BOSTON HARBOR ISLANDS – A NATIONAL PARK AREA,

MASSACHUSETTS

WATER RESOURCES SCOPING REPORT

Mark D. Flora

Technical Report NPS/NRWRD/NRTR-2002/300

WATER RESOURCES DIVISION

National Park Service - Department of the Interior
Fort Collins - Denver - Washington

United States Department of the Interior • National Park Service

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December, 2002

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United States Department of the Interior

National Park Service

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ACKNOWLEDGEMENTS

Information contained within this water resources scoping report is derived from many sources, including a review of the existing hydrologic information pertaining to past and present water resource conditions, a scoping session held for members of the Boston Harbor Islands Partnership and other interested parties (May, 2000), field trips and site visits, and discussions held with island managers and subject-matter experts familiar with water-related conditions within the Boston Harbor Islands national park area.

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EXECUTIVE SUMMARY

Boston Harbor Islands national park area is a unique unit of the national park system. Rather than having the National Park Service own and manage the park, the federal law establishing the national park area made the National Park Service a nonland-owning participant in the 13 member Boston Harbor Islands Partnership. This Boston Harbor Islands National Park Area Water Resources Scoping Report was developed by the National Park Service's Water Resources Division in order to assist the Boston Harbor Islands Partnership in identifying and understanding water-related issues relevant to the management of the national park area.

Section I of this report (Introduction) provides national park area background information pertinent to natural resource planning. This includes a description of park location, legislation, park purposes and management.

Section II of the water resources scoping report (Hydrologic Environment) consists of a retrospective analysis designed to provide the Partnership with a description of the water-related resources of the national park area and an assessment of the current condition of water-related resources affecting the national park area.

Section III of the water resources scoping report (Significant Water-Related Issues) provides a discussion of water-related management issues identified by national park area partners. A water resources issues identification and scoping workshop was held on May 3, 2000, in order to identify concerns and exchange information pertaining to water-related issues among the various members of the Boston Harbor Islands Partnership and other interested entities. The results of this scoping session listed in rank order as identified by the workshop participants include:

Inadequacy of available baseline resource information

intertidal resources (salt marshes, tidal flats, rocky intertidal)
coastal processes / erosion
wetland resources (ponds, freshwater marshes, brackish marshes)
subtidal resources (eel grass beds)

Water Quality Issues

potential impacts of marinas/mooring areas
infrastructural issues (septic/sewage management/hazmat)
public health / recreational water quality monitoring
impacts of water quality on shellfish harvesting
need for additional spill contingency planning

Water Supply / Groundwater Issues

Section IV of this report (Considerations for Future Actions) provides the Boston Harbor Islands Partnership with suggestions for future action pertaining to these issues based upon follow-up discussions with recognized local and regional subject matter experts and a review of the current scientific literature. Considerations for future action include:

- endorse and support Massachusetts Water Resources Authority's (MWRA) harbor-wide water quality monitoring efforts and support collaboration with the pending NPS "vital signs" monitoring program;

- endorse further erosion research and monitoring and the development of potential mitigation alternatives;
- consider additional intertidal zone inventory and research activities;
- enhance water and wastewater infrastructural planning;
- continue Metropolitan District Commission (MDC) recreational water quality monitoring within the Boston Harbor Islands national park area;
- assess needs and establish priorities for the completion of necessary environmental audits;
- endorse The Trustees Of Reservations (TTOR) wetlands restoration activities / support actions to identify other potential restoration activities;
- enhance awareness of invasive species issues and concerns;
- facilitate the exchange of additional sensitive resource information for incorporation into spill contingency planning activities;
- commission a study to evaluate maintenance needs of sea walls and rip-rap and to determine the impact of these structures on geomorphic processes;
- incorporate water-related recommendations into the Boston Harbor Islands national park area strategic plan.

This report was accepted and the recommendations endorsed by unanimous vote of the Boston Harbor Islands Partnership on December 17, 2002.

I - Introduction

Whether supporting natural systems or providing for visitor use, water is a significant resource in units of the national park system. Consistent with its fundamental purpose, the National Park Service seeks to protect surface and ground waters as integral components of a unit's aquatic and terrestrial ecosystem by carefully managing the consumptive use of water. The National Park Service also strives to maintain the natural quality of surface and ground waters in accordance with all applicable federal, state, and local laws and regulations. Water-based recreation such as swimming, fishing, shell fish harvesting, and recreational boating as well as ecosystem health are also highly dependent upon the maintenance of adequate water quality.

Water is perhaps the key visible landscape element for the Boston Harbor Islands. Given the region's legacy of environmental problems, efforts over the last two decades to resolve these problems, and the increasing demand upon the harbor as an important commercial, recreational, and historical resource, it has become paramount that the preservation and conservation of water resources be seen as critical to the maintenance of the harbor's biological diversity.

a. Park Location, Legislation, Purpose and Management

Boston Harbor Islands national park area (BOHA) consists of over 1500 acres of coastal woodlands, dunes, freshwater, estuarine, and marine wetlands, and sandy and rocky beaches scattered over 30 glacial drumlins and/or bedrock outcrops within the 50 sq mi Boston Harbor (Figure 1).

The Boston Harbor Islands became a unit of the national park system in November, 1996 by an act of Congress (Public Law 104-333) that contains special provisions which make this a unique unit of the national park system. Rather than having the National Park Service own and manage the park, P.L. 104-333 made the National Park Service a nonland-owning participant in the 13-member Boston Harbor Islands Partnership. The Partnership was directed by the legislation "to coordinate the activities of the Federal, State and local authorities and the private sector in the development and implementation of a general management plan". Members of the Boston Harbor Islands Partnership include the National Park Service, U.S. Coast Guard, Massachusetts Department of Environmental Management, Metropolitan District Commission, Massachusetts Water Resources Authority, Massachusetts Port Authority, City of Boston, Boston Redevelopment Authority, Thompson Island Outward Bound Education Center, The Trustees of Reservations, and Boston Harbor Islands Advisory Council. The legislation also established the 28-member Boston Harbor Islands Advisory Council to advise the Partnership regarding the development of the general management plan, as well as the Island Alliance, a non-profit organization charged with generating private funding for the park.

The purpose of the Boston Harbor Islands national park area is threefold: to preserve and protect a drumlin island system within Boston Harbor, along with the associated natural, cultural, and historic resources; to tell the islands' individual stories and enhance public understanding and appreciation of the island system as a whole; and to provide public access, where appropriate, to the islands and surrounding waters for the education, enjoyment, and scientific and scholarly research of this and future generations (National Park Service, 2000).

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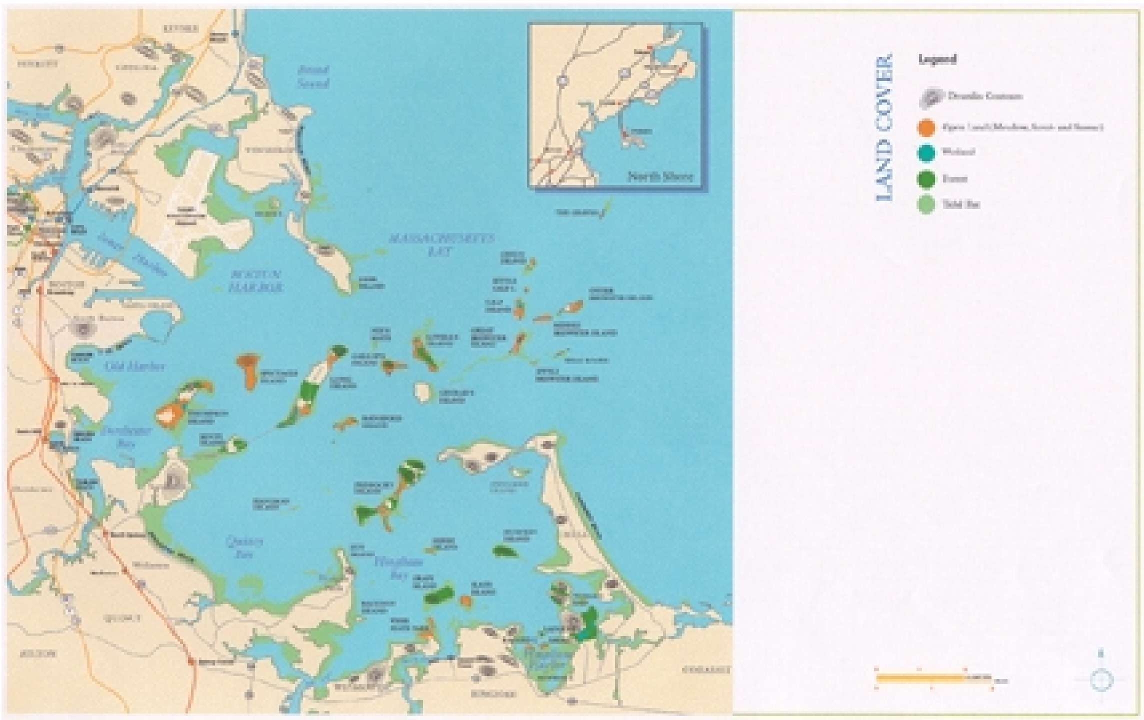


Fig. 1. Boston Harbor Islands National Park Area.

Table 1. Areas within the Boston Harbor Islands national park area.

Area	Town	Size	Management
Bumpkin Island	Hull	35 acres	DEM
Button Island	Hingham	< 1 acre	Town of Hingham
Calf Island	Hull	17 acres	DEM
Deer Island	Boston	210 acres	MWRA
Gallops Island	Boston	16 acres	DEM
Georges Island	Boston	28 acres	MDC
Grape Island	Weymouth	50 acres	DEM
The Graves	Hull	1 acre	US Coast Guard
Great Brewster	Hull	23 aces	DEM
Green Island	Hull	1 acre	DEM
Hangman Island	Quincy	<1 acre	DEM
Langlee Island	Hingham	4 acres	Town of Hingham
Little Brewster	Hull	4 acres	US Coast Guard
Little Calf Island	Hull	< 1 acre	DEM
Long Island	Boston	214 acres	City of Boston
Lovell Island	Boston	62 acres	MDC
Middle Brewster Island	Hull	12 acres	DEM
Moon Island	Quincy	44 acres	City of Boston
Nix's Mate	Boston	< 1 acre	US Coast Guard
Nut Island	Quincy	17 acres	MWRA
Outer Brewster I.	Hull	17.5 acres	DEM
Peddocks Island	Hull	188 acres	MDC
Raccoon Island	Quincy	3 acres	DEM
Ragged Island	Hingham	4 acres	Town of Hingham
Rainsford Island	Boston	11 acres	City of Boston
Sarah Island	Hingham	2 acres	Town of Hingham
Shag Rocks	Hull	< 1 acre	US Coast Guard
Sheep Island	Weymouth	2 acres	DEM
Snake Island	Winthrop	3 acres	Town of Winthrop
Slate Island	Weymouth	12 acres	DEM
Spectacle Island	Boston	97 acres	City of Boston / DEM
Thompson Island	Boston	157 acres	Thompson Island Outward Bound Education Center
Webb State Park	Weymouth	45 acres	DEM
Worlds End	Hingham	251 acres	The Trustees of Reservations

Day-to-day operation of the national park area is provided by the agency property owners and managers (Table 1) who work through the Partnership to enhance consistency and coordination parkwide and to create parkwide programs. The role of the National Park Service is to help coordinate the Partnership and the Boston Harbor Islands Advisory Council, to provide information and orientation to the public, to develop and operate programs, and to help assure that the park will be managed to NPS standards, as the enabling legislation requires (National Park Service, 2000).

b. Purposes of a Water Resources Scoping Report

The purposes of a Water Resources Scoping Report include identifying major water resources-related issues and presentation of relevant information and management considerations to assist the land / resource manager in meeting their management objectives. Typically, a water resources scoping report is presented in three major parts.

The first major part of the water resources scoping report is the "Hydrologic Environment" which provides the land /resource manager with a thorough knowledge of the water-related resources of the area. This retrospective analysis will generally provide a basic description of the water-related resources, a summarization of past and current inventory, monitoring, research and management efforts, and the identification of issue-related data gaps.

The second part of the water resources scoping report is the "Significant Water-Related Issues" which identifies and discusses the significant water-related issues pertaining to park management. This process is usually initiated with a "scoping session" where land and resource managers, subject matter specialists, and other interested parties come together in order to develop a water-related "issues list". During the scoping process participants are provided an opportunity to identify issues, discuss the management implications of the issues, and to highlight those issues which present the greatest level of concern. The results of this issues scoping session are then used to develop a draft scoping report outline. The author of the water resources scoping report will then develop this section in accordance with identified issues both utilizing discussions with regional and local subject matter experts as well as conducting a thorough literature review.

The third major part of the water resources scoping report is the "Considerations for Future Actions". This section provides the land / resource manager management considerations for further addressing the identified issues, based upon the author's assessment of the available information.

The Boston Harbor Islands Water Resources Scoping Report follows the pattern described above with Section II (Hydrological Environment) providing a management oriented synthesis of the status of the existing resource condition and data availability, Section III (Significant Water-Related Issues) providing a current assessment of identified issues, and Section IV (Considerations for Future Action) providing the Boston Harbor Islands Partnership with recommendations pertaining to the current issues.

II - Hydrologic Environment

a. Description of the Boston Harbor Islands and Surrounding Waters

Boston Harbor is a more than 50-square mile estuary that is part of the Massachusetts Bay system. Upland inflow into the harbor is derived from eight primary watersheds including the Quincy Bay, Inner Harbor, Winthrop Bay, Mystic River, Charles River, Neponset River, Weymouth River and Weir River watersheds (Leo et al., 1995). This extensive area includes the City of Boston and the large surrounding metropolitan area.

The Boston Harbor Islands national park area contains 34 islands, former islands, and peninsulas lying within or adjacent to Boston Harbor (National Park Service, 2000). They range in size from less than 1 acre to 251 acres and together include more than 1500 acres of land (Figure 1). Ownership and management responsibility for these areas includes the Massachusetts Department of Environmental Management (DEM), the Metropolitan District Commission (MDC), the Massachusetts Water Resources Authority (MWRA) , the City of Boston, the US Coast Guard, Thompson Island Outward Bound Education Center, The Trustees of Reservations, and the Towns of Hingham and Winthrop (Table 1).

Unlike many of the islands typical of the New England coast, several of the Boston Harbor islands are coastal extensions of drumlin features, which are glacially-formed, asymmetrical, elongate masses of till formed into smooth-sloped hills on the Boston Basin lowlands. In addition, several of the “outer” islands are the more typical bedrock outcrops more commonly found along the coast of New England.

For many years Boston Harbor was notorious for its polluted waters. Sources of pollution to Boston Harbor included the discharge of sewage treatment plant effluent, sanitary sewer overflow, stormwater runoff, and combined sewer overflows (CSOs). In 1994, there was discharge to Boston Harbor from two major sewage treatment plants as well as 81 CSOs within the Boston Harbor watershed (Leo, et al., 1995). Recent infrastructural improvements have greatly improved water quality within the harbor (see Boston Harbor Project section).

For discussion purposes within this report, the Boston Harbor Islands national park area islands, former islands, and peninsulas are grouped into four geographic sub-areas: (1) the Inner Harbor group, (2) the Quincy Bay group, (3) Hingham Bay group, and (4) the Outer Harbor group (National Park Service, 1994). These are described briefly below.

1. Inner Harbor Group

The Inner Harbor Group include those islands located within the Inner Harbor, Old Harbor and Dorchester Bay/Neponset Estuary areas of Boston Harbor. This part of Boston Harbor includes some of the larger islands within the national park area including Long Island (214 acres), Deer Island (210 acres), Thompson Island (157 acres), Spectacle Island (97 acres) and Moon Island (44 acres). Because of their size, close proximity, and, in some cases, easy access to the mainland, several of these islands have historically seen intensive land use (Figure 1).

Deer Island is currently the site of MWRA’s Deer Island Treatment Plant, which treats the wastewater for the metropolitan area before discharging the effluent into Massachusetts Bay.

Long Island and Moon Island, connected to the mainland by a bridge and a causeway have, since the Civil War era, housed a succession of military and municipal installations including Fort Strong (Long Island) , a series of coastal artillery emplacements, Cold War-era missile batteries, a poor house, a mental hospital, a homeless shelter, the remains of 19th century-era municipal wastewater facilities, and currently operated fire and police training facilities. An area of freshwater wetlands is also located on Long Island (National Park Service, 1994).

Thompson Island consists largely of a naturalized setting made up of open fields, forests, a freshwater pond, freshwater wetlands, tidal flats, and a 50-acre saltwater marsh. It contains both a drumlin and a moraine and has not been as heavily developed as some of the other Inner Harbor Islands, being used in succession as a farm and trading post, a boys asylum, a vocational school, and an academic campus. It is currently operated as an outdoor and environmental education center by the Thompson Island Outward Bound Education Center (National Park Service, 2000) and contains some premier outdoor recreational and natural resources.

Spectacle Island, located just west of Long Island and southeast of Castle Island received its name because its two drumlins (East and West Spectacle) are connected by a sandbar, and the island resembled a pair of eyeglasses. The island was first used for agriculture in the 1660s and has also served as a site of a quarantine hospital, a summer resort, a rendering factory and as a municipal dump for the City of Boston. Spectacle Island is currently 97 acres in size and is being used as a fill disposal site for the Central Artery Project. The former landfill has been stabilized and capped and the island is being restored as a recreational facility which will feature a Visitor Center, marina, two sandy beaches, and five miles of pathways and trails which will offer 360 degree views of the harbor and city. The island is owned jointly by the City of Boston and the Massachusetts Department of Environmental Management and is planned to be opened to the public (National Park Service, 2000).

The aquatic environments and water quality within the inner harbor area are heavily influenced by their close proximity to the urban and industrial activities of Boston, Charlestown and East Boston. These municipalities contain major metropolitan development as well as port facilities, and parts of the Inner Harbor continue to experience severe water quality problems. Bacteria counts are high in wet weather due to combined sewer overflows (CSOs) and stormwater discharges. The Inner Harbor also has the highest levels of sediment contamination measured in Boston Harbor. Sources of toxic contaminants include inflows from the Charles, Mystic and Chelsea rivers, stormwater discharges, and a large number of CSOs. If current plans and projects are fully implemented , the Inner Harbor will become relatively clean for an urban harbor, especially if water quality of the Charles and Mystic rivers can be improved (Leo et al., 1995).

The aquatic environments and water quality in the vicinity of the Old Harbor, Dorchester Bay and Neponset River estuary sections of the harbor are somewhat better than those found within the Boston Inner Harbor itself. The tidal portion of the Neponset River (downstream from Baker Dam) contains some of the richest wetlands remaining in Boston Harbor, though they are abutted by highways, a gas storage tank, railroads, commercial buildings, and dense residential areas (Leo et al., 1995).

The Dorchester Bay beaches are among the most popular in Boston Harbor. Although the water quality in Old Harbor and Pleasure Bay is relatively good, sewage pollution prevents the full use of the bay area. CSOs, contaminated storm drains, and upstream pollution of the Neponset River contribute sewage-borne pathogens to the bay. Water quality is often worse after heavy rains, when high bacterial indicator counts may cause beach closures in Old Harbor. Beaches that are unaffected by CSOs (Pleasure Bay) or which have only small CSOs (Carson Beach and L Street Beach) have generally good water quality. However, nearby Tenean and Malibu beaches continue to be affected by stormwater contamination and the poor water quality of the Neponset River (Leo et al., 1995).

South Dorchester Bay is a very important recreational area with three beaches (Malibu, Savin Hill and Tenean). Soft-shell clams are abundant here, but are too contaminated with pathogens to harvest. Recreational boating is also popular with several yacht clubs located in the area. Four CSOs and several large stormwater drains rim the shoreline. Stormwater, contamination from the Neponset River and CSOs are the main sources of pathogen contamination to this bay during heavy rainstorms. However, water quality is generally good during dry weather. The CSO Plan includes the elimination of CSOs in this sensitive shellfishing and swimming area (Rex, 2000).

Other problems are found in the sediments – toxic chemicals and organic matter which enter the estuary through storm drains and CSOs. Past discharges of sewage sludge and untreated sewage also formerly contaminated small embayments like Savin Hill Cove, depleting sediment oxygen and affecting the health of marine life (Leo et al., 1995).

2. Quincy Bay Group

The Quincy Bay Group of islands includes Lovell Island (62 acres), Georges Island (28 acres), Nut Island (17 acres), Gallops Island (16 acres), Rainsford Island (11 acres), Hangman Island (0.25 acre) and Nixes Mate, all located in the Quincy Bay / Nantasket Roads areas of Boston Harbor. Two of these islands, Georges (Fort Warren) and Lovell (Fort Standish), were of strategic military importance from the mid 19^{th} century (Fort Warren) through at least World War I (Fort Standish) as they controlled the navigational approaches (Presidents Roads, The Narrows and Nantasket Roads) to Boston Harbor (Figure 1).

