient fluxes. The dye will be tracked for four days as it disperses horizontally and vertically. Measuring the vertical distribution of the dye will be critical for investigators to determine the rate of vertical mixing within the bay.

The results of this study will be particularly useful for calibrating numerical models of the hydrodynamics and nutrient dynamics of coastal environments such as Massachusetts Bay. The results will be used by environmental managers and engineers to assess the impact of future sewage effluent in Massachusetts Bay.

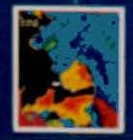
SEA GRANT PROGRAM
Woods Hole Oceanographic Institution

WHOI Sea Grant Program Supports Research on the Boston Harbor Outfall

Toxic Red Tides in Massachusetts and Cape Cod Bays



Vertical Mixing Processes in Massachusetts Bay



Benthic Processing of Sewage Additions: Role in Anoxia and Nitrogen Cycling