Today, Georges Island is the centerpiece of the Boston Harbor Islands State Park. It is largely occupied by Fort Warren, a partially restored National Historic Landmark which was constructed between 1833 and 1869 of hand-hewn granite from the neighboring community of Quincy and the Cape Ann region. Fort Warren achieved national prominence during the Civil War as a prison for captured Confederates, and for over a century the Fort served as a key location for the defense of Boston (http://www.state.ma.us/mdc/harbor.html). Seven miles from downtown Boston, it contains a park visitor center, a large dock, picnic grounds, and a gravel beach. Natural features on Georges Island are limited.

In contrast, nearby Lovell Island is a peaceful and primitive island offering boat and fishing piers, picnic grounds, walking trails, permit camping and the only designated swimming beach of the Boston Harbor Islands. Natural resource features of Lovell Island include rocky tide pools, salt marshes, sand dunes, a freshwater wetland, meadows and woods supporting a large population of feral rabbits and attracting a variety of birds (National Park Service, 1994; US Fish and Wildlife Service, 1995a). Culturally, the remnants of Fort Standish, a late 19^{th} century / early 20^{th} century military installation are hidden in the center of the island. Lovell Island also offers some of the best views of the outer harbor (http://www.state.ma.us/mdc/harbor.html).

Gallops Island, located just west of Georges and Lovell islands, is comprised primarily of a high drumlin feature surrounded by trees, meadow and salt marsh. Developed as a popular summer resort in the 1830s, Gallops Island later hosted a quarantine hospital, an immigration station, and a radio school and hospital. After World War II the island was sold at auction and used for a time as a dump. Today, it is managed for its natural and landscape features including a sandy beach, a heron rookery, and its impressive views of both Boston Light and the City of Boston skyline. While there are trails and picnic areas, the island is presently closed to public access because of asbestos-related issues. Just to the north of Gallops Island lies Nixes Mate. Once a 12-acre island, Nixes Mate today is little more than a channel marker containing a distinctive black and white-striped buoy (National Park Service, 1994).

Three additional national park properties located in Quincy Bay are Nut, Rainsford and Hangman islands. Nut Island, which in colonial times was a four-acre island has been developed into a 17-acre peninsula. At the end of the 19th century the Metropolitan District Commission established a sewage treatment plant on Nut Island. The plant, now outmoded, has been reconstructed into a headworks to provide screening and separation of larger solids before the wastewater is pumped to Deer Island for more advanced wastewater treatment. Eventually, a small urban park will be constructed on Nut Island. Rainsford Island is an 11-acre island composed of a large eastern head and a smaller western head connected by a sand spit. Originally a farm, the island was converted in 1737 into a quarantine facility for persons with small pox and other infectious diseases and hundreds of victims are thought to be buried in the island's cemetery. In later years, the island housed a municipal poor house, a veterans home, and a school for delinquent youth. These facilities were abandoned by the 1920s and today the island is largely an open field with a small stand of hardwoods on its eastern head and relatively rare slate outcroppings on its western head. The island contains many ruins, includes two curving, fine gravel beaches (which are highly subject to erosion during winter storms), is home to a tern colony, and is to be managed largely as a natural area. Hangman Island is 0.25-acre rocky outcrop in the middle of Quincy Bay (National Park Service, 1994; National Park Service, 2000).

Water quality in Quincy Bay is generally good, with the land-use in Quincy Bay's small watershed being primarily residential. The major pollution source appears to be stormwater discharge contaminated by sewer cross connections. Until 1988, Quincy Bay was sometimes also affected by effluent discharge from the MWRA Nut Island treatment plant under certain wind and tidal conditions. There are currently no CSOs in Quincy Bay, though the bay was affected by CSOs from Moon Island until 1990. Wollaston Beach in Quincy Bay has variable water quality for swimming, with the amount of time the waters exceed recommended standards varying greatly over the years. Quincy Bay has also historically been one of the great recreational flounder fishing areas on the east coast, though the numbers caught fell dramatically from the late 1980s through mid-1990s (Leo, et al., 1995). Quincy Bay also has productive shellfish beds and though they require depuration prior to being brought to market, half of the soft-shell clams harvested in Massachusetts come from Boston Harbor, with a significant percentage originating in Quincy Bay (Leo et al., 1995).

A major milestone in the Boston Harbor Project was achieved in July 1998 when discharges from the Nut Island Treatment Plant in Quincy ended. Until then, approximately 100 million gpd of sewage from MWRA's South System received only primary treatment before being discharged into Quincy and Hingham Bays. Water quality improvements in the former Nut Island Treatment Plant outfall areas were immediate as effluent plumes disappeared. Indicator bacteria levels in nearby waters decreased, and have stayed low since the discharges ended and sewage odors have disappeared. Water clarity in the former discharge areas, usually at its worst (3 – 6 feet) in mid-summer, continued to improve rapidly to 9 – 12 feet during the summer of 1998 (Rex, 2000).

3. Hingham Bay Group

The Hingham Bay Group includes the Worlds End peninsula (251 acres), Peddocks Island (134 acres), Grape Island (50 acres), Bumpkin Island (35 acres), Slate Island (12 acres), Langlee Island (4 acres), Ragged Island (4 acres), Raccoon Island (3 acres), Sheep Island (2 acres), Sarah Island (2 acres), and Button Island (< 1 acre) (Figure 1). In addition, Webb State Park (45 acres), which occupies the northernmost portion of Weymouth is currently being proposed for inclusion in the Boston Harbor Islands national park area (National Park Service, 2000).

Worlds End, which was probably an island until recent times, shares many of the features found on the harbor islands. Overlooking Hingham Bay, the property consists of a 251-acre peninsula owned and operated by The Trustees of Reservations. The reservation includes four coastal drumlins and also contains rocky beaches, ledges, cliffs, patches of salt marsh and freshwater wetlands. Just offshore in the subtidal zone, are some of the most robust eel grass beds (*Zostera marina)* remaining in Boston Harbor. European settlers farmed the area from settlement time until the late 1800s. In 1890, the farm estate was converted into a park-like setting according to a plan designed by famed landscape architect, Frederick Law Olmstead. The area is noted for its relatively diverse plant communities and is managed for landscape conservation and the management and preservation of natural areas (National Park Service, 2000). The reservation is open for public use.

Peddocks Island, the third largest island in Boston Harbor, is composed of four drumlins connected by sand or gravel bars known as tombolos. It is one of the most naturally diverse of the harbor islands and also contains its longest shoreline. The east head contains dense woods of maple, pine, apple, cottonwood and birch. Interspersed in this area are the remnants of 26 structures in various states of rehabilitation or disrepair, which formed part of Fort Andrew (established 1900). The middle part of the island consists primarily of a sand spit beach, dune systems, and the middle head. A number of former summer cottages remain in this area. The west head contains a wildlife sanctuary and consists largely of a salt marsh community. A black-crowned night heron rookery, one of only two in the Commonwealth of Massachusetts has been reported on the island. Management goals for Peddocks Island include historical preservation, the management of historic cultural landscapes, and the management and preservation of natural areas (National Park Service, 2000).

Grape Island, Slate Island, Bumpkin Island, Raccoon Island and Sheep Island, are all located in central Hingham Bay. All are managed by the Department of Environmental Management with emphasis on maintaining managed landscapes (Grape and Bumpkin islands) or preserving the natural areas (Slate, Raccoon and Sheep islands). Grape Island, is comprised of two large drumlins connected by a marshy lowland. The island displays widely different topography at each end. A flat-topped drumlin ends in rock outcroppings at the northern end, while the southern end gradually slopes seaward supporting extensive tidal marshes and gravel beaches. Grape Island offers relatively easy accessibility, just off the coast of Weymouth, which makes it popular with hikers, picnickers, and campers. Slate Island, as the name suggests, is composed primarily of a series of slate ledges. Beginning in the mid-17th century, the northwest side of the island was quarried for slate used for the foundations of homes throughout the area. Today the island is largely covered with dense thickets of raspberry, barberry and poison ivy, though a walking trail allows access to the remains of the 17th century quarries. Bumpkin Island, was generally used for agricultural/fisheries activities from Colonial times until the end of the 19th century. In the late 1800s, a children's hospital was built upon the island and during World War I the island housed up to 1300 naval personnel. The island today contains the stone foundations of some of these structures and a derelict orchard. The island also provides camping sites, picnic areas, and hiking trails but lacks a public water supply. Raccoon Island is comprised primarily of a bedrock outcropping which supports a variety of habitats including gravel beaches, a rocky intertidal zone, and mud flats. This small island has seen little use and is in a largely natural state. Sheep Island is said to have once been comprised of almost 25 acres though it has been worn away to its present size of less than 2 acres since settlement time. It is a low island consisting of meadow, scrub and sumac (National Park Service, 1994).

Ragged Island, Langlee Island, Sarah Island and Button Island are located in Hingham Harbor and managed by the Town of Hingham. Ragged Island was inhabited by an early settler, John Langlee and is the only Hingham Harbor island that has ever been inhabited. During the late 19^{th} century it was connected to the mainland by a bridge and was the site of a popular restaurant. Today, it is in a largely natural state and is popular for picnickers. Langlee Island features two sandy beaches and is also a popular picnic spot for boaters. Sarah Island and Button Island are smaller islands within the harbor. Both are in a natural state. The rocky shoreline of Button Island makes it difficult to approach by boat.

Webb State Park, located in Weymouth, MA occupies the northernmost portion of Weymouth Neck, extending approximately 1.25 miles into Hingham Bay. The site consists of 45 acres and is operated as a public park by the Massachusetts Department of Environmental Management. Webb State Park contains walking trails and beaches (though no swimming is allowed) as well as three buildings which were formerly part of a Nike Missile Facility. The Upper Neck of Webb State Park is a low drumlin formed by glacial activity during the last ice age. The Lower Neck consists of a sand and gravel spit built from debris worn from the Upper Neck. Historically, the eastern end of Weymouth Neck was home to a large scale fertilizer facility (1861 – 1960s), which generated large amounts of solid wastes. Construction of a Nike missile site, including underground silos and several buildings, occurred on northern portion of the former fertilizer facility in the 1960s. Much of the remaining topography of Webb State Park has been altered by grading and landscaping, which occurred primarily in the 1970s and 1980s. The intertidal zone surrounding Webb State Park primarily consists of emergent wetlands and unconsolidated shore.

The Hingham and Hull bays are among the most pristine waters of the Boston Harbor waterfront. The good water quality is due largely to the undeveloped nature of the watershed and the lack of large point sources of pollution. Swimmers enjoy Nantasket Beach on the ocean side and other beaches on the bay side of the Hull peninsula. Boating and fishing are popular and shellfish are harvested by commercially licensed master diggers. The Weir River sustains fairly good smelt runs and a small alewife run. Stormwater is the most significant source of pathogen pollution in the watershed, and although water quality is generally good, there are local sources of pollution that cause some problems, especially in the Weir River (Leo et al., 1995).

Both the Weymouth Fore and the Weymouth Back rivers drain into Hingham Bay and support important fishery resources, including two of the three largest smelt runs in Massachusetts Bay and river herring runs. Shellfish flats are also important with more than 12,000 bushels of clams harvested annually (Leo, et al., 1995). In 1994, the water quality in the Fore River was still affected by the discharge of MWRA’s Nut Island treatment plant into Nantasket Roads. Although strong currents helped disperse the effluent, studies have shown that some of the effluent washed into the mouth of the river. This ended in 1998 with the elimination of the discharges from the Nut Island facility. There is also some localized sewage contamination, especially overflows from MWRA’s Braintree-Weymouth Interceptor in wet weather, an issue that was to be addressed by the replacement of this interceptor (Leo et al., 1995).

4. Outer Harbor Group

The Outer Harbor Group, sometimes referred to as the “Brewsters”, includes Great Brewster Island (23 acres), Outer Brewster Island (17.5 acres), Calf Island (17 acres), Middle Brewster Island (12 acres), Little Brewster Island (4 acres), Green Island (1 acre), The Graves (1 acre), Little Calf Island (< 1 acre), and Shag Rocks, all of which are located at the eastern edge of Boston Harbor and are generally exposed to the open waters of Massachusetts Bay (Figure 1). Most of the Outer Harbor group falls under the management jurisdiction of the Massachusetts Department of Environmental Management. The exception to this is Little Brewster Island (site of Boston Light), The Graves (site of Graves Light), and Shag Rocks, which are administered by the U.S. Coast Guard.

Great Brewster Island is the largest of the Outer Harbor group islands and the only one containing a drumlin. The drumlin, located on the north end of the island rises to about 100 feet above mean sea level (MSL), while deeply eroded ledges and a smaller drumlin feature mark the southern end. A salt marsh occupies the middle of the island. Farming may have occurred on the island in the late 1800s but the dominant man-made features are World War II-era bunkers. Some wooded areas, though generally sparse, exist on the island but the dominant upland features are scrub and open field areas. Great Brewster Island does, however, contain a number of tidal pools, is home to a large gull colony (National Park Service, 1994) and is used for nesting by the American oyster catcher (Robert Buchsbaum, Massachusetts Audubon Society, personal communication, 2002).

Outer Brewster Island is the largest outcrop of solid bedrock in Boston Harbor. It is treeless, and where vegetation exists, it is shrub and grass covered. The island remained largely undisturbed until WWII, when the US Army constructed a coastal fortification named Battery Jewell, which included a bomb and chemical-proof enclosure protecting coastal artillery guns and the infrastructure needed to support them. Battery Jewell was abandoned in 1946 (National Park Service, 1994).

Calf Island is located north of Great Brewster Island and was for some years home to a colony of lobster fishermen. An estate was built on the island in the early 20^{th} century but was destroyed by fire after WWII. The island contains a freshwater pond, tidal marshes and shrub vegetation. While no drinking water is provided, the island is popular with hikers, campers, and fishermen (National Park Service, 1994).

Middle Brewster Island is the least accessible of all the harbor islands. It has been the home of a fishing colony and the summer residence of a wealthy yachtsman, but its location and topography have kept it remote. Today it is valued both for its natural character and its wildlife resources. Two species of herons have established rookeries on the island’s southeast corner. Because of this, recreational use of the island is discouraged (National Park Service, 1994).

Little Brewster Island is best known for being the home of Boston Light. While most of the island is maintained as a National Historic Landmark, the island does contain a rugged shoreline of cliffs, ledges and beach offering a variety of habitats for intertidal and subtidal resources. The ocean facing side of the island is experiencing severe erosion (National Park Service, 1994).

Little Calf Island, Green Island, and Shag Rocks are all small bedrock outcroppings of less than 1-acre in size. All are used primarily as nesting sites for gulls and cormorants and public use is discouraged. Similarly, The Graves is a small, one-acre bedrock outcropping, which since the beginning of the 20th century has hosted the outermost lighthouse of Boston Harbor (National Park Service, 1994).

Though sometimes influenced by sewage effluent discharge from the MWRA's Deer Island Treatment Facility, the significant tidal exchange between Boston Harbor and Massachusetts Bay would highly dilute any pollutants reaching the waters of the Outer Harbor. The water quality situation of these waters improved even more in 2000 with the opening of the new outfall for the Deer Island plant, which extends more than nine miles into Massachusetts Bay (Rex and Connor, 1997).

b. Boston Harbor Project

Beginning as early as 1820, residents of Boston discharged human waste into the city's storm sewers which emptied directly into Boston Harbor (Doneski, 1985). As the area's population grew, so did the enormous amount of domestic and industrial waste loading into Boston Harbor, generally with inadequate treatment. Even with the passage of the Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act), hundreds of millions of gallons of inadequately treated sewage and 60 tons of sewage sludge continued to be discharged into Boston Harbor daily (Dolan, 1992). By the 1980s Boston Harbor had the reputation as being one of the most polluted harbors in the United States (National Oceanographic and Atmospheric Administration, 1987; 1988).

The Boston Harbor Project was ordered in 1985 by U.S. District Court Judge A. David Mazzone, who ruled that wastewater discharged into Boston Harbor from the outdated and malfunctioning Metropolitan District Commission's (MDC) Deer Island Treatment Plant violated the Clean Water Act of 1972 . The overall objective of the Boston Harbor Project is to "restore Boston Harbor to an environmental standard that the citizens of the Commonwealth want and deserve" (Pawlowski et al., 1996). A generalized timeline summarizing the clean-up and recovery of Boston Harbor as a result of the Boston Harbor Project is provided in Table 2 (adapted from Pawlowski et al., 1996).

Initially, an aggressive program of source reduction aimed at reducing industrial discharges directly to the sewers reduced toxic discharges from the treatment plants by 31% (Pawlowski et al.,1996). By 1991, sewage sludge and scum discharges were terminated, significantly reducing biological oxygen demand (BOD) and solids loading, which had caused tremendous damage to benthic biological communities.

Additional milestones were again reached in the mid-1990s with the opening of the new MWRA Deer Island primary (1995) and the secondary (1997) treatment facility. These allowed for the decommissioning of the obsolete Nut Island sewage treatment facility and the cessation of discharges into Hingham and Quincy bays (1998).

Another significant milestone was achieved in 2000, with the commissioning of a new outfall consisting of a deep rock tunnel which conveys up to 1.27 billion gallons per day of secondary treatment effluent about 9.5 miles to a deep water discharge point in Massachusetts Bay. The effluent, which has received secondary treatment to remove approximately 85% of the suspended solids, 85% of the oxygen consuming material (BOD), and up to 90% of the toxic contaminants from the wastewater stream then enters a diffuser system which disperses the effluent over a broad area of Massachusetts Bay with a diffusion ratio of about one part treated effluent to 100 parts seawater. Design details of this system are provided by Brocard et. al, 1994. The outfall site, while

Table 2. Generalized timeline of the recovery of Boston Harbor as it relates to significant milestones of the Boston Harbor Project (adapted from Pawlowski et al., 1996; Taylor, 2001a)

YEARS	BOSTON HARBOR SITUATION
Pre-1990	• Deer Island and Nut Island treatment plants discharged primary treated effluent and digested sludge (including scum) into Boston Harbor. • Poor pumping capacity at plant caused frequent combined sewer overflows (CSOs) during rainstorms. • Disinfection failures at treatment plant common. • Discharges of oxygen consuming materials (BOD), solids, and nutrients resulted in low dissolved oxygen levels in some Harbor sediments, preventing normal plant and animal communities from living on the bottom. • Toxic substances from sewage, industrial and road runoff probably caused high rates of liver disease in flounder; high levels of PCBs found in lobster.
1990-1995	• Aggressive source reduction programs reduced industrial discharges into the sewers so that toxic discharges from treatment plants were reduced by 31%. • Sludge and scum discharges ceased in December, 1991 significantly reducing solids inputs, BOD, nutrient (N and P) and pathogen indicator loadings to the harbor. • Pumping improvements and better maintenance reduced the incidences of CSOs.
1995-1999	• The new primary treatment plant on Deer Island opened in 1995, with improved removal of solids and BOD and improved disinfection resulting in decreased loadings especially of TSS but also of pathogen indicators, BOD, N and P. • Secondary treatment, which began on Deer Island in 1997 further reduced loadings especially of BOD but also of TSS, N, P, and pathogen indicators . • Inter-island transfer tunnel and outfall were completed in mid-1998 allowing decommissioning of the Nut Island Sewage Treatment Facility and the cessation of discharges into Hingham and Quincy bays. While flows from Deer Island increased, total proportion of wastewater flows subjected to secondary treatment increased, reducing total loadings of BOD and also total loadings of TSS, N, P and pathogen indicators to the harbor. • Bottom-dwelling communities continue a gradual recovery becoming more diverse and sediment oxygenation continues to improve
2000 – 2005 & beyond	• Full secondary treatment is underway and with the completion of a 9.5 mile tunnel/ diffuser system into Massachusetts Bay, all effluent discharges to Boston Harbor ceased in September 2000. Loadings especially of N and P decreased further, but also of TSS, BOD and pathogen indicators. • Ecosystem recovery continues with diverse communities of plants and animals returning to Boston Harbor. Contaminated sediments are gradually buried under cleaner sediments and bioaccumulation of toxic chemicals abates in the harbor. • Efforts will be initiated to address and mitigate infrastructural issues such as CSOs. Although not pristine, most of Boston Harbor will gradually become an example of a more typical New England coastal ecosystem.

initially controversial, was chosen after considerable scientific and technical study and extensive public participation (http://www.mwra.com/harbor/html/outfall_update.htm). Visitor facilities which convey the history of the Boston Harbor Project to the public are planned for Deer Island.

In less than two decades no other urban harbor has experienced the remarkable turn around from "near disaster" to environmental success story as has Boston Harbor. Although not pristine, much of Boston Harbor should with time, resemble less polluted New England coastal ecosystems. Continuing efforts are underway to address serious issues resulting from CSOs found in many of the older urban areas of the United States including Boston. The primary problems with CSOs are the risk to public health from sewage-borne pathogens (disease causing bacteria and viruses), which make swimming and the consumption of shellfish unsafe. By separating sewers or re-locating CSOs to other, less sensitive areas, the beaches and shellfish beds can be better protected. A detailed source of information on the CSO improvement plan for Boston Harbor is found in Leo et al., 1995.

c. Water Quality

Contaminants can remain in the marine environment for decades and Boston Harbor is only now slowly recovering from many years of unregulated discharges through sewers, storm drains, and direct commercial or industrial discharge. In the mid-1980s, the harbor's sediments contained such high levels of contaminants that it was labeled the "dirtiest harbor in the nation." On average, the Inner Harbor contained the most contaminated sediments with concentrations in the Outer Harbor lessening from Dorchester and Winthrop bays to Quincy Bay. Historically, the lowest contamination levels were found in Hingham and Hull bays. Even though change is slow, several recent studies suggest that, as contaminant inputs decline, water quality is improving and sediments are beginning to cleanse themselves (Pawlowski et al., 1996).

1. Water Quality-related Indicators of Environmental Health

Over the last decade the MWRA has implemented a monitoring program for Boston Harbor focussed primarily upon a number of constituents which can be viewed as indicators of the environmental health of the harbor ecosystem. Table 3 provides a listing and rationale for the physical, chemical, and biological constituents which have been suggested as appropriate indicators of the ecosystem health of Boston Harbor.

2. MWRA Water Quality Monitoring Programs

The MWRA is the primary agency responsible for the monitoring of water quality in Boston Harbor. For more than a decade, the MWRA has been implementing comprehensive water quality monitoring programs not only in Boston Harbor, but also in its tributary rivers and in selected areas of Massachusetts Bay. The MWRA initiated its harbor-wide Boston Harbor Water Quality Project (BHWQMP) in 1993. The purpose of the BHWQMP is to measure water quality changes throughout the harbor in response to improvements brought about by the Boston Harbor Project, including improved primary treatment (1995), improved secondary treatment (1997), inter-island transfer and discharge of treated effluent (1998), and the cessation of effluent discharges to Boston Harbor with the completion of the new outfall and diffuser system

Table 3. Listing of the "key indicators" used for monitoring the environmental health of Boston Harbor (adapted from Taylor, 2001a; Kropp et al., 2000; Lefkovitz et al., 2000, Colarusso, 2002).

Ecosystem Indicator	Constituent Type	Description of Ecosystem Indicator
Water Clarity	Physical Water Quality	Water clarity, as measured by secchi depth and influenced by total dissolved solids concentration, is an important indicator of both recreational water quality and ecosystem health (Taylor 2001a). Water clarity can impact the "aesthetics" influencing the desirability of water for recreational use. Water clarity can also regulate the structure and productivity of the aquatic plant communities of shallow coastal systems, also influencing the habitat availability for animal communities. Especially sensitive to changes in water clarity are submerged aquatic vegetation such as eelgrass (*Zostera marina*) (Roman et al., 2000).
Nutrient / Eutrophication Status	Chemical / Biological Water Quality	Taylor (2001b) reports that numerous symptoms of eutrophication have previously been documented in Boston Harbor including elevated concentrations of nutrients, elevated standing stocks of phytoplankton, excessive growth of macroalgae, and the loss of submerged aquatic vegetation. Trends in the nutrient / eutrophication status are monitored in Boston Harbor by monitoring the concentrations of the total and dissolved inorganic forms of nitrogen and phosphorus, as well as measuring chlorophyll *a* concentrations, an indicator of algal biomass. Taken together, these constituents are important indicators of the organic enrichment of aquatic ecosystems.
Sewage Indicator Bacteria	Recreational Water Quality	Sewage indicator bacteria, including fecal coliform bacteria and *Enterococcus spp.*, are used within Boston Harbor to determine if waters are suitable for recreational activities including swimming, wading, and the harvesting of shellfish.
Sediment Profile / Geochemistry	Benthic Physical Habitat (soft bottom)	Almost a century of sewage sludge discharge to Boston Harbor (ending in 1991) significantly impacted the physical structure of the benthic habitat. Sediment profiling images (SPI) which monitor the general condition of the soft-bottom benthic habitats, coupled with geochemistry studies consisting of grain size analysis and total organic carbon concentration determination are utilized by the MWRA to monitor the long term recovery of soft-bottom benthic physical habitats (Kropp et al, 2001).
Benthic Infaunal Community Structure	Benthic Community Structure	Benthic infaunal community structure and abundance have been monitored at 8 key sites since 1991 in order to document the continuing recovery and succession of soft-bottom benthic communities within Boston Harbor. The increase in abundance and geographic distribution of the tube-dwelling amphipod *Ampelisca* spp., as well as the general increase in infaunal species numbers and abundance have been the most dramatic indicators (Kropp et al., 2001).
		CONTINUED

Table 3 (continued). Listing of the "key indicators" used for monitoring the environmental health of Boston Harbor (adapted from Taylor, 2001a; Kropp et al., 2000; Lefkovitz et al., 2000, Colarusso, 2002)

Ecosystem Indicator	Constituent Type	Description of Ecosystem Indicator
Blue Mussel Bioaccumulation	Contaminant Effects & Bioaccumulation	Bioaccumulation monitoring in the blue mussel (*Mytilus edulis*) has been undertaken since 1992 at two sites within Boston Harbor (Boston Inner Harbor and Deer Island Flats). Utilizing data from this program, the MWRA has developed a contingency plan (MWRA, 1997) that specifies numerical thresholds which may suggest environmental conditions are changing (Lefkovitz et al., 2001).
Winter Flounder Monitoring	Contaminant Effects & Bioaccumulation	Winter Flounder (*Pseudopleuronectes americanus*) have been monitored since 1992 in order to establish baseline conditions of biological parameters (e.g. length, age, weight), external condition (e.g. extent and severity of lesions), and to determine the concentrations of organic and inorganic compounds in both edible and liver/hepatopancreas tissue as indicators of environmental contamination (Lefkovitz et al., 2001).
Lobster Monitoring	Contaminant Effects & Bioaccumulation	Lobster (*Homarus americanus*) have been monitored since 1992 in order to establish baseline conditions of biological parameters (e.g. size, sex), external condition (e.g. black gill disease, shell erosion, external tumors, etc.), and concentrations of inorganic and organic contaminants in edible tail meat tissue and the hepatopancreas as indicators of environmental contamination (Lefkovitz et al., 2001).
Eel Grass	Submerged Aquatic Vegetation	The role of submerged aquatic vegetation (SAV) as an important component of sub-tidal estuarine systems, serving as a food source and nursery for a variety of organisms, contributing to water quality, and serving as an indicator of ecosystem health has been well recognized (Orth and Moore, 1984). An analysis of U.S. Coast and Geodetic Survey maps produced in the mid-19th century shows that submerged aquatic vegetation [most likely eel grass (*Zostera marina*)] was once fairly widespread throughout much of Boston Harbor (P. Colarusso, U. S. Environmental Protection Agency, personal communication, 2002). Today, eel grass is found only in five small areas of Boston Harbor. However, as water quality improves, there is the possibility of a gradual recolonization of the shallower areas of the harbor with seagrasses. While this is likely to take decades, the geographic extent and health of submerged aquatic vegetation is likely an important long- term indicator of the ecosystem health of Boston Harbor.

in Massachusetts Bay (2000). Because Boston Harbor once received some of the highest loadings of total nitrogen and phosphorus of any estuary in the United States (Nixon et al., 1996; Kelly, 1997), one focus of the harbor-wide water quality monitoring program is to measure the nutrient/ eutrophication status-related constituents (Rex and Taylor, 2000). In addition, data from this program are also used to monitor trends in water clarity and sewage indicator bacteria, because of their importance both from a recreational standpoint and their role as indicators of the overall health of the harbor ecosystem (Taylor, 2001a). Table 4 provides location and monitoring parameter information for selected stations from the BHWQMP, which are in close proximity to the national park area.

The MWRA began its current Combined Sewer Overflow (CSO) monitoring program in both the receiving waters of Boston Harbor and its tributary river systems in 1989. The purposes of this monitoring include: (1) measuring the effects of CSOs on the rivers and harbor, (2) meeting National Pollutant Discharge Elimination System (NPDES) permit requirements for the CSOs, and (3) monitoring changes in water quality over time as CSO remediation plans are effected (Rex and Taylor, 2000). As the most damaging water quality effect of pollution from untreated CSOs is the contamination of recreational waters and shellfish beds with the disease causing organisms associated with sewage, this monitoring program focuses primarily upon measuring bacterial pollution in the water column via the intensive monitoring of *Enterococcus* and fecal coliform bacterial indicators (Rex and Taylor, 2000). Table 5 provides location and monitoring parameter information for two sites of the CSO monitoring program which are in close proximity to sites within the national park area.

In 1995, MWRA initiated a Wastewater Treatment Plant Outfall Monitoring Program for the Deer Island and Nut Island wastewater treatment plants' harbor outfalls. The purposes of this monitoring program include: (1) providing feedback as to if the plants were operating as permitted, and (2) measuring changes in water quality as new treatment facilities became operational. Locations monitored as part of this program include sites within close proximity of the outfalls as well as areas predicted by computer models as potentially most affected by the discharges (Rex and Taylor, 2000). Three locations of this monitoring program are within close proximity to sites within the national park area (Table 5).

Figure 2 shows locations of selected water quality monitoring sites from these three MWRA monitoring programs which are in close proximity to sites within the national park area.

In addition to the fixed-station water quality monitoring networks, the MWRA and other entities have also sponsored a number of related studies within Boston Harbor in order to better understand water quality conditions and the overall health of the harbor's aquatic ecosystem. These include studies relating to sediment contamination (Durrell et al., 1991; Leo et al., 1993; Bothner, 1998), benthos community structure and recovery (Kropp et al., 2000, 2001), fish and shellfish populations (Lefkovitz et al., 2000; Moore, 2001), anthropogenic virus monitoring (Margolin and Mounce, 1996; Margolin and Beauchesne, 1997), and assessments of chlorinated pesticide and PCB concentrations in biological tissue (Lefkovitz et al., 2001).

3. National Coastal Assessment – Coastal 2000

While the MWRA water quality monitoring program provides a comprehensive look at water quality throughout Boston Harbor and parts of Massachusetts Bay, the US Environmental Protection Agency (EPA), in partnership with the coastal states, initiated in 2000 a multi-year coastal monitoring program to assess water quality conditions from a broad-scale perspective. Using a compatible probabilistic design and a common set of survey indicators, the 24 coastal states will provide information necessary to assess coastal water quality conditions at the regional, biogeographical and national levels (US Environmental Protection Agency, 2000). In Massachusetts, the EPA has teamed with the Massachusetts Office of Coastal Zone Management (CZM), the Massachusetts Department of Fisheries, and the University of Massachusetts in a joint effort which will ultimately enable a comparison of local coastal water quality, sediment quality, and fish and benthos conditions in Massachusetts with other U.S. coastal states, as

MWRA Site #	Location	Latitude (N)	Longitude (W)	Parameters
24	**Mouth of Inner Harbor**	42^o 20.59	71^o 00.48	**Surface + Bottom: temperature, dissolved oxygen, salinity, turbidity, pH, Photosynthetically Active Radiation, secchi depth, transmissivity, fecal coliform bacteria, *Enterococcus* bacteria, Total Suspended Solids, Particulate Nitrogen, Total Dissolved Nitrogen, Nitrate/Nitrite, Ammonium, Total Dissolved Phosphorus, Orthophosphate, Particulate Organic Carbon, Chlorophyll *a*, Phaeophytin**
106	**Long Island** (President Roads / NW of Long Island Head)	42^o 20.00	70^o 57.60	Same as 24
142	**President Road (Broad Sound)** (approximately midway between Deer Island and the Outer Harbor Islands)	42^o 20.35	70^o 55.89	Same as 24
140	**Mouth of Neponset River / South Dorchester Bay** (SW of Thompson Island)	42^o 18.35	71^o 02.43	Same as 24
77	**Inner Quincy Harbor** (SW of Nut Island)	42^o 16.51	70^o 59.31	Same as 24
139	**Quincy Bay** (N of Hangmans Island)	42^o 17.20	70^o 58.10	Same as 24
141	**Peddock's Island** (Nantasket Road North of Peddocks Island)	42^o 18.30	70^o 55.85	Same as 24
124	**Hingham Bay** (South of Bumkin Island)	42^o 16.36	70^o 53.86	Same as 24

Table 4: Selected long term harbor-wide water quality monitoring sites located in the vicinity of the Boston Harbor Islands national park area from the MWRA's Boston Harbor Water Quality Monitoring Project (BHWQMP) (adapted from Rex and Taylor, 2000; Taylor, 2001a)

MWRA Site #	Location	Latitude (N)	Longitude (W)	MWRA Program	Parameters
44	**Dorchester Bay** **Green Buoy #5** (NW of Spectacle Island)	42^o 19.95	71^o 00.01	CSO	**Surface + Bottom: temperature, dissolved oxygen, salinity, turbidity, pH, secchi depth, transmissivity, fecal coliform bacteria, *Enterococcus* bacteria**
38	**Mid Old Harbor (Dorchester Bay)** (West of Thompson Island)	42^o 19.30	71^o 01.28	CSO	Same as 38
105	**Nixes Mate (Green Can #15)** vicinity of Deer Island outfall	42^o 20.02	70^o 56.75	WWTP Outfall Monitoring	**Surface Only: temperature, dissolved oxygen, salinity, turbidity, pH, Photosynthetically Active Radiation, secchi depth, transmissivity, fecal coliform bacteria, *Enterococcus* bacteria, Total coliform bacteria, Total Suspended Solids, Nitrate/Nitrite, Ammonium, Orthophosphate**
118	**Lovell Island** (off NW end of Lovell Island)	42^o 19.97	70^o 56.24	WWTP Outfall Monitoring	Same as 105
50	**Calf Island** (off SW end of Calf Island)	42^o 20.18	70^o 53.19	WWTP Outfall Monitoring	Same as 105

Table 5 : Selected supplemental water quality monitoring sites in the vicinity of the Boston Harbor Islands national park area from the MWRA Combined Sewer Overflow (CSO), Wastewater Treatment Plant (WWTP) Outfall Monitoring (adapted from Rex and Taylor, 2000)

Figure 2. MWRA water quality monitoring locations in close proximity to the Boston Harbor Islands national park area (adapted from Rex and Taylor, 2000)

well as providing a framework for a nation-wide assessment of coastal resources.

The National Coastal Assessment Program, which evolved from the estuaries component of the Environmental Monitoring and Assessment Program (EMAP) begun in 1990, includes a probabilistic sampling design and a common set of environmental indicators. Several sample sites are located in greater Boston Harbor. At each site, data or samples are collected to assess water and sediment quality, as well as fish community structure, tissue residues and pathology. Data from the first year of sampling in Massachusetts are now becoming available, and a draft condition report of the coastal waters of Massachusetts should be ready by the end of 2002 (Don Cobb, U.S. Environmental Protection Agency, personal communication, 2002).

4. Recent Trends in Water Quality

Pawlowski et al. (1996) presents a general overview of important water quality-related constituents within Boston Harbor including dissolved oxygen (DO), biological oxygen demand (BOD), suspended solids, and nutrients. Bottom waters in Boston Harbor have tended to have lower levels of dissolved oxygen than surface waters, where oxygen can be exchanged directly with the atmosphere. In extreme situations, all DO can be used up (anoxia) causing fish kills. While DO levels in Boston Harbor rarely get to zero, DO has frequently been lower than the Massachusetts standard of 6 ppm, especially in water near the seafloor. In the summertime, low DO in bottom water is particularly frequent in the narrow channels of Boston's Inner Harbor (Pawlowski et al., 1996). Factors that decrease levels of dissolved oxygen in water include: high water temperature (oxygen is less soluble at warmer temperatures and respiration rates of all life increase); too much oxygen-demanding organic matter in the sediment; and stratification of the water column, which prevents highly oxygenated surface waters from reaching the bottom (Rex and Connor, 1997).

Utilizing data available from the MWRA Boston Harbor Water Quality Monitoring Project, Taylor (2001a) documents Boston Harbor baseline water quality / water quality trends for a number of key water quality constituents for the eight year period preceding the transfer of the wastewater effluent discharge from Boston Harbor to Massachusetts Bay (Aug 1993-Sept, 2000). In these assessments, Taylor (2001a) focuses upon the nutrient / eutrophication-related constituents, water clarity / total suspended solids, and sewage indicator bacterial contamination because of their relevance to the health of the harbor ecosystem. Taylor (2001b) further assesses water quality trends for these constituents at inner harbor / northern harbor sites vs. central harbor /southern harbor sites during a two year period (1998-2000) following the completion of a deep rock tunnel that allowed for the inter-island transfer of wastewater. This effluent which was previously discharged into the central / southern harbor after treatment at the Nut Island Wastewater Treatment facility could then be transferred to the Deer Island Wastewater Treatment Facility where it received more effective wastewater treatment prior to discharge into northern Boston Harbor. While both studies serve to document water quality baseline and trends during the critical implementation phase of the Boston Harbor Project, the greatest long-term relevance of these data may be to provide a baseline from which to assess the response of water quality conditions and ecosystem health to the recent total cessation of wastewater treatment plant effluent into Boston Harbor which occurred in September, 2000.

The eutrophication-related constituents assessed by Taylor (2001a; 2001b) include dissolved inorganic nitrogen, total nitrogen, dissolved inorganic phosphorus, total phosphorus, chlorophyll-a, and dissolved oxygen. Symptoms of eutrophication in Boston Harbor have included elevated N and chlorophyll concentrations (HydroQual, 1995), lowered dissolved oxygen concentrations

(HydroQual, 1995), the shallow depth of dissolved oxygen penetration into the sediments (Kropp et al., 2000) and possibly elevated rates of benthic metabolism (Tucker et al., 2001). In addition, extensive mats of drift macroalgae reported in the past in harbor embayments (Sawyer, 1965) and the extensive decline of seagrass (*Zostera marina*) throughout the harbor may also be symptomatic of eutrophication (Taylor, 2001a).

Water clarity (secchi depth) and total suspended solids are important water quality indicators both because of the aesthetic impacts they may have on recreational water usage and also because reduced water clarity can alter the structure of plant and animal communities within the ecosystem. Discharges of wastewater, such as those that historically came from Nut Island and Deer Island may have affected water clarity either directly by contributing solids to the water column or indirectly through increased phytoplankton growth (Taylor 2001a).

Contamination of the water column with sewage-related bacteria including fecal coliform and *Enterococcus spp.* is important because of the contamination caused by the discharge of untreated or partially treated sewage in limiting the public use of the harbor over the past 50 years. All of the beaches (Rex, 2000) and most of the shellfish beds of Boston Harbor have been closed to public use at least part of each year over the last decade due to sewage-related contamination.

On September 6, 2000, the MWRA stopped all discharges from the Deer Island sewage treatment plant into Boston Harbor. Instead, these discharges were transferred 9.5 mi (16 km) offshore for diffusion into the bottom waters of Massachusetts Bay. The purpose of this transfer was to improve water quality in Boston Harbor, with minimal impacts on water quality offshore (Taylor, 2002).

Figure 3 displays a recent MWRA water quality update (September, 2000 – May, 2001) showing that water quality improved harbor-wide for four key water quality indicators – nutrients, algal biomass, water clarity, and sewage indicator bacteria, within nine months of the cessation of discharges into Boston Harbor (Taylor, 2001c). Ammonium, the main form of nitrogen found in secondary treated wastewater, decreased harbor-wide approximately 80% (from 7 micromoles per liter to 1 micromole per liter) (Taylor 2001c). Chlorophyll *a*, an indirect measurement of algal biomass, displayed a harbor-wide decrease of approximately 50 % (from 3.7 micrograms per liter to 2.0 micrograms per liter) (Taylor 2001c). *Enterococcus* bacteria, an important sewage indicator bacteria used to assess the health risk of marine waters for recreational use decreased approximately 80% harbor-wide (from 11 colonies per 100 ml to 2 colonies per 100 ml) (Taylor 2001c). Secchi disk depth, a common measure of water clarity indicated that water is now twice as clear around the old Boston Harbor outfalls, and harbor-wide, water clarity increased from 3.2 to 3.7 meters (Taylor 2001c). Taylor (2002) provides a comprehensive assessment of 21 water quality variables in Boston Harbor during the first 12 months of the transfer. Of the 21 water quality variables monitored, 15 showed significant improvements when averaged harbor-wide (Taylor, 2002).

5. Recent Trends in Benthic Infaunal Communities and Habitats

Small animals and bottom-feeders that live on or in the seafloor ingest contaminants from contaminated sediments. Since these organisms are prey for fish or shellfish, the contaminants they contain can become concentrated in the bodies of larger animals. Seafloor benthic communities are susceptible to pollutants because (1) contaminants tend to collect in the sediments, (2) these

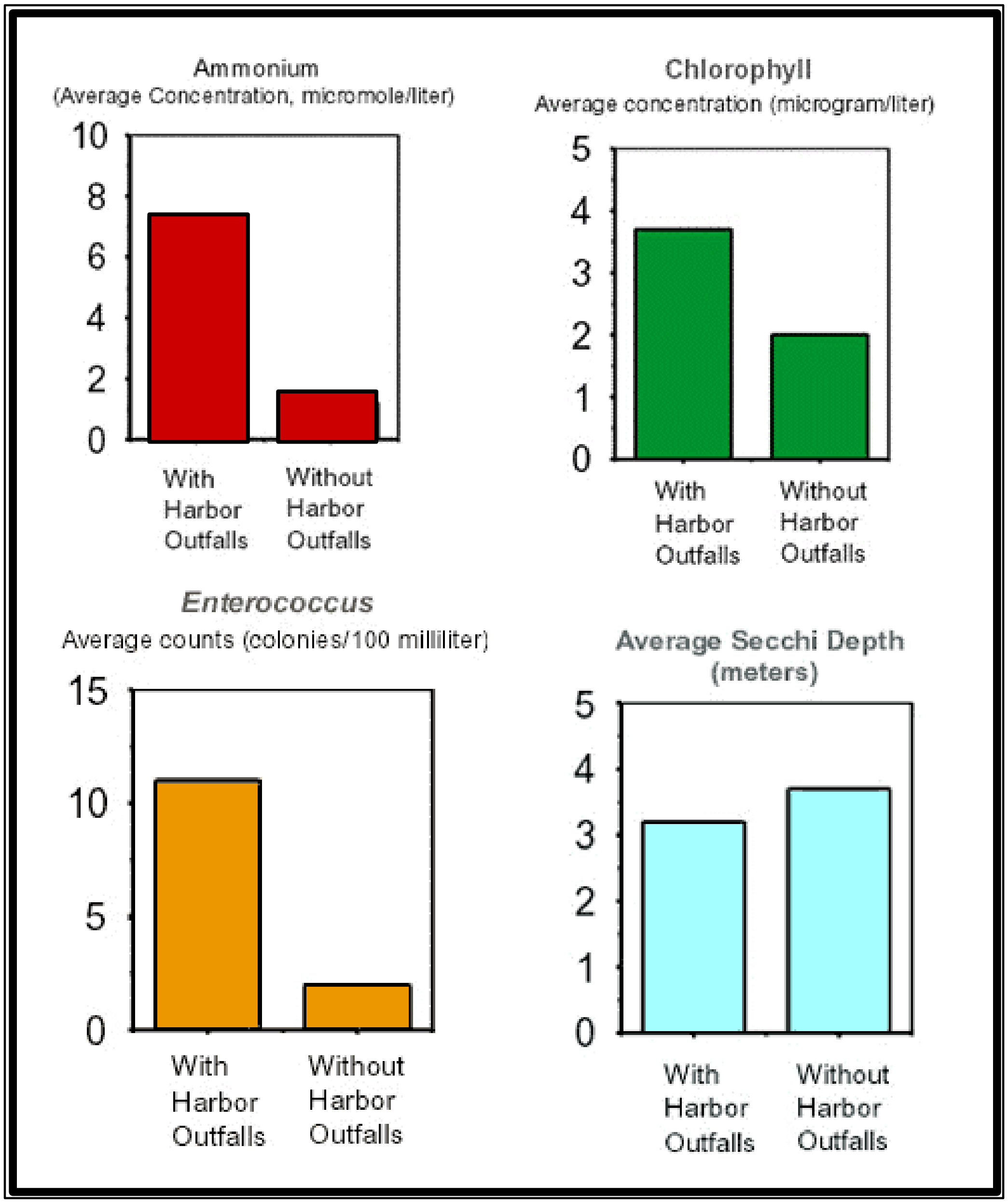


Figure 3. Recent improvements in water quality in the vicinity of the former Deer Island outfalls before and six months after the cessation of discharges from the Deer Island Sewage Treatment Plant to Boston Harbor. (adapted from Taylor, 2001c)

organisms have little mobility, and (3) sewage solids use up oxygen in the sediments. Studies of the benthic communities of Boston Harbor made in the late 1970s and early 1980s showed that much of the northern part of Boston Harbor was seriously degraded, with very low numbers of a few pollution-tolerant species. The southern parts of the harbor, which were more distant from the major sewage discharges and better flushed, had healthier benthic communities (Pawlowski et al., 1996).

The MWRA began its systematic studies of the benthic communities of Boston Harbor in 1991, just prior to the cessation of sludge dumping into the harbor. The primary objective of these studies is to document the continuing recovery of the benthic communities in areas of the harbor as improvements are made to the quality of wastewater discharges (Kropp et al., 2000). Reports from these studies over the last decade have indicated that the condition of the infaunal communities and benthic habitats in the harbor have improved since the cessation of sludge discharge in 1991. Most notable has been a dramatic increase in abundance and geographic spread of the amphipod *Ampelisca spp.*, a major food source for the winter flounder (Pawlowski, et al., 1996). In addition, general increases in infaunal abundance and species numbers have also been noted (Kropp et al., 2000). The most significant changes in the benthos are thought to have occurred within the first 2 – 3 years after the sludge discharges ended (Kropp et al., 2000). Most recently, however, Kropp et al. (2000) found indications that the infaunal communities continue to be in transition from those that appeared soon after release from the stress caused by the sludge discharges to those more likely to be found in a less-polluted system that is still prone to periodic natural disturbance.

6. Recent Trends in Fish and Shellfish Indicators

The MWRA has sponsored contaminant effects and bioaccumulation trend monitoring since 1992 in three shellfish/fish indicator species, the blue mussel (*Mytilus edulis*), winter flounder (*Pseudopleuronectes americanus*) and lobster (*Homarus americanus*), which are important to Boston Harbor (Lefkovitz et al., 2000).

Bioaccumulation monitoring in the blue mussel has been undertaken at two Boston Harbor locations (Boston Inner Harbor and Deer Island Flats) and one off-shore reference site. As might be expected, contaminant levels in the blue mussel are routinely found to be highest at the Boston Inner Harbor site, lower at the Deer Island site, and lowest at the Offshore reference site for organics, lead, and mercury (Lefkovitz et al., 2000). As the discharges from the treatment plants of toxic organic chemicals like polynuclear aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) have decreased, the levels of these toxic chemicals found in the tissue of the blue mussel have generally fallen (Rex, 2000). All contaminant concentrations in the blue mussel fall below both the U.S. Food and Drug Administration (FDA) and MWRA Appreciable Change Levels (Lefkovitz et al., 2000).

Winter flounder has long been a mainstay of the commercial and recreational fisheries of Boston Harbor and Massachusetts Bay. Like lobster, the flounder lives and feeds on the sea floor, making it vulnerable to contaminants in the sediments (Pawlowski et al., 1996). Winter flounder populations have been monitored since 1992 in order to establish baseline conditions of biological parameters (e.g. length, age weight), external condition (e.g. extent and severity of lesions), and to determine the concentrations of organic and inorganic compounds in both the edible and the liver / hepatopancreas tissue (Lefkovitz et al., 2000). While contaminants concentrate in the flounder's liver, contaminant levels are generally so low in the flounder's lean filet that the meat poses no significant health risk to humans (Pawlowski et al., 1996). In the mid-late 1980s, contaminants in the liver of the flounder found within Boston Harbor had caused the fish to develop several types of diseases or lesions (Pawlowski et al., 1996). However, in recent years reports of liver disease have been at relatively low levels (Rex, 2000) with none of the high neoplasm found that was prevalent in the fish sampled from the harbor in the earlier years (Lefkovitz et al., 2000). Further, all filet contaminant concentrations were found to be below both the FDA and MWRA Appreciable Change Levels (Lefkovitz et al., 2000).

The American lobster (*Homarus americanus*) sustains a major commercial fishery along the entire New England coast. More lobsters are caught in and around Boston Harbor than anywhere else in Massachusetts. The MWRA has been monitoring contaminants in lobster tissue since 1992 in order to establish baseline conditions of biological parameters (e.g. size, sex), external condition (e.g. black gill disease, shell erosion, external tumors, etc.) and concentrations of inorganic and organic contaminants in the edible tail meat tissue and the hepatopancreas (Lefkovitz et al., 2001). Although Boston Harbor lobsters have somewhat higher levels of contamination than lobsters caught elsewhere in Massachusetts Bay and Cape Cod Bay, these contaminant levels have also declined significantly since the mid-1980s (Pawlowski et al., 1996) and the lobster edible tissue contaminant concentrations are well below the FDA Action Limits and the Appreciable Change levels set by the MWRA (Lefkovitz et al., 2001).

d. Critical Habitats

1. Intertidal / Freshwater Wetland Habitats

The US Fish & Wildlife Service, through its National Wetlands Inventory (NWI) Program, last published maps of the wetlands of the Boston Harbor Islands in 1995 (US Fish and Wildlife Service 1995a, 1995b). This mapping was based upon stereographic analysis of 1:58,000-scale color infra-red photography taken in 1986 and generally classified wetlands of greater than 1-acre in extent. These wetlands were classified according to the system developed by Cowardin et al. (1979). Table 6 provides a summary of the general wetland types mapped by the National Wetlands Inventory for the Boston Harbor Islands national park area (US Fish and Wildlife Service 1995a, 1995b).

Marine Intertidal Wetlands

The National Wetlands Inventory maps indicate that marine intertidal wetlands are the predominant coastal wetland type found in both the Outer Harbor Islands (Great Brewster Island, Middle Brewster Island, Outer Brewster Island, Calf Island, Little Calf Island, and Green Island) and along the eastern exposures of Deer Island and Lovell Island. These habitats are exposed to the waves and currents of the open ocean (Massachusetts Bay) with the water regimes being determined primarily by the ebb and flow of the tides. Salinity in these habitats will exceed 30 ppt and generally support typical marine biota (Cowardin et al., 1979). The distribution of plants and animals within the marine intertidal wetlands primarily reflects differences in four factors: (1) the degree of exposure of the site to waves; (2) the composition and physiochemical nature of the substrate ; (3) the amplitude of the tides; and (4) latitude, which governs water temperature, the intensity and duration of solar radiation, and the presence or absence of ice (Cowardin et al., 1979). Classes of marine intertidal wetlands within the national park area include rocky shore, aquatic bed and unconsolidated marine intertidal wetlands (USF&WS 1995a; 1995b).

Estuarine Intertidal Wetlands

Estuarine intertidal wetlands are the predominant wetland type in the shoreline habitats of the majority of the Inner Harbor, Quincy Bay and Hingham Harbor areas within the Boston Harbor Islands national park area. These include the shorelines of Bumpkin Island, Button Island, Gallops Island, Georges Island, Grape Island, Hangman Island, Long Island, Moon Island, Nut Island, Peddocks Island, Raccoon Island, Ragged Island, Rainsford Island, Sarah Island, Sheep Island, Slate Island, Spectacle Island, Thompson Island, and Worlds End, as well as the western shores of both Deer Island and Lovell Island (USF&WS 1995a; 1995b). Estuarine wetlands may also be found in low-lying areas adjacent to the shoreline which may be partially or fully enclosed by land, but have regular or sporadic access to tidally influenced harbor water. These habitats include low-lying regions on Thompson Island, Spectacle Island, Deer Island, Long Island, Moon Island, Peddocks Island, Sheep Island, Worlds End and Calf Island (USF&WS 1995a; 1995b). Salinity in estuarine intertidal wetlands is influenced by freshwater dilution caused by the river systems discharging into Boston Harbor. Salinity in these habitats may fluctuate significantly, being influenced not only by freshwater input but also by winds and tidal factors, and in some cases by evaporation in those estuarine wetlands which are periodically cut off from the tidal cycle. Classes of estuarine intertidal wetlands within the national park area include unconsolidated, emergent, aquatic bed and rocky shore estuarine intertidal wetlands (USF&WS 1995a; 1995b). A review of the general geomorphological, physical, and biological characteristics of the estuarine wetland resource habitat types found in the northeastern United States has recently been published by Roman et al. (2000).

While most of the estuarine intertidal wetlands fringing the properties of the national park area are quite small in extent, the estuarine intertidal wetlands found at Worlds End comprise the northern edge of a larger system, the Weir River Area of Critical Environmental Concern (ACEC) as defined by the Massachusetts Department of Environmental Management. The Weir River ACEC, which contains both Straights Pond and the tidally influenced portion of the Weir River, is one of the most extensive salt marsh systems in the greater Boston metropolitan area. Designated in 1986, the Weir River ACEC is located adjacent to the boundaries of the national park area. It is regionally significant both for its size and its importance in providing a relatively undisturbed marshland wildlife habitat (Massachusetts Department of Environmental Management, 1986). The Weir River ACEC contains a significant shellfish resource, supports an active anadromous fish run, and provides extensive nursery and feeding habitat for a wide variety of finfish including alewives (herring), smelt, flounder, bluefish, and striped bass. It also provides important habitat for over 100 species of migratory and indigenous birds and serves as an important food source for migratory waterfowl (Massachusetts Department of Environmental Management, 1986).

Similarly, two additional ACECs and part of a third, are located in the general proximity of the national park area. The Weymouth Back River ACEC, designated in 1982, comprises a natural area of approximately 950 acres in the midst of an urban/suburban environment (Massachusetts Department of Environmental Management, 1982). Approximately 180 acres of the Weymouth Back River ACEC are tidal waters flushing into Hingham Bay and support productive clam flats as well as nursery and feeding areas for finfish ecologically important to Boston Harbor. The ACEC also includes extensive salt marsh and salt pond habitats, and the lower portion of Herring

	Palustrine Wetlands	Estuarine Subtidal Wetlands	Estuarine Intertidal Wetlands (emergent)	Estuarine Intertidal Wetlands (unconsol)	Estuarine Intertidal Wetlands (rocky shr)	Estuarine Intertidal Wetlands (aq bed)	Marine Intertidal Wetlands (unconsol)	Marine Intertidal Wetlands (rocky shr)	Marine Intertidal Wetlands (aq bed)
Bumpkin Island			**X**	**X**					
Button Island			**X**	**X**					
Calf Island							**X**	**X**	**X**
Deer Island	**X**			**X**					**X**
Gallops Island				**X**					
Georges Island				**X**					
Grape Island	**X**		**X**	**X**					
Great Brewster	**X**						**X**	**X**	**X**
Green Island								**X**	**X**
Hangman Island				**X**					
Langlee Island					**X**	**X**			
Little Brewster								**X**	
Little Calf Island									**X**
Long Island	**X**			**X**					
Lovell Island	**X**			**X**			**X**		
Middle Brewster I.								**X**	**X**
Moon Island				**X**					
Nut Island			**X**						
Outer Brewster I.								**X**	**X**
Peddocks Island		**X**	**X**	**X**					
Raccoon Island			**X**			**X**			
Ragged Island					**X**				
Rainsford Island			**X**	**X**		**X**			
Sarah Island					**X**				
Sheep Island				**X**					
Slate Island			**X**	**X**					
Spectacle Island				**X**					
Thompson Island	**X**		**X**	**X**					
Webb State Park			**X**	**X**					
Worlds End	**X**		**X**	**X**		**X**			

Table 6. Types of wetlands classified in the Boston Harbor Islands national park area. (US Fish and Wildlife Service, 1995a;1995b)

Brook, Hingham's Fresh River, and several unnamed tributary streams, which provide spawning sites for an annual anadromous fish (herring) runs (Massachusetts Department of Environmental Management, 1982).

The Neponset River Estuary ACEC, designated in 1995, consists of 1,260 acres between Lower Mills Dam and the mouth of the Neponset River. The central resource features of the Neponset River Estuary ACEC are the Neponset River and portions of its tributaries, estuarine wetlands including salt marsh, floodplains, and fisheries and wildlife habitat (Massachusetts Department of Environmental Management, 1995). Open water, salt marsh and other estuarine wetland habitats comprise about 830 acres of this ACEC and support substantial soft-shell clam beds, valuable anadromous fishery habitat, spawning areas, and bird and wildlife habitat surrounded by an urbanized setting.

Most of the 2800-acre Rumney Marshes ACEC, designated in 1988, is located north of Boston Harbor principally within the Saugus River / Pines River estuary. However, the Belle Isle Marsh area of the Rumney Marshes ACEC empties into Winthrop Bay along the northern shore of Boston Harbor. The Belle Isle Marsh contains 275 acres of salt marsh, salt meadow, and tidal flats (Massachusetts Department of Environmental Management, 1988). It is publicly owned by the Metropolitan District Commission and the municipalities of Boston, Winthrop and Revere and provides both important ecological habitat and flood water storage (Massachusetts Department of Environmental Management, 1988).

While the ACECs are located almost entirely outside of the boundary of the national park area they are biologically connected and the habitats they provide are of great significance to the overall ecological health of the entire Boston Harbor area.

Damde Meadows Wetlands Restoration (Worlds End)

While little is known about the current condition and function of many of the wetland areas within the Boston Harbor Island national park area, this is not the situation for Damde Meadows. Damde Meadows is one of the prominent features of The Trustees of Reservations' Worlds End property.

Prior to European settlement in the 1600s, Damde Meadows was a typical New England salt marsh located between Cushing Neck and Planter's Hill. It occupied a low-lying, long, thin area extending from Martin's Cove to the Weir River. It is generally believed that early colonists constructed small stone dams at both ends of the salt marsh, preventing tidal flow from reaching the marsh, in order to control tidal flow for salt marsh hay cultivation. Sometime around 1890, a second more substantial dike was constructed. Early 20th century manipulation included the installation of tide gates, a tile drain system, and pumps to control both the backflow of salt water into the marsh and to remove groundwater from the meadow in the spring (J. Andrew Walsh, TTOR, personal communication, 2001). Since the 1940s, the drain tiles, drainage pipe, pump house and tide gates have either fallen into disrepair or been removed, allowing both fresh water and salt water to accumulate at times in Damde Meadows. The "meadow" today is in a somewhat degraded condition, resulting from wide swings in salinity over time, with the area fluctuating from a nearly freshwater pond in the spring to a saltwater pond in the summer. Over the past five years, The Trustees of Reservations has consulted with a number of wetland ecologists, botanists, and wildlife ecologists who have concluded that Damde Meadows is a good candidate for salt marsh restoration (J. Andrew Walsh, TTOR, personal communication, 2001).

In the late 1990s, Curry College and the Natural Resources Conservation Service assisted The Trustees of Reservations by conducting a feasibility study and developing specific conceptual design alternatives for restoring Damde Meadows (USDA-Natural Resources Conservation Service, 1999). The Trustees of Reservations, working in cooperation with the Massachusetts Wetlands Restoration Program (MWRP), Coastal America, and the Massachusetts Corporate Wetlands Restoration Project (MCWRP) selected a restoration plan which would correct the current drainage problems by restoring the normal flow of tidal sea water into and out of Damde Meadows, restoring the area to a naturally functioning salt marsh (J. Andrew Walsh, TTOR, personal communication, 2001). This would be accomplished by placing an appropriately-sized box culvert through each dike, allowing the free flood and ebb of the tide.

A Notice of Intent has been filed with the Commonwealth of Massachusetts and necessary environmental compliance in support of this project is underway. This project could ultimately restore approximately 14.7 acres of important salt marsh habitat, potentially increasing the primary productivity, nutrient production and export, fish habitat and biodiversity of the system (J. Andrew Walsh, TTOR, personal communication, 2001).

Palustrine (Freshwater) Wetlands

Palustrine wetlands occur in areas where the salinity due to ocean derived salts is less than 0.5 ppt (Cowardin et al., 1979). Within the national park area these are limited to a few small areas (freshwater marshes and/or small ponds) located on Deer Island, Thompson Island, Worlds End, Long Island, Lovell Island and Great Brewster Island (US Fish and Wildlife Service 1995a, 1995b). While small in area, these freshwater resources may be of significant biological value. For example, Ice Pond, a small, shallow pond located at Worlds End is the only surface freshwater source in the reservation and functions as a woodland vernal pool, which could be of biological significance during the reproductive cycles of resident amphibian and/or reptile populations.

In addition to the National Wetlands Inventory maps, the Wetlands Conservancy Program of the Massachusetts Department of Environmental Protection is in the process of completing a mapping inventory of the state's wetlands, based upon 1:12000-scale imagery geo-rectified and mapped on 1:5000 digital orthophoto quads (C. Costello, Massachusetts Department of Environmental Protection, personal communication, 2000). The classification system used is similar to the federally accepted Cowardin classification system and a fairly accurate conversion is possible. These maps are now available from 1995 imagery and the Commonwealth plans to update these maps from new imagery to be obtained in 2001 (C. Costello, Massachusetts Department of Environmental Protection, personal communication, 2000).

Current Wetlands Study Efforts

Wetland Habitat Mapping of the Boston Harbor Islands*:* NWI maps exist for the Boston Harbor Islands in a scale that limits their use in identifying the presence and extent of wetlands at a scale desirable for natural resource protection and management. While the location of larger wetlands are known, the presence of smaller wetlands may have been missed and little documentation exists pertaining to wetland habitat composition or their current condition.

A recent cooperative effort initiated by the US Fish and Wildlife Service's National Wetlands Inventory Program and the National Park Service was designed to delineate and document all critical freshwater, brackish, and coastal wetland habitats in the Boston Harbor Islands National Park Area. The utilization of finer-scale imagery and increased ground-truthing will allow for this study to generate a comprehensive survey of all coastal and freshwater wetland habitats in the national park area (Tiner and Farris, 2000). Anticipated products from this study include:

- a delineation of critical wetland habitats
- a report summarizing the results of the wetlands habitat classification efforts (Tiner and Farris, 2000).

Intertidal Biotic Overview and Assessment: Boston Harbor Islands*:* While a considerable amount of information is known about the community structure of the intertidal habitats of New England in general (Lubchenco and Menge, 1978; Nixon, 1982; Teal, 1986; Whitlatch, 1982; Roman et al., 2000), little quantitative information has been available specific to the intertidal biological resources of the Boston Harbor islands. While Menge (1976, 1978) and Lubchenco and Menge (1978) completed limited sampling of rocky intertidal areas on the Brewster islands in the mid-1970s, a geographically extensive inventory of the intertidal resources of the Boston Harbor islands has been lacking.

In 2001, a study was initiated by the National Park Service and the Island Alliance on behalf of the Boston Harbor Islands Partnership to provide an intertidal resources overview and assessment for the Boston Harbor Islands national park area. This study was conducted by researchers from the New England Aquarium, the US Geological Survey and the Massachusetts Audubon Society. Objectives of this study include:

- developing a comprehensive, GIS-compatible database of the marine and estuarine intertidal habitats for the Boston Harbor islands;
- providing a narrative description of the intertidal habitats found within the Boston Harbor Islands national park area, including habitats and species of management concern (e.g. sensitive, rare, exotic or invasive species);
- compiling a species list for major taxonomic groups based upon literature review and field surveys;
- identifying issues which may be of interest to managers charged with the protection of intertidal resources; and,
- identifying and recommending long-term monitoring and research needs (Chandler et al., 2001).

In 1991, Bell et al. (2002) developed the Boston Harbor Intertidal Classification System (BHICS). The BHICS is built upon the wetland classification system created by Cowardin et al. (1979), but also incorporates features found in the regional schemes of Dethier (1990) and Brown (1993). In particular, Bell et al. (2002) attempt to include cultural features commonly found in a marine system that has been heavily altered by centuries of human activity including rip-rap, armature, jetties, piers, groins, etc.

In this study, Bell et al. undertake intensive intertidal habitat mapping in order to apply the BHICS to 15 representative areas of the Boston Harbor Islands national park area. These include Worlds End, Slate Island, Thompson Island, Long Island, Grape Island, Spectacle Island, Rainsford Island, Georges Island, Lovell Island, and Peddocks Island which represent areas consisting primarily of unconsolidated sediment and are partially protected from direct wave exposure; Outer Brewster Island, Little Brewster Island, Calf Island which are exposed bedrock islands; Langlee Island a protected bedrock island within Hingham Harbor; and Great Brewster Island which is largely composed of unconsolidated sediments but exposed to heavy wave action (Bell et al., in review). The results include detailed maps of the substrata and biotic assemblages for the 15 areas as well as a species list of the 95 animal species, 70 marine algae, 15 vascular plants and 3 fungi identified to the species level during the 2001 intertidal surveys.

Bell et al. (2002) also provide a series of recommendations pertaining to future inventory, monitoring, and research needs pertaining to the intertidal resources of the Boston Harbor Islands national park area. These recommendations are discussed in more detail in Section IV (Considerations for Future Actions) of this water resources scoping report.

2. Submerged Aquatic Vegetation

The role of submerged aquatic vegetation (SAV) as an important component of sub-tidal estuarine systems, serving as a food source and nursery for a variety of organisms, contributing to water quality, and serving as an indicator of ecosystem health has been well recognized (Orth and Moore, 1984). Historically, eelgrass grew in most of the bays and estuaries of the northeastern United States (Roman et al., 2000). Figure 4, compiled from an evaluation by the U.S. Environmental Protection Agency of U.S. Coast and Geodetic Survey maps produced in the mid-late 19th century , shows that submerged aquatic vegetation [most likely eel grass (*Zostera marina*)] was once fairly widespread throughout much of Boston Harbor where the appropriate geomorphological conditions existed (P. Colarusso, U.S. Environmental Protection, personnel communication, 2002).

While not consistently documented, it is known that eelgrass began to disappear locally from many systems in the northeast during the 19th century as a result of land clearing, deforestation, and industrial development (Roman et al., 2000). In addition, in the 1930s an epidemic disease threatened to eliminate eelgrass throughout the northeastern United States and elsewhere throughout the North Atlantic and Europe (Rasmussen, 1977). This eelgrass decline, known as "wasting disease" (Milne and Milne, 1951) was a naturally occurring disease caused by *Labryrinthula zosterae* (Muehlstein et al., 1991) that devastated large eelgrass populations and eliminated up to 90% of the North Atlantic eelgrass. Following this episode, eelgrass slowly reestablished itself over much, though not all, of its historic range throughout the northeastern United States (Roman, et al., 2000). However, the decline of submerged aquatic vegetation due to a combination of wasting disease, increased water turbidity often exacerbated by

(Click here for full image)

Figure 4. Boston Harbor mid-late 19th century eelgrass distribution (US EPA, 2002)

(Click here for full image)

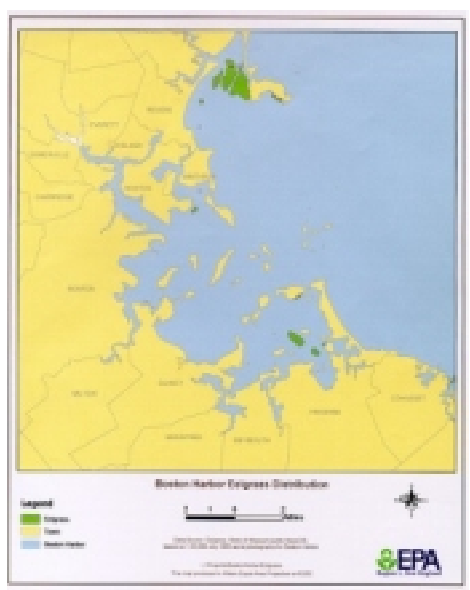


Figure 5. Boston Harbor mid-1990s eel grass distribution (USEPA, 2002)

human-induced increases in nutrient loading, and the loss of habitat due to filling has been widespread in many estuaries worldwide.

Figure 5 shows locations within the Boston area where the U.S. Environmental Protection Agency and the Wetlands Conservation Program of the Massachusetts Department of Environmental Protection have recently mapped locations of eel grass beds. Five of these locations, mostly in the Hingham Harbor vicinity, are in close proximity to the national park area. These include: (1) off the eastern edge of Logan Airport (approx. 1600' long and 600' wide), (2) off the south side of Hull opposite Hog Island (2000' long by 300' wide), (3) SW of Bumpkins Island midway to Grape Island (4600' long by 900' wide), (4) SE of Bumpkins Island about 2/3 of the distance to Worlds End (2000' long by 500' wide) and (5) off the NW edge of Worlds End (1000' long by 200' wide) (C. Costello, Massachusetts Department of Environmental Protection, personal communication, 2000).

As water quality throughout Boston Harbor improves, there is the possibility of a gradual recolonization of the shallower areas of the harbor with seagrasses. The recovery of the seagrass beds, however, is likely to take decades as few beds remain in Boston Harbor to serve as a seed population, and seagrasses release heavy seeds which do not travel long distances (Pawlowski, 1996). The health and extent of the eelgrass beds may, however, serve a role as one of the key "vital signs" indicators of the health of the Boston Harbor ecosystem . Some of the key environmental conditions for eelgrass survival which include nutrient levels, light penetration, water temperature, salinity, and appropriate geomorphological conditions may be affected by local, regional, and global stressors including shoreline filling (local), boating activities (local), point source and non-point source pollutant management (local/regional), and changing water temperature / salinity conditions (global) .

e. Geohydrology / Groundwater Resources

The Boston Harbor islands are composed primarily of glacial materials that directly overlie the bedrock surface. The surficial materials that overlie the weathered bedrock surface were deposited by continental ice sheets that covered New England twice during the Pleistocene Epoch, and by near-shore processes in the Holocene Epoch. The thickness of these materials, where present, ranges from less than 1 foot to about 300 feet thick (Masterson et al., 1996).

Many of the islands of the Boston Harbor Islands national park area consist of glacially deposited drumlins composed of a thick, dense, homogeneous till core, which is overlain by a thin layer of stratified beach deposits (Masterson et al., 1996). The till is characterized as an unsorted matrix of sand, silt, and clay intermixed with variable amounts of stones and large boulders. The stratified deposits primarily consist of sorted and layered sand and gravel that accumulated and formed the beaches and tombolos of the islands (Masterson et al., 1996).

In 1996, the US Geological Survey conducted an investigation of the geohydrology and of the potential for water supply development for six of the Boston Harbor islands including Bumpkin, Gallops, Georges, Grape, Lovell and Peddocks islands (Masterson et al., 1996). The primary purpose of this study was to investigate the possibility of developing permanent, small-capacity water supplies capable of supporting recreational activities such as hiking, camping, and swimming.

Masterson et al. (1996) found that the hydrology of each of the six islands studied was characterized by hydraulically independent freshwater-flow systems that consisted of about 10 to

30 feet of weathered till containing a dense substratum near the land surface that may perch water. The freshwater flow systems of the six islands is underlain by either bed rock or saltwater and they are also laterally separated from one another by the saline waters of Boston Harbor (Masterson et al., 1996). Thus, the sole source of freshwater to each of the islands studied is the infiltration of precipitation into the soils of the island.

The amount of precipitation reaching the saturated zone (recharge) would be expected to vary spatially and temporally in response to climatic (e.g. precipitation patterns, etc.) and biologic (e.g. evapotranspiration) factors, as well as to the local topography. The recharge rates would also be affected by local differences in the infiltration capacity and other hydraulic properties in the unsaturated zone. Using estimates of recharge rates from previous investigations in similar hydrogeologic settings, Masterson et al. (1996) were able to model approximate groundwater movements for the six islands.

Masterson et al. (1996) determined that groundwater flow generally is radial from the center of the island towards the coast. Topographically high areas, such as the upper slopes and crests, are typically the recharge areas. Groundwater discharge would typically occur at the lower slope areas of the drumlins, the topographically low areas such as coastal marshes or ponds, or directly along the coast (Masterson et al., 1996).

The position of the water table relative to land surface is an extremely important consideration in selecting sites for water-supply development, especially given the difficulties associated with drilling in till material. However, Masterson et al. (1996) found that the depth to water table was impossible to estimate for each of the Boston Harbor islands due to the lack of available hydrologic data. Therefore, they developed a conceptual 2-dimensional cross-sectional groundwater flow model which indicated that nearly all of the saturated portion of the drumlin-island flow system occurred in the compact drumlin till, the beach-type deposits, and the underlying weathered-bedrock zone (Masterson et al., 1996).

For the purposes of their investigation, Masterson et al. (1996) assumed that drawing water from a standard “pitcher” pump would be most efficient at a depth to water of less than 20 feet below the land surface. Thus, their model indicated that a freshwater water table at this depth would be located within 240 feet of the shoreline, which generally coincides with the high hydraulic conductivity zones of beach-type and weathered till deposits on the fringes of each drumlin island (Masterson et al., 1996). However, Masterson et al. (1996) did not model the possible effects of ground-water withdrawal on the position and movement of this interface or whether groundwater withdrawals from these areas would be affected by saltwater intrusion.

III. Significant Water-Related Issues

1. Issues Identification/Scoping Workshop (May 3, 2000)

A water resources issues identification and scoping workshop was held on May 3, 2000, in order to identify concerns and exchange information pertaining to water-related issues among the various members of the Boston Harbor Islands Partnership and other interested entities. Attendees at the scoping session included representatives of the National Park Service, US Geological Survey, US Coast Guard, Massachusetts Executive Office of Environmental Affairs, Massachusetts Department of Environmental Management, Massachusetts Coastal Zone Management and the Boston Harbor Islands Advisory Council. Representatives of the Metropolitan District Commission, Massachusetts Department of Environmental Management, The Trustees of Reservations, and the Thompson Island Outward Bound Education Center also hosted field trips as part of the scoping process.

After a short overview of the purpose and objectives of the scoping process, discussions were held pertaining to the various water-related concerns. Following the discussions of the various issues, the participants were provided an opportunity to identify those water-related issues they felt to be of the greatest concern in the management of the national park area. The following were identified as the primary water-related concerns of the scoping session participants:

Inadequacy of Available Baseline Resource Information (52%)

Many of the participants felt that the current status of water-related baseline information was inadequate for proper management decision making. The following habitats/processes were specifically identified as lacking adequate baseline resource information:

Intertidal resources (salt marshes, tidal flats, rocky intertidal)
Coastal processes/erosion
Wetland resources (ponds, freshwater marshes, brackish marshes)
Subtidal resources (eel grass beds)

Water Quality Issues (32%)

While the overall water quality of Boston Harbor has improved dramatically over the last two decades, many participants felt that there were important aspects of water quality that affect the "nearshore" management of the Boston Harbor Islands. These issues include:

Potential impacts of marinas/mooring areas/commercial boat discharge
Potential infrastructural impacts (septics/sewage disposal)
Need for public health/recreational water quality monitoring
Impacts of water quality on shellfish harvesting
Need for additional spill contingency planning

Water Supply/Groundwater Issues (16%)

With rapidly increasing visitation, the issue of providing a safe and adequate public drinking water supply is a concern. While Georges Island currently has a waterline, other islands with increasing recreational use will eventually need more reliable water supplies. It is important that these water supplies be developed in a manner that will not impact sensitive wetland resources, which may be dependent on groundwater inputs from fragile freshwater lenses. While "solutions" to this issue are beyond the scope of this report, existing information pertaining to current water supplies and alternative sources will be summarized.

2. Issues Assessment

a. Adequacy of Available Baseline Resource Information

Early in the scoping process, several of the Boston Harbor Islands Partnership agency representatives acknowledged that the lack of adequate baseline data was one of the most important water-related issues confronting the management of natural resources within the national park area. The most critical water-related information gaps for the Boston Harbor islands were considered to be intertidal resources baseline information and information pertaining to coastal shoreline erosion processes. These were followed by baseline information deficiencies relating to wetland and subtidal resources (National Park Service, 2000).

In recognition of these needs, the Partnership has been active in developing proposals and initiating inventory activities necessary to begin to fill these information gaps. Recently initiated or proposed activities include:

Natural Resource Bibliography. Pennsylvania State University has recently developed a Natural Resource Bibliographic Database providing an annotated bibliography of published and unpublished materials pertaining specifically to the natural and cultural resources of the Boston Harbor Islands. Materials include books, reports, journal articles, research data, maps, photographs, computer data files, memos and specimens. Each database record contains a complete citation, abstract, key words, and storage location of the document/specimen (http://www.bostonislands.com/manage/manage_opps_rsrch.html).

Natural Resource Overview & Assessment: Intertidal Habitats. The New England Aquarium, US Geological Survey, and the Massachusetts Audubon Society, in cooperation with the Island Alliance and National Park Service, are currently conducting a survey of biotic communities in the intertidal zone of all the harbor islands (Chandler et al., 2001). This comprehensive inventory of intertidal resources is expected to provide a GIS-compatible database, comprehensive species lists, narrative descriptions of intertidal zone habitats filling important baseline information needs for Boston Harbor Islands national park area. Additional information regarding this inventory project may be found in Section II.D.1. of this report.

Boat Wake Impacts and their Role in Shore Erosion Processes. Researchers from Boston University, the US Geological Survey, and Northeastern University have developed a proposal for a multi-phased study to address patterns of natural erosion and assess impacts of boat wakes on shoreline erosion for the national park area (Fitzgerald et al., 2002). Phase I field work for this study was initiated in 2001 (Emily Himmelstoss, Boston University, personal communication, 2002). Funding to implement future phases of this project has been included in the FY03 National Park Service budget request to Congress. More details regarding these studies may be found in Section III.E.1. of this report.

Wetland Habitat Mapping. The U.S. Fish and Wildlife Service National Wetland Inventory Program and National Park Service are currently conducting a comprehensive survey of all coastal, brackish, and freshwater wetlands in the national park area. Wetland habitats on all islands will be delineated and mapped based on the Cowardin (1979) system of wetland classification, and additional descriptors will be used to classify the wetland's hydrogeomorphology. The wetland inventory report will also include descriptions of wetland communities and acreage by wetland type for each island. More details regarding this work may be found in Section II.D.1. of this report.

Natural Resource Overview and Assessment: Upland Habitats. The Massachusetts Natural Heritage & Endangered Species Program, in cooperation with the Island Alliance and the National Park Service, is conducting a comprehensive survey of plants and animals for the upland areas within the national park area. While the focus of this inventory is the upland resources, plant and animal surveys will be conducted in water-related upland resources including freshwater ponds and wetlands. In 2001, a survey of aquatic invertebrates was undertaken for a number of the Boston Harbor islands as part of this research efforts (Karnauskas, 2001). While limited in scope, this short-duration survey does provide some basic fundamental inventory information (http://www.bostonislands.com/manage/manage_opps_rsrch.html).

Historic Vegetation & Land Use History. The University of Massachusetts – Amherst is tracing the history of natural vegetation and land use on the Boston Harbor islands from the time of European settlement in the 1600s in order to produce historic vegetation and land use maps, descriptions of period vegetation, and catalogs of species which will demonstrate changes over time (http://www.bostonislands.com/manage/manage_opps_rsrch.html). While the focus, once again, will be primarily upon the island's upland resources, it is expected that the historical vegetation and land use maps will be of interest in the management of water-related natural resources.

The studies noted above are designed to provide important baseline resource information to fill information gaps similar to those discussed at the scoping session. Upon the completion of these studies, it is important that the Boston Harbor Islands partnership consider study results and recommendations in order to develop a strategy for integrating this baseline information with future long term monitoring needs for the national park area.

b. Water Quality Issues

1. Impacts of existing water quality on island resources

Although the waters of Boston Harbor are not included within the national park area boundary, they influence significant portions of the island shores during the twice-daily tidal cycle. With a mean tidal range of approximately 10.3 feet, Boston Harbor is well flushed. Visitor use and enjoyment, in addition to natural resource conditions, have historically been linked to the water quality of Boston Harbor. Prior to the mid-1980s, more than a century of deteriorating water quality conditions within Boston Harbor had been largely overlooked by generations of Bostonians who had grown accustomed to polluted beaches, odoriferous waters, and harbor islands whose aesthetics offered few recreational amenities. While important in commerce, the harbor itself had largely become a "dumping ground" for poorly treated sewage and polluted urban storm water runoff. Indeed, some of the Boston Harbor islands also served as locations for municipal solid waste disposal. Only since the successes of the Boston Harbor Project in improving water quality conditions have the natural, historical, cultural, and recreational attributes of Boston Harbor come to be viewed as assets by the general public.

As discussed earlier in this report (see section II.C.) the water quality of Boston Harbor has improved greatly since the late 1980s. The number of advisories against swimming at harbor beaches, which was high in the 1980s, decreased markedly during the 1990s (Rex, 2000). The concentrations of toxic metals and organic compounds have decreased dramatically with improvements in wastewater treatment, and water clarity has greatly improved (Rex, 2000). Ecosystem health, as represented by a number of quantifiable indicators, began to improve in the early 1990s and continues a trend towards long-term improvement today. These results have been so encouraging that the governor of Massachusetts and the mayor of Boston appointed a Joint Commission on the Future of Boston Harbor Beaches in order to recommend a restoration plan for the waterfront and island beaches with funding of $30 million. While this initiative primarily involves beaches from Winthrop to Wollaston, improvements are also planned for the Boston Harbor island beaches. Short-term objectives within the national park area include the construction of a large picnic pavilion, repair of a waterline, plantings and the installation of composting toilets on Georges Island. Longer term objectives include reconstruction of piers at Peddocks and Lovell islands, seawall repairs and a major utility upgrade on Georges Island as well as general landscape and site improvements (www.state.ma.us/mdc/bchplan.htm).

Encouraging as the results have been over the past decade, more remains to be done. Contaminated stormwater including combined sewer overflows (CSOs) still poses problems in many areas of the harbor. Combined sewer systems, which still service large areas of Boston, Cambridge, Somerville, and Chelsea, discharge overflow volumes into the Neponset River, Charles River, Mystic River, Alewife Brook and Boston Harbor. In 1997, the MWRA presented its long-term CSO control plan, which recommended 25 wastewater system improvement projects to bring CSO discharges at 84 outfalls in the metropolitan Boston area into compliance with the Clean Water Act and state water quality standards (MWRA, 1997). The CSO plan also proposes the elimination of CSO discharges to sensitive use areas (i.e. beaches and shellfish growth areas), a significant reduction or treatment of discharges to less sensitive waters, and a means to control floatable materials where CSO discharges will remain (MWRA, 2002).

Over the next few years the Massachusetts Water Resources Authority plans to spend more than $600 million to increase the capacity of the interceptor/tunnel systems adding to their capacity and flexibility to handle peak wet weather flows (MWRA, 2002). As these projects are completed, it is expected that the number of swimming advisories will continue to decrease throughout the Boston Harbor area. Full implementation of the CSO plan is currently expected by 2008 (MWRA, 2002).

Additional water quality-related challenges remain within the Boston Harbor watershed. The National Research Council reports that nearly 85% of the 29 million gallons of petroleum that enter North American ocean waters is a result of urban stormwater runoff, small watercraft utilizing 2-stroke engines, polluted rivers and airplanes. Many of the municipalities also have older sanitary sewer systems, where overflows of sewage from manholes or underground sewage structures can occur (Rex, 2000). In wet weather, stormwater and groundwater may enter sanitary sewer systems through infiltration in volumes sometimes great enough to cause overflow. The MWRA is currently working with communities to plan, design and construct sewer relief projects, which will eliminate sanitary sewer overflows except during the most extreme storm events. Controlling sanitary sewer overflows and improving management are all long-term goals, which will probably be required before large areas of Boston Harbor would again be suitable for recreational shellfish harvesting (Dave Roach, Division of Marine Fisheries, personal communication, 2002).

2. Potential impacts of marinas and mooring areas

Boston Harbor is the home of the oldest continually active major port in the Western Hemisphere. Today, the Port of Boston handles more than 1.3 million tons of general cargo, 1.5 million tons of non-fuel bulk cargo, and 12.8 million tons of bulk fuel cargo annually (Massport, 2002). In addition to serving as a modern container port, the Port of Boston also hosts a robust passenger ship industry, two shipyards, an enormous complex of privately owned petroleum and liquified natural gas terminals, numerous public and private ferry operations, a major U.S. Coast Guard facility, a world-renowned aquarium, numerous recreational vessel marina facilities, and one of America's highest-value fishing ports (Massport, 2002).

Co-existing alongside this major commercial activity, Boston Harbor supports a robust recreational boating industry with the Boston Harbor Islands national park area providing popular destinations for recreational boating enthusiasts ranging from sea-kayakers to yachtsmen. At the present time, marina and maintained mooring facilities within the national park area are limited.

Over the past several years the Central Artery/Tunnel Project (http://www.bigdig.com) has utilized Spectacle Island as a deposition site for more than 3 million cubic yards of clay, dirt and gravel that was dug for the Ted Williams Tunnel and other construction. From 1912 – 1959 Spectacle Island had been used as a City of Boston municipal dump. Prior to the Central Artery / Tunnel Project, the island existed largely as an open mountain of decaying garbage, leaching thousands of gallons of material into the surrounding waters (Massachusetts Department of Public Works, 1990). Working with the islands owners (City of Boston and DEM) and the Massachusetts Department of Environmental Protection, the Central Artery/Tunnel Project has developed a plan to reshape and clay cap the island transforming the former landfill into a 100-acre public park, which will soon contain public docking facilities, a marina, beaches, picnic areas, a trail system, recreational areas and a visitor center (Central Artery/Tunnel Project, 2002).

In addition, the Boston Harbor Islands national park area initiated a recreational mooring program in 2001. In 2002, mooring fields will provide access alternatives for recreational boaters near Long Island (20 moorings), Peddocks Island (16 moorings), Rainsford Island (7 moorings), Gallops Island (4 moorings), Georges Island (2 moorings), and Bumpkin Island (1 mooring) (Island Alliance, 2002). In return for a daily fee, this program will not only provide a maintained mooring but also on-site waste pump-out, garbage removal, and other services.

With the probable expansion of marina facilities and mooring opportunities throughout the national park area in future years, the island managers will need to institute appropriate management practices in order to avoid negative environmental impacts which have sometimes been associated with marinas and moorings activities. These negative environmental impacts can often-times be easily avoided by adopting best management practices (BMPs) associated with marina/mooring facility siting, design, and operations. National guidance for management measures to control nonpoint source pollution from marinas and recreational boating has been developed by the U.S. Environmental Protection Agency (U.S. Environmental Protection Agency, 2001). Best management practices for the implementation of appropriate management measures may be found in the Massachusetts Clean Marina Guide (Massachusetts Office of Coastal Zone Management, 2001). Table 7 provides a partial listing of best management

Table 7. Best Management Practices (BMPs) for marina siting, design, and operations. [adapted from the Massachusetts Clean Marina Guide (Massachusetts Office of Coastal Zone Management, 2001) and the Virginia Clean Marina Handbook (Commonwealth of Virginia, 2001)].

BMPs FOR MARINA SITING	BMPs FOR MARINA DESIGN
• Redevelop Existing Sites • Avoid Rare & Endangered Species • Avoid Submerged Aquatic Vegetation • Minimize Disturbance to Wetlands • Avoid Shellfish Waters • Avoid Critical Migration / Nesting / Spawning Areas • Consider Bottom Configuration • Minimize Impervious Areas to Reduce Runoff • Provide for the Management of Stormwater Runoff	• Avoid site designs where marina bottoms / entrance channels are deeper than the adjacent waters • Minimize Dead Water in Marina Designs • Use Fixed or Floating Piers to Enhance Water Circulation • Use Environmentally Neutral Material • Limit Shaded Areas Over the Water • Minimize the Need for Dredging • Minimize the Impacts of Dredging • Employ Nonstructural Shore Erosion Control Measures • Provide Adequate and Convenient Pump-out Facilities

BMPs FOR MARINA/MOORING FIELD OPERATIONS
• Assure adequate staff training in fueling procedures, spill prevention and control, and emergency response plans (including the use of containment measures)
• Conduct emergency response drills at least twice annually; maintain records of training dates, topics and names of instructors/trainees.
• Assure staff training regarding the proper management and disposal of used oil, spent solvents, spent abrasives, vessel wastewater, painting and blasting wastes and used batteries.
• Establish appropriate speed limits and no-wake zones.
• Educate boaters of appropriate environmental management practices via posting signs detailing appropriate environmental procedures, hosting a "clean marina" workshop, and incorporating environmental BMPs into contracts.
• Develop appropriate "conflict resolution" procedures to politely address boaters/contractors not meeting environmental expectations and training / instructing employees to notice and (where appropriate) halt activities including: sewage discharge into marinas, bilge water discharge with a sheen, colored plumes in water where hull is being cleaned, uncontained sanding or painting activities, and the use of environmentally harmful cleaning materials.

practices, which should be considered in the planning, development and operations of marinas and/or mooring fields located within the national park area.

One common environmental impact sometimes associated with recreational boating activities is the discharge of untreated and treated sewage from recreational boats into the harbor. During periods of heavy boating usage, water quality testing at popular mooring areas within many units of the national park system have shown significant increases in levels of sewage indicator bacteria. These have, at times, required the posting or closing of areas to swimming activities. In order to address this type of issue, in July, 2001, Boston Mayor Thomas M. Menino instructed the Boston harbormaster to aggressively prosecute anyone caught discharging untreated sewage from boat toilets into Boston Harbor and also announced his intention to work with state and federal authorities to make Boston Harbor a "no discharge zone" (City of Boston, 2001). Several local organizations within the Boston area including the Boston Harbor Association (http://www.tbha.org), the City of Boston Environment Department, the Massachusetts Coastal Zone Management Information Line (http://www.state.ma.us/czm) and the U. S. EPA Vessel Discharge Program (http://www.epa.gov/owow/oceans/vessel_sewage) can provide more information about vessel sewage discharge and marine debris issues within Boston Harbor.

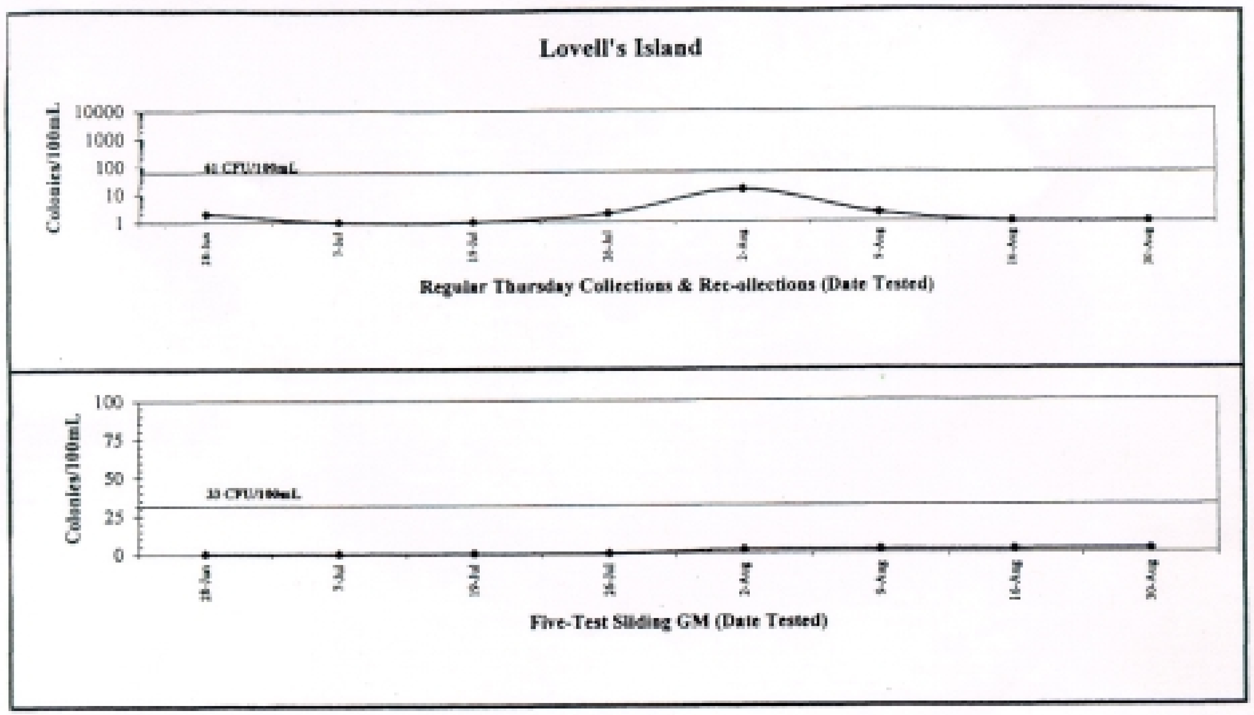
3. Need for public health/recreational water quality monitoring

Both the swimming conditions and the aesthetics at most of the Boston Harbor beaches are better than they have been in decades. As most of the Boston Harbor beaches are managed by the Metropolitan District Commission (MDC), the MDC in cooperation with the MWRA maintains an extensive seasonal recreational water quality monitoring program. During the July and August recreational season, the MDC and MWRA conduct daily recreational water quality monitoring at five key Boston Harbor beaches including Wollastan Beach (Quincy), Tenean Beach (Dorchester), Carson Beach (South Boston), Pleasure Bay Beach (South Boston), and Constitution Beach (East Boston). In addition, the MDC also conducts weekly recreational water quality testing at all of the additional designated Boston Harbor swimming beaches as well as designated swimming beaches in Revere, Nahant and Nantasket (MWRA, 2000).

The biggest risk of water quality pollution at the Boston Harbor beaches occurs after heavy rainstorms. Stormwater runoff can be contaminated, and overflows from combined sewer systems may sometimes affect beaches. Thus, swimming in urban areas is generally not recommended for 24 hours after any heavy localized rain storm. After recreational water quality laboratory results are processed by the MWRA, these results are quickly communicated to the MDC lifeguards who flag the beaches. A beach displaying a blue flag indicates that recreational water quality meets EPA recommended recreational water quality criteria. These criteria for marine water bathing beaches are *Enterococci* less than 35 colonies per 100 ml (geometric mean of previous 5 samples) and *Enterococci* less than 104 colonies per 100 ml for any individual sample. A beach displaying a red flag does not meet these criteria, which indicates the potential for increased health risks. Results of the monitoring are also promptly posted on both the MWRA and MDC web pages (MWRA, 2000).

The Lovell Island Beach is currently the only designated swimming beach within the Boston Harbor Islands national park area. The MDC has intermittently monitored recreational water quality on a seasonal basis (1987 – 1991; 1995; 2000 – 2001) at the Lovell Island Beach since 1987 (Mark Doolittle, MDC, personal communication, 2002). Occasional (and sometimes irregular) monitoring occurring from 1987 – 1991 showed only one instance (August 10, 1988) when the EPA recommended criteria for fecal coliform bacteria was exceeded and no sampling date when the

MDC BEACH ENTEROCOCCI TESTING 2001



Beach Collection & Posting Summary Data

GM	Thursday Collections	Re-collections	Total Collections	Postings	Exceedances of Standards*			Test Lab.
					SDM	GM	BOTH	
2	7	1	8	0	0	0	0	MDC

* SDM: Single Day Maximum
GM: Geometric Mean (GeoMean)
BOTH: Single Day Maximum & Geometric Mean

Figure 6: MDC recreational water quality monitoring for *Enterococci* bacteria at Lovell Island Beach (2001). Source: Mark Doolittle, Metropolitan District Commission, personal communication, 2002.

EPA recommended criteria for *Enterococci* was exceeded (Mark Doolittle, MDC, personal communication, 2002). Occasional monitoring in 2000 for both fecal coliform bacteria and *Enterrococci* and regular weekly (Thursday) monitoring for *Enterrococci* from late June through August (Figure 6) also showed that the recreational water quality at the Lovell Island Beach never exceeded the recommended EPA criteria (Mark Doolittle, MDC, personal communication, 2002).

4. Impacts of water quality on shellfish harvesting

The Shellfish Sanitation and Management Program of the Massachusetts Division of Marine Fisheries (DMF) has responsibility for protecting public health related to shellfish harvest and exercises direct or indirect management authority of the State's molluscan shellfish resources (i.e. clams, mussels, oysters and crabs).

Public health protection for shellfish growing areas is managed by the DMF in accordance to protocols established by the National Shellfish Sanitation Program (NSSP). The NSSP is a voluntary federal/state/industry cooperative program for protecting the public from shellfish-borne fecal pathogens, which may be associated with contaminated waters (US Food and Drug Administration, 1995). The DMF has classified all 1,745,723 acres of overlying waters within the Commonwealth's territorial sea in accordance with NSSP protocols with each shellfish growing area classified under one of six designations as "approved", "conditionally approved", "restricted", "conditionally restricted", "management closure" or "prohibited" (Massachusetts Division of Marine Fisheries, 1999). The current designated shellfish growing areas for Boston Harbor are shown in Figure 7.

The Shellfish Sanitation and Management Program also conducts required water sampling for fecal coliform bacteria in all "approved", "conditionally approved", "restricted" or "conditionally restricted" coastal waters to meet the monitoring and annual reevaluation requirements of the NSSP (Massachusetts Division of Marine Fisheries, 1999). In addition, the Shellfish Sanitation and Management Program conducts monitoring for naturally occurring marine biotoxins produced by microscopic algae known as phytoplankton. In Massachusetts waters, the main concern is for blooms of the algae *Alexandrium sp.*, the cause of paralytic shellfish poisoning (PSP) also known as "red tide". Consumed at high enough concentrations, the PSP toxin can produce severe illness and even death (Massachusetts Division of Marine Fisheries, 1999).

Generally in Massachusetts, local authorities (i.e. elected officials and shellfish officers) of the coastal cities / towns and the Division of Marine Fisheries share management responsibilities for the shellfish fishery. Local authorities manage recreational harvest in all areas designated as "approved" shellfish growth areas, and partner with the DMF to develop local plans for the management of shellfish resources for areas designated as "conditionally approved". Municipal shellfish officers also have enforcement authority in those local waters designated "conditionally restricted", "restricted" or "prohibited" (Dave Roach, Massachusetts Division of Marine Fisheries, personal communication, 2002).

However, the DMF undertakes more direct involvement in the management of shellfish resources within Boston Harbor. Specially designated "conditionally restricted" shellfish growth areas currently exist for commercial harvest within the municipalities of Winthrop, Boston, Quincy, Hingham and Hull. Clams from these "conditionally restricted" shellfish growth areas are managed in accordance with local management plans developed in partnership with the DMF and may be harvested by DMF-licensed master diggers for transport to the DMF Shellfish

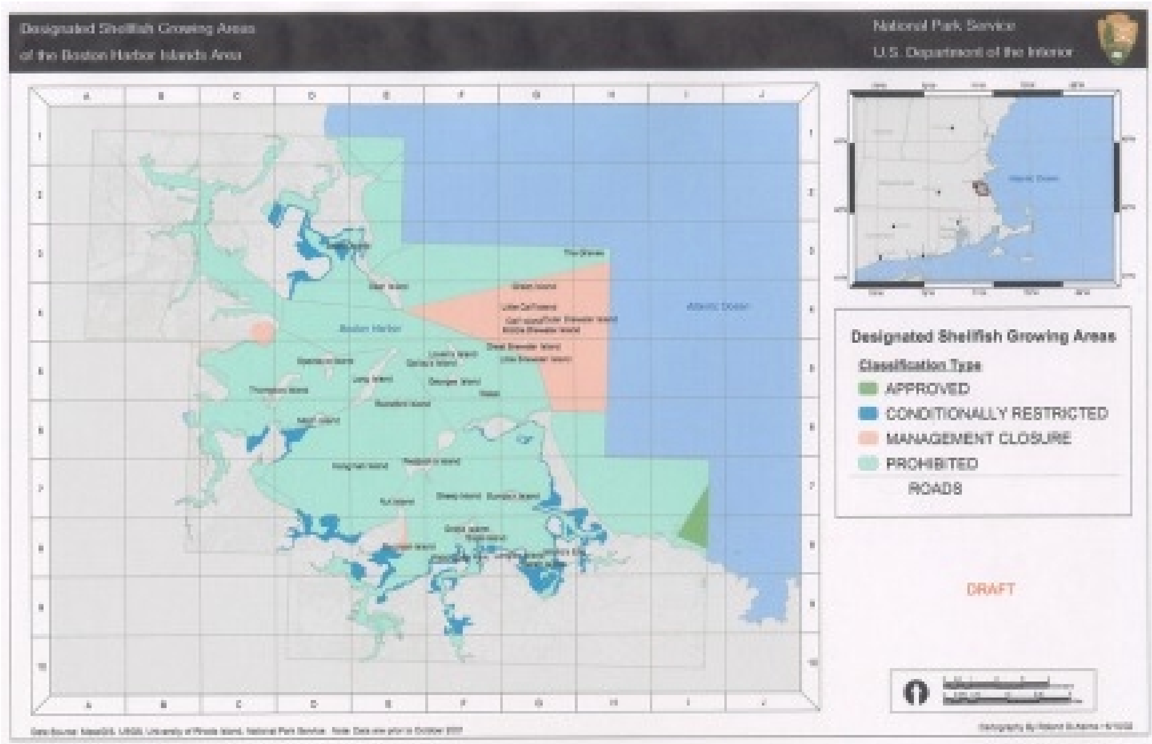


Figure 7. Designated Shellfish Growing Areas in Boston Harbor

Purification Plant located in Newburyport where they are treated in a controlled aquatic environment and purified (Dave Roach, Massachusetts Division of Marine Fisheries, personal communication, 2002).

While Boston Harbor water quality currently does not allow a recreational shell harvest, it is hoped that improvements in water quality brought about by the Boston Harbor Project and future efforts associated with local municipal sewage conveyance systems may someday allow areas of Boston Harbor to be designated in a manner which would support a recreational shellfish harvest. The DMF is currently conducting monitoring and pollution source studies, in the hope that it may be possible to re-designate shellfish growth areas in the intertidal areas of Peddocks Island as "conditionally restricted" at some time in the not too distant future (Dave Roach, Massachusetts Division of Marine Fisheries, personal communication, 2002).

c. Water-Related Island Infrastructure Issues

1. Water supply needs and development

The availability of a safe and adequate fresh water supply has long been a concern for many of the Boston Harbor islands. There are remnants, ruins, and historic accounts of a number of shallow, large diameter, dug wells on many of the islands. In addition, as the use of the islands for military, civic, and commercial purposes expanded during the mid - 19^{th} and early - 20^{th} centuries, pipelines were sometimes utilized to supply some of the islands with water from the mainland. Today, however, functional water pipelines exist only from Hull to Georges Island; from Squantum to Thompson Island; from Squantum to Moon Island and Long Island; and from Winthrop to Deer Island. A non-functioning water line also exists from Nut Island to Peddocks Island, though this system has been out of commission for a number of years (Joe Orfant, MDC, personal communication, 2002).

Currently, drinking water is available to park visitors only on Georges Island, Thompson Island, and Deer Island (National Park Service, 2000). While drinking water lines exist to both Moon Island and Long Island, no visitor services are currently available on these islands. It is also anticipated that a new water pipeline will be developed to serve park visitors on Spectacle Island once that island is opened to public recreational use.

While Masterson et al. (1996) undertook an initial assessment of groundwater use for potential water-supply development on six of the Boston Harbor Islands (Bumpkin, Gallops, Georges, Grape, Lovell, and Peddocks islands), it was beyond the scope of the study to either quantify the amounts of groundwater that might be available or to predict the effects of groundwater withdrawals on potential salt water intrusion or on aquatic resources. Additional work concerning these issues would necessarily be required prior to developing plans for ground water supplies on these islands. Therefore, there are no plans at the present time to develop ground water supplies on these islands (Al Kenney, DEM, personal communication, 2002 / Joe Orfant, MDC, personal communication, 2002). However, a feasibility study may be warranted to evaluate the repairs or engineering enhancements and costs that would be associated with repairing or re-establishing a water supply line from Nut Island to Peddocks Island to meet the needs of future water and sewage management requirements (Joe Orfant, MDC, personal communication, 2002).

As future visitor use to a number of the Boston Harbor islands increases, the demand to provide increased access to safe and adequate drinking water supplies is also likely to increase. Consequently, long-term drinking water supply issues will need to be addressed in current and future management planning activities.

2. Sewage management issues

Limited toilet facilities are currently available to park visitors at 10 of the Boston Harbor islands. Restroom facilities, which include running water, are currently available at Deer Island, Georges Island, and Thompson Island and are anticipated to be in place at Spectacle Island when it opens to visitor use. In addition, waterless composting and/or pump-out toilets are available to park visitors at Thompson Island, Bumpkin Island, Gallops Island, Grape Island, Lovell Island, Peddocks Island and Worlds End (National Park Service, 2000).

The Deer Island restroom facilities are connected to the state-of-the-art MWRA Deer Island Sewage Treatment Facility (see Boston Harbor Project section of this report).

Thompson Island has a septic leachfield system rated for use at up to 8,000 gallons per day, as well as two composting toilets in more remote locations on the island (Tim O'Loughlin, Thompson Island Outward Bound Education Center, personal communication, 2002).

Domestic wastewater from toilet facilities located at the Administration Building at Fort Warren (Georges Island) is discharged to a sub-surface tank. This tank contains settleable solids with liquids overflowing into a second sub-surface tank. Overflow from the second tank is discharged directly to Massachusetts Bay (Rizzo Associates, Inc, 1998). This system, as currently configured, is out of compliance with State Environmental Code (Title 5) and the resultant discharge is a violation of the State surface water discharge regulations (Rizzo Associates, Inc, 1998). This situation is currently a high priority concern to both the Metropolitan District Commission and the Massachusetts Department of Environmental Protection. The MDC is working with the DEP to develop an acceptable septic system alternative to the current direct discharge system (Joe Orfant, MDC, personal communication, 2002).

In 1989, a septic/leachfield system was installed to service MDC facilities on Peddocks Island. However, this system was deactivated in 1991 due to the loss of the water supply line from Nut Island. (Joe Orfant, MDC, personal communication, 2002).

The most apparent immediate need pertaining to wastewater management is the remediation of the antiquated wastewater system on Georges Island. However, as future visitor use to a number of the Boston Harbor islands increases, the demand to provide increased toilet facilities is also likely to increase. Consequently, current and future management planning activities need to fully consider the alternatives and costs involved in providing adequate and environmentally responsible toilet facilities and sewage management activities for the Boston Harbor islands.

3. Environmental Audits / Remediation Activities

The Boston Harbor islands have been affected by the more than 350 years of Boston's history. Their strategic location, along the major shipping routes in and out of Boston has long given them significance both commercially, as locations for aids to navigation (Boston Light was established in 1716), and as coastal defensive positions, which evolved with changing threats from the 18th century through the mid- 20th century (Fort Warren, Fort Andrews, Fort Standish, Fort Strong, and numerous coastal artillery batteries, etc.). Also, the close proximity of the Boston Harbor islands to the Boston metropolitan area has sometimes made them an attractive alternative for dealing with urban infrastructural issues including serving as receiving waters for stormwater and sewage discharge, providing sites for solid waste disposal, and hosting various public institutions including immigration processing facilities, correctional facilities, quarantine hospitals, sewage treatment facilities, a major airport and other institutions. Until recently, pollution, antiquated institutions, and military activities have collectively diminished the public's opportunity to enjoy these significant and near-by natural, cultural, and recreational resources (Kales and Kales, 1976).

Suffice it to say with their extended and somewhat eclectic history of land use, it should be expected that the islands would contain a number of environmental concerns that may require remediation. In 1993, the Commonwealth of Massachusetts implemented Executive Order 350, known as the "Clean State Initiative" under which state-owned properties were to be self-audited for compliance with current environmental regulations. Because of this initiative, the 13 islands managed by the Department of Environmental Management (DEM) and the 3 islands managed by the Metropolitan District Commission (MDC) were required to complete environmental audits to identify situations requiring potential remediation. Table 8 provides a listing of locations (known to the National Park Service) within the Boston Harbor Islands national park area that are known to have conducted environmental audits, site assessments, and/or undertaken environmental remediation activities to address water-related environmental concerns.

In 1998, Stone and Webster Environmental Technology & Services conducted an environmental audit on 12 of the islands within the Boston Harbor Islands State Park including Gallops, Bumpkin, Grape, Sheep, Hangman, Raccoon, Slate, Middle Brewster, Outer Brewster, Green, Calf and Great Brewster islands (Stone and Webster Environmental Technology & Services, 1998). Items evaluated in their environmental audit included air emission control and permitting, asbestos management, wetlands protection, wastewater treatment and disposal, drinking water supply, emergency and contingency planning, PCB management, hazardous materials management, and underground and above ground storage tanks.

While these audits are somewhat cursory, they typically provide an important initial overview of environmental concerns deemed "low," "medium," or "high" priority based upon their potential threat to public health, environmental impact, and/or enforcement potential. In the Boston Harbor Islands State Park audit, no environmental concerns significant enough to be denoted as "high" priority were documented. Two issues were deemed to be "medium" priority concerns including: (1) the need for asbestos tile remediation on Gallops, Outer Brewster, and Great Brewster islands; and (2) the existence of various unused open wells on several of the islands (Stone and Webster Environmental Technology & Services, 1998).

In 2000, the results of this initial environmental audit were used by the DEM to justify more detailed "site assessments" for Gallops, Great Brewster, Outer Brewster, Calf, and Bumpkin islands. The Gallops Island site assessment was conducted to determine if contamination from a former incinerator or from structural remains contaminated surface or subsurface soils (Stone and Webster Environmental Technology & Services, 2000a). The site assessment revealed soil contamination by arsenic, beryllium and lead in the vicinity of the former incinerator and soil contamination by lead and organic compounds in the structural waste remains area (Stone and

Webster Environmental Technology & Services, 2000a). Arsenic remediation, including the removal of contaminated soils, has been completed at the incinerator site and the DEM is currently trying to involve the Department of Defense, as the former site owner, in the clean-up of the structural waste remains. In addition, the DEM has recently instituted asbestos containment measures on Gallops Island where large quantities of asbestos transite on the ground (Darryl Forgione, DEM, personal communication, 2002).

A site assessment was conducted on Great Brewster Island to evaluate potential soil and groundwater contamination associated with World War II-era abandoned above ground (AST) and underground storage tanks (UST) and from a rusted drum (Stone and Webster Environmental Technology & Services, 2000b). This site assessment indicated that the concentrations of hazardous materials in soils were below reportable limits at all examined sites and that only one groundwater sample was found to be contaminated with petroleum-based hydrocarbons (Stone and Webster Environmental Technology & Services, 2000b). DEM completed a follow-up assessment in 2002, which resulted in the removal of one 1000 gallon underground storage tank (UST) and appropriate testing/remediation of adjacent soils (Darryl Forgione, DEM, personal communication, 2002). In addition, the DEM has conducted asbestos abatement work in the former mine casement building and has implemented temporary asbestos containment activities in areas of soil contamination. In conducting asbestos contamination activities, the DEM also discovered evidence of contamination from a former coal pile (Darryl Forgione, DEM, personal communication, 2002).

A site assessment was conducted on Outer Brewster Island to evaluate potential soil and groundwater contamination from one rusted World War II-era above ground storage tank (AST) and three World War II –era underground storage tanks/vaults (UST), two with a 5,000 gallon capacity and one with a 1,000 gallon capacity (Stone and Webster Environmental Technology & Services, 2000c). This site assessment found reportable levels of hydrocarbon contamination in soil samples from boring sites in the vicinity of the rusted AST and the 1,000 gallon UST. These were recommended for removal (Stone and Webster Environmental Technology & Services, 2000c). A contract for UST and contaminated soil removal is currently in place with removal activities scheduled for the summer of 2002 (Darryl Forgione, DEM, personal communication, 2002). In addition, asbestos abatement work in the former barracks building (excluding Battery Jewell) will also commence in 2002 (Darryl Forgione, DEM, personal communication, 2002).

A site assessment was conducted on Calf and Bumpkin islands to evaluate potential soil contamination from a former coal pile area on Calf Island and a former coal bunker on Bumpkin Island (Stone and Webster Environmental Technology & Services, 2000d). The site assessment consisted of the collection and analysis of surface soil samples. Soil analysis indicated elevated beryllium concentrations at both sites, and an evaluation of site remediation options was recommended (Stone and Webster Environmental Technology & Services, 2000d). While it is currently estimated that up to 2,500 cubic yards of coal pile remnants remain on Calf, Bumpkin, and Great Brewster islands, no permanent mitigation plan has yet been devised (Darryl Forgione, DEM, personal communication, 2002).

As the location of a former fertilizer manufacturing facility (1860s – 1960s) and site of a former Nike Missile facility (1950s – 1970s), contamination issues should also be anticipated at Webb State Park. The DEM has recently identified three former dump sites in Webb State Park with suspected arsenic contamination. Further investigation is underway to characterize the extent of the contamination with results expected in late 2002 (Darryl Forgione, DEM, personal communication, 2002). In addition, the Nike Missile chamber is currently being investigated with

Table 8. Environmental audits and remediation activities within the Boston Harbor Islands national park area. **(Source: US Army Corps of Engineers, 1992, Stone and Webster Environmental Technology & Services, 1998; 2000a;2000b;2000c;2000d;Rizzo Associates, Inc., 1998;Camp Dresser and McKee 1998a;1998b)**

Area	Environmental Audit Report	Environmental Site Assessment	Hazmat Remediation	Comments
Bumpkin Island	1998	2000		coal pile remnants
Button Island				
Calf Island	1998	2000		coal pile remnants
Deer Island				MWRA STP
Gallops Island	1998	2000	arsenic remediation, asbestos containment	seeking military assistance as PRP at structural waste site
Georges Island	1998		UST Removal	Fort Warren existing issues with wastewater system
Grape Island	1998			
The Graves				Graves Light
Great Brewster	1998	2000	asbestos abatement asbestos containment	UST removal (2002) ; coal pile remnants
Green Island	1998			
Hangman Island	1998			
Langlee Island				
Little Brewster				Boston Light
Little Calf Island				
Long Island				
Lovell Island	1998		UST Removal	Fort Standish
Middle Brewster	1998			
Moon Island				
Nixes Mate				
Nut Island	1998	2000		
Outer Brewster I.	1998			USTs / contaminated soils scheduled for removal in 2002; partial asbestos abatement scheduled for 2002
Peddocks Island	1998			Fort Andrews
Raccoon Island				
Ragged Island				
Rainsford Island				
Sarah Island				
Sheep Island	1998			
Snake Island	1998		UST Removal	
Slate Island	1998			
Spectacle Island				
Thompson Island				
Webb State Park				former dump sites and Nike Missile chamber under investigation
Worlds End				

the intention of remediating contaminant hazards to a level which may ultimately allow the utilization of this site as an interpretive exhibit (Darryl Forgione, DEM, personal communication, 2002). Also in response to Executive Order 350 (Clean State Initiative), the MDC commissioned environmental audits for properties they manage including Georges Island (Fort Warren), Lovell Island (Fort Standish), and Peddocks Island (Fort Andrews).

Georges Island was acquired by the Federal government from the City of Boston in 1825. Fort Warren, which consists of a pentagonal granite fort once equipped with up to 300 guns, was constructed by the Army from 1836 to 1853 as part of the Boston Harbor Defense system (US Army Corps of Engineers, 1992). In 1902, several new 10 and 12 inch disappearing guns were installed as well as 3 and 4-inch guns. Improvements to the site were numerous and included a powder magazine, reservoir, hospital, storehouse, pump house, guardhouse, administration buildings, quarters, as well as a kitchen, mess hall, chapel, and library (US Army Corps of Engineers, 1992). Fort Warren was decommissioned in 1946 and purchased by the MDC in 1958.

In 1992, the US Army Corps of Engineers proposed a remediation plan which included the emptying, cleaning and disposal of one 2,500-gallon, one 1,000-gallon, and two 370-gallon underground storage tanks and two 50-gallon ASTs as well as the installation of safety fences along the top of Battery Lowell and Battery Barrett (US Army Corps of Engineers, 1992).

In 1998, Rizzo Associates, Inc. conducted an environmental compliance audit of Fort Warren, the Administration Building, and the Generator Building, all located on Georges Island (Rizzo Associates, Inc., 1998). A significant water-related concern of this audit involves the current waste water disposal system. The current system for the Administration Building consists of the discharge of domestic waste water to a subsurface tank. Liquids from this tank overflow into a second subsurface tank which overflows directly to Massachusetts Bay (Rizzo Associates, Inc., 1998). The current system is out of compliance with State Environmental Code (Title 5) and the existing discharge constitutes a violation of the State surface water discharge regulations (Rizzo Associates, Inc., 1998). The environmental audit report further outlines three remediation options for consideration to correct this finding. In addition, the environmental audit also noted that boiler water is discharged to a manhole in the boiler room, which probably discharges directly to Massachusetts Bay. Such discharges of boiler blowdown are also prohibited to surface waters without a permit.

Rizzo Associate, Inc. (1998) also noted that a 12,000-gallon diesel fuel UST located in front of the Generator Building on Georges Island was out of compliance with existing fire code regulations and was not equipped with appropriate spill containment or overflow protection devices. In 2000, the MDC and NPS entered into a cooperative agreement to remove the existing UST and replace it with one that was compliant with existing fire code and environmental regulations (National Park Service/ Metropolitan District Commission, 2000).

Also in 1998, MDC contracted for environmental audit reports for Lovell Island (Fort Standish) (Camp, Dresser & McKee, 1998a) and Peddocks Island (Fort Andrews) (Camp Dresser & McKee, 1998b).

Acquired from the City of Boston in 1825, the Department of the Army began the development of Fort Standish on Lovell Island beginning in approximately 1900 as part of the Boston Harbor Defenses. During this time several military-related structures were constructed including six batteries of 10, 8, 6, and 3-inch rifles (Batteries Williams, Whipple, Burbeck, Weir, Vincent, and Terrill), barracks, an observation station and a rifle range (US Army Corps of Engineers, 1992).

Military operations ceased in approximately 1946, and the island was vacated. In 1958, the MDC purchased the island from the Department of Defense. Due to erosion one battery has been lost to the sea, but five of the six original batteries, the switchboard room, radio communications building, and the base end station remain. In 1992, the US Army Corps of Engineers proposed a remediation plan for Fort Standish, which involved the removal, testing and disposal of five 370-gallon and one 2,500-gallon USTs, welding steel covers onto a number of uncovered manholes and a cistern, and either sealing openings and/or fencing areas to mitigate safety concerns (US Army Corps of Engineers, 1992). During their environmental audit, Camp, Dresser & McKee (1998a) documented the presence of friable asbestos and a 1993 incident report referring to a leaking petroleum storage tank. The incident report indicated that the contamination source was subsequently removed to a licensed facility. In addition, a radiation survey was completed in order to investigate unsubstantiated concerns that the gun emplacements may have been used for the interim storage of radioactive materials during the 1950s (Camp, Dresser & McKee, 1998a). However, the test results were not elevated beyond those levels which would be expected from radon emissions expected from structures made with concrete containing granitic materials (Peter J. Howe, Boston Globe, November 23, 1998).

The Department of the Army established Fort Andrews on the northern end of Peddocks Island in the early 1900s, finally abandoning the installation in 1946. While many of the former structures of the fort were demolished in place during the 1970s, a total of 27 vacant military-related structures (in various states of disrepair) remained at the time of this audit (Camp, Dresser & McKee, 1998b). The majority of environmental compliance issues pertaining to Fort Andrews involve asbestos and lead paint remaining in the standing structures. However, building demolition debris possibly containing asbestos and lead paint remnants are also scattered throughout the site (Camp, Dresser & McKee, 1998).

While likely warranted, environmental audits are not currently available for the non-state owned properties within Boston Harbor Islands national park area (see table 7). It is recommended that the Boston Harbor Islands Partnership work cooperatively to establish priorities and support strategies to complete environmental audits for those areas which have hosted more than agricultural/pastoral land use over the years. These audits could then be used to collectively develop strategies and priorities to remediate necessary environmental issues. A good example of this type of activity may be found on Thompson Island, where the National Park Service and the Thompson Island Outward Bound Education Center entered a cooperative agreement to remove and replace four actively used but inadequate storage tanks and to replace them with a state-of-the-art 20,000-gallon double-walled underground fluid containment system. (NPS/Thompson Island Outward Bound Education Center, 2000).

4. Spill contingency planning

Internal operations within the Boston Harbor Islands national park area require that oil and hazardous substances, such as petroleum products used by maintenance operations, be handled and stored on a routine basis. Although it is a goal of all the managing entities to minimize releases of these substances into the environment, accidental releases still occur. The action of those employees who first encounter contamination in the national park area could well determine the severity of the impact(s) on human health and the environment. Therefore, it is important that those responsible for managing these areas be properly trained and understand the basic requirements for response to oil or hazardous substance spills.

An even greater threat for the Boston Harbor Islands national park area exists from oil or hazardous materials spills that may result from external sources. Oil tankers constitute the greatest tonnage shipping in Boston Harbor, with most of this cargo being unloaded into the Chelsea tank farms. Because of its location, the probability of a major oil or hazardous substances spill occurring in the vicinity of the Boston Harbor Islands national park area is extremely high. The major shipping channel to and from the Port of Boston transits close to islands of both the Inner Harbor Group and Outer Harbor Group. Similarly, areas within the Inner Harbor Group, Quincy Bay Group and Hingham Bay Group are susceptible to spills occurring along industrialized urban coastal areas, which lie in close proximity of the national park area. In many ways, however, the Boston Harbor Islands national park area is fortunate in that it is located in close proximity to the US Coast Guard Marine Safety Office Boston (MSO Boston). This close proximity would almost assure a rapid and professional response in the event of a major spill incident.

Should a major spill incident occur, response activities in the vicinity of the Boston Harbor Islands national park area would occur in accordance with procedures outlined in the Plymouth to Salisbury (MA) Area Contingency Plan (http://www.uscg.mil/units/msobos/Acp/ACP.html). The purpose of this plan is to:

- Outline an incident response plan and provide guidance for the protection of people, natural resources, and property from the impacts of oil or hazardous substance spills; and

- Present a strategy for coordination of federal, state, and local agencies with industry, response contractors, and the local community for unified responses to discharges or substantial threats of discharges of oil or releases of hazardous substances (US Coast Guard, 2000).

From the resource protection perspective, an important component of the Area Contingency Plan (ACP) are the Priority Protection Maps. The Priority Protection Maps are intended as a guide and will be used to determine the best use of available resources during a pollution incident. Typically, they will endeavor to identify sensitive natural resource areas, water intakes, etc. Areas identified as "high priority areas" will normally receive consideration for protection before lower priority areas, though as a practical matter, protection priorities will be decided on a case-by- case basis as resources and conditions permit (US Coast Guard, 2000).

Priority Protection Maps for the vicinity of the Boston Harbor islands include Map 8 (Boston Inner Harbor), Map 9 (Dorchester Bay Area), and Map 10 (Outer Boston Harbor Area) of the Plymouth to Salisbury, Massachusetts ACP (www.uscg.mil/d1/units/msobos/ACP/bos_sens.pdf). A listing of the priority protected areas within the vicinity of the Boston Harbor Islands national park area is provided in Table 9. A recommendation to facilitate the exchange of sensitive resources information achieved as part of the Boston Harbor Island Partnership efforts to address baseline information needs to the US Coast Guard for consideration into future spill contingency planning activities is presented in Section IV of this report (Considerations for Future Actions).

Table 9. Priority Protection Areas in the vicinity of the Boston Harbor Islands national park area. (Source: Plymouth to Salisbury Massachusetts Area Contingency Plan – Maps 8, 9, 10 (US Coast Guard, 2000)

USCG ID	NAME	SHORELINE TYPES	HABITAT	WILDLIFE
A08-07	Thompson Island (Eastern Shore)	marshes	no data	shellfish, waterfowl
A08-09	Snake Island (Winthrop / Belle Isle Marsh)	sheltered tidal flats, marshes	marsh	common tern nesting, shellfish
A08-10	West Winthrop	sheltered tidal flats	tidal flats	no data
A09-01	Neponset River Mouth / Tenean Beach	sheltered tidal flats, marshes, beach, mudflats	salt marsh	waterfowl, shore birds, hawks, shellfish
A09-02	Squantum Island South	marshes	salt marsh	shellfish
A09-03	Black's Creek	sheltered tidal flats, marshes	tidal flats, marshes	waterfowl, birds, shellfish
A10-03	Whitehead Flats (Hull)	marshes, mud, beach	marshes, mud, beach	clams
A10-04	Weir River ACEC (Hingham & Hull)	sheltered tidal flats, marshes	marsh, eelgrass	shellfish beds, anadromous fish, osprey
A10-05	Hingham Harbor	marshes, beach	eelgrass	shellfish
A10-06	Gull Point (Quincy)	marshes	marshes	shellfish
A10-07	Broad Meadows (Quincy)	sheltered tidal flats, marshes	eelgrass	anadromous fish, shellfish
A10-08	Weymouth Back River ACEC	sheltered tidal flats, marshes	eelgrass, salt marsh	osprey, herring, alewife runs, smelt runs, shellfish
B10-11	Sarah Island (Hingham Harbor)	rock	rock	heron and egret rookeries

Note: ID numbers beginning with "A" receive the highest protection priority; ID numbers beginning with "B" are protected after the highest priority areas.

d. Shoreline Erosion Issues

1. Potential Impacts of Boat Wakes

The shoreline of many of the Boston Harbor islands is composed largely of unconsolidated glacial sediment (till and reworked till), which are highly susceptible to erosion. Considerable reaches of many of these shorelines also consist of bluffs which may erode and oversteepen when subjected to wave attack (Fitzgerald, et al., 2002). For example, bluff retreat along Thompson Island averaged 0.3 m/yr from 1938 – 1977 (Jones et al., 1993). Similarly, Sheep Island in Hingham Bay has been reduced from about 25 acres to less than one acre and Nubble Island (the present Nixes Mate shoal) has completely disappeared over the last 250 years (Fitzgerald et al., 2002).

Much of the land loss occurring to most of the islands can be attributed to sea level rise, storms, and wave erosion. The short-term rate of natural erosion and shoreline recession is related to incident wave energy, exposure to storms, extent of coastal vegetation, near-shore bathymetry, sediment composition, meteorological effects and other factors affecting the near-shore environment (Sunamura, 1983). However, recent observations suggest that the wake from commuter boat traffic, an increasingly important component in the regional mass transit infrastructure, may be exacerbating natural shoreline erosion processes. Casual observations over the last several years indicate that considerable erosion is occurring along shoreline bluffs at several areas in close proximity to commuter ferry routes (Figure 8) including the southwest aspect of West Head on Long Island, the eastern aspect of Moon Head on Moon Island, the Prince Head vicinity of Peddocks Island, the Lower Neck of Webb Memorial State Park, and along the slope of the southern drumlin of Grape Island (Al Kenney, DEM, personal communication, 2002). It has been hypothesized that waves created by boat wakes break at the top of the beach during spring high tides and other periods of elevated water levels, removing sediment from and steepening the bluffs (Fitzgerald et al., 2002).

Recently, researchers from Boston University, the US Geological Survey, and Northeastern University have collaborated to propose a study to investigate the potential affects of boat wake impacts and their role in shoreline erosion processes in the Boston Harbor islands (Fitzgerald, et al., 2002). Objectives of this proposed study, should it be fully funded, would include:

- Identification of erosional trends on island shorelines within the Boston Harbor Islands national park area and calculation of the rate of shoreline recession over varying time intervals;

- Determination of which island shorelines are most susceptible to short-term erosion;

- Determination of the height, period, and energy density of waves generated by commuter ferry boats during varying wind and tidal conditions;

- Implementation of a detailed monitoring program at critical island shorelines to determine short-term shoreline recession rates (per storm, per season and/or per year), the effects of episodic meteorological events, seasonal effects and the impacts of boat wakes (Fitzgerald et al., 2002).

In the fall of 2001, a pilot study was initiated in cooperation with the National Park Service to identify the types of processes influencing coastal erosion along the Boston Harbor islands shorelines, and in particular to assess the influence of boat wakes produced by high-speed ferries (Fitzgerald et al., 2002). This pilot study is providing baseline physical data on the shoreline morphology and processes, particularly at sites with eroding glacial bluffs. Four initial sites were established, two areas directly adjacent to commuter ferry routes (Long Island SW and Webb State Park) and two areas with protected or semi-protected bluffs (Long Island NW and Moon Island). Data collected include repetitive topographic surveys of the study sites, Click here for full image

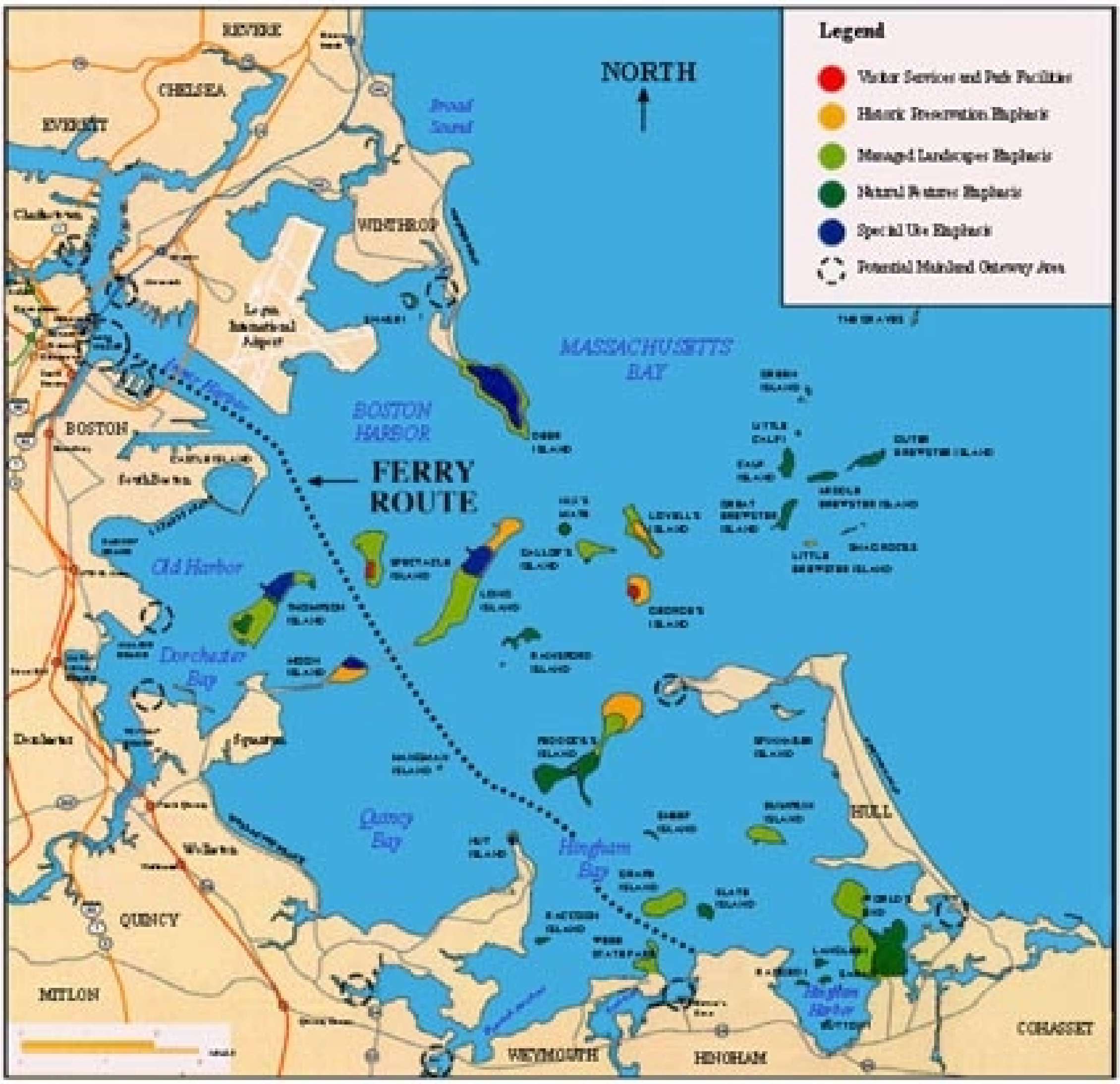


FIGURE 8: Commercial Ferry Routes & Shipping Lanes in the vicinity of Boston Harbor Islands national park area (adapted from: Fitzgerald et al., 2002).

compositional analysis of bluff sediment samples, determination of beach form and vegetative cover, determination of short-term erosion rates, and a qualitative determination of wind-generated waves and boat wake (Emily Himmelstoss, Boston University, personal communication, 2002.

2. Management of Seawalls and Rip Rap

Many of the Boston Harbor islands, most especially those composed of unconsolidated, glacially-deposited sand and gravel, have some sections of coastal embankment that have been armored over the centuries to control shoreline erosion. While some of these seawalls protect important historical and cultural features, they also may interfere with natural coastal processes including the movement of sand along the coast. In some cases, this may create erosional problems downdrift in the intertidal zone or impede the natural accretion of sandspits which provide important habitat for birds, mussels, and other organisms (Bell et al., 2002).

Casual observation has indicated that sections of the seawall on the southeastern side Great Brewster Island have eroded away during the past year (Al Kenney, Massachusetts Department of Environmental Management, personal communication, 2002). Because of the unconsolidated sediment composition and its unprotected exposure to wave energy from Massachusetts Bay, significant undercutting and erosion of the southern drumlin opposite of Boston Light has occurred just within the past year (Al Kenney, Massachusetts Department of Environmental Management, personal communication, 2002).

e. Intertidal / Wetland Introduced (Non-indigenous) Species Concerns

Accidental or intentional introduction of non-indigenous species into the estuaries of the northeastern United States is not a new phenomenon. Two invasive invertebrates, the green crab (*Carcinus maenus*) and the common periwinkle (*Littorina littorea*), have been in the New England Region so long and are so common that they are no longer even recognized as being non-native (Bertness, 1999). However, world-wide recognition of the bioinvasion issue has increased in recent years as the process has accelerated over the last three decades due to the globalization of the economy and with it, an increase in opportunities for world-wide commercial shipping (Carlton and Geller, 1993). Today, frequent sources of introduced species to estuarine systems may occur as a result of ship ballast discharge, introduction of species via hull fouling, inadvertent transfers coincident with mariculture expansion, as a consequence of the worldwide expansion of the aquarium trade, and the distribution and handling of nonindigenous organisms used for education and research (US Environmental Protection Agency, 2000; Massachusetts Office of Coastal Zone Management, 2002).

Studies of introduced species have provided a range of results with respect to the effects of invading species on the native community. At times, invading species have been found to have significant impacts by outcompeting or preying on native species, sometimes significantly altering the ecosystem (Carlton, 1996). Effects may include shifts in resource utilization patterns by native species (Brenchley and Carlton, 1983), fundamental alterations of the food web (Zaret and Paine, 1973), and population reduction or even the eradication of native species (Clarke et al., 1984). In other cases, invading species have been found to cause few, if any changes to the native communities (Berman and Carlton, 1991).

A recent inventory of the intertidal biotic communities of the Boston Harbor islands documented a number of recent (i.e., within the past 30 years) invertebrate invaders within the intertidal zone for most of the islands surveyed including the Pacific colonial sea squirt (*Botrylloides violaceous*), the Asian Shore Crab (*Hemigrapsus sanguineus*), the Pacific Rough Sea Squirt (*Styela clava*) and the golden star tunicate (*Botryllus schlosserei*) (Bell et al., in review). In addition, the inventory also documented a number of invasive seaweeds including *Dumontia contora*, *Polysiphonia harveyi, and Bonnemaisonia hamifera* (Bell et al., 2002). On a positive note, Bell et al. (2002) note that they did not find any *Codium fragile* (green fleece), an invasive Pacific seaweed which is common in other areas extending from the Isle of Shoals to Cape Cod.

A Rapid Assessment Survey conducted in 2000 of bioinvaders on floating docks and piers, documented 23 non-indigenous species (four of which were non-indigenous species reported for the first time) living in this specific habitat in coastal Massachusetts and Rhode Island (Judith Pederson, MIT Sea Grant Program, personal communication, 2002). A similar Rapid Assessment Survey focused on bioinvaders in the intertidal zone is currently being planned for 2003 (Judith Pederson, MIT Sea Grant Program, personal communication, 2002).

While the geographic distribution of many intertidal and shallow sub-tidal introduced species are fairly well documented along the New England coast (Whitlatch and Osman, 1999; Harris and Tyrell, 2001) their ecological and economic impacts are less well understood. The ecological impacts of the green crab (*Carcinus maenus*) and common periwinkle (*Littorina littorea*) are difficult to assess as there are no observations from before their invasions. However, both are likely to have had impacts on the structure of the intertidal zone (Bertness, 1999). The Pacific colonial sea squirt (*Botrylloides violaceous*), which is currently one of the most common encrusting marine organisms in the low intertidal zone of the Boston Harbor islands is possibly outcompeting barnacles and seaweeds for space in these habitats (Bell et al., 2002). It also encrusts eelgrass blades in the subtidal zone, potentially having a negative impact on eelgrass habitats (Bell et al., 2002).

Berman et al. (1992) provides some useful insights into the variability of the ecological histories of ecologically similar introduced species and demonstrates the difficulties in predicting potential ecosystem impacts. In their study of three ecologically similar sessile invertebrates (*Styela clava*, *Botrylloides diegensis*, and *Membranipora membranacea*) recently introduced into the waters of the northeastern United States, Berman et al. (1992) show that ecological similarity among species is not an accurate criterion to predict either the mechanism of invasion or the means of persistence. Rather, they concluded that biological invasions need to be examined on broad spatial and temporal scales and that short-term or narrowly focused studies can lead to incorrect conclusions (Berman, et al., 1992).

Two invasive wetland plants, the common reed (*Phragmites australis*) and purple loosestrife (*Lythium salicaria*) also occur in the Boston Harbor islands. Invading both fresh and brackish marshes, *Phragmites australis* forms dense monocultures, displacing native vegetation and reducing habitat value of many wetland systems (Crow and Hellquist, 2000). Purple loosestrife (*Lythrum salicaria*), which is still sold in Massachusetts nurseries, is dispersed through seeds and rhizomes and forms dense mats excluding all other plant types in many types of freshwater and brackish wetlands (Hellquist, 2001). Both are found in abundance around a salt pond on the southeastern shore of Thompson Island (Bell et al., 2002). In addition, *Phragmites australis* also occurs at a number of other wetland locations, including Damde Meadows (Worlds End), and Calf Island.

The introduction of aquatic invasive species is recognized as a serious threat to the water resources of Massachusetts. A draft Massachusetts Aquatic Invasive Species Management Plan (Massachusetts Office of Coastal Zone Management, 2002) was recently developed under the auspices of the Massachusetts Secretary of Environmental Affairs by the Massachusetts Aquatic Invasive Species Working Group, comprised of representatives of 14 state and federal agencies and academic institutions. The Massachusetts Aquatic Invasive Species Management Plan is the first comprehensive effort to assess the impacts and threats of aquatic invasive species in the Commonwealth. The Plan also lays out a series of management strategies intended to curb the spread of invasive species (Massachusetts Office of Coastal Zone Management, 2002).

IV. Considerations for Future Actions

Although the waters of Boston Harbor are not included within the park boundary, they are an integral part of the island ecosystem and most often, a major component of the visitor educational and recreational experience. In some areas, they are integral to the visitor experience. For even more areas, the harbor waters constitute a major component of the landscape. Certainly, with Boston Harbor's large tidal range (mean tidal range of 10 1/3 feet), Boston Harbor's waters wash large areas of the national park area's shoreline during their twice daily tidal cycle. It is not an exaggeration to characterize the waters of Boston Harbor as the "life blood" of the national park area.

Thus, the protection and preservation of the water-related resources both within and surrounding the national park area in as healthy condition as is possible for an urban environment should be an important objective within this unit of the national park system. Achieving this objective will require the close cooperation of the 13 Boston Harbor Islands Partnership agencies, other regional and local entities with resource-related responsibilities within the boundary of the national park area, and importantly, concerned citizen groups with interest in these resources.

Specific issues and considerations for future actions are provided to the Boston Harbor Islands Partnership as follows:

- **Endorse and support the Massachusetts Water Resources Authority's harbor-wide water quality monitoring program and incorporate harbor-wide monitoring data into the National Park Service "vital signs" monitoring program.**

  While not included within the national park area, the waters of Boston Harbor are intimately linked to the aesthetic appeal, recreational use, and ecosystem health of the Boston Harbor islands. Over the last decade, the MWRA has implemented an extensive research and monitoring program for Boston Harbor with a focus on a number of physical, chemical, and biological indicators of ecosystem health (see Section II.c.1.). Of particular relevance to the Boston Harbor Islands national park area is the harbor-wide monitoring program of the Boston Harbor Water Quality Monitoring Project (BHWQMP). This monitoring program, initiated in 1991, has been successfully used to measure water quality changes throughout the harbor in response to improvements brought about by the Boston Harbor Project (see Section II.c.2.). While it is the intent of the MWRA to continue the harbor-wide monitoring program for the foreseeable future (Andrea Rex, MWRA, personal communication, 2002), the Boston Harbor Islands partnership is strongly encouraged to recognize and endorse the importance of this program in not only monitoring the recovery of Boston Harbor over the intermediate term, but as an essential core monitoring component for measuring the ecological health of the Boston Harbor ecosystem over the long term.

  In order to facilitate the detection of changes and the quantification of long-term trends in conditions of natural resources, the National Park Service is currently implementing an Inventory and Monitoring Program for approximately 270 units of the national park system (http://www.nature.nps.gov/facts/fi&mbase.htm). An important component of this program is a "vital signs" ecosystem monitoring program designed to provide long term information on the status and trends of key indicators of ecosystem health. The Northeast

Coast / Barrier Island network of the National Park Service's Inventory and Monitoring Program, which includes coastal units of the national park system from Massachusetts to Maryland, is currently developing strategies for the "vital signs" monitoring component (Elizabeth Johnson, National Park Service, personal communication, 2002). While the scope and scale of the MWRA and NPS programs were designed to meet different objectives, the programs should be highly complementary. The Boston Harbor Islands Partnership is encouraged to support efforts which would promote the interchange of information and knowledge from these programs in order to both assist with the long-term monitoring and protection of natural resources within the Boston Harbor Islands national park area, and where appropriate, to facilitate the use of information from the local efforts into the broader scale ecosystem health monitoring program for the northeast coastal / barrier island units of the national park system.

- ♦ **Endorse and support the need for erosion research and monitoring, and develop potential mitigation alternatives.**

The shorelines of many of the Boston Harbor islands are composed largely of unconsolidated glacial sediment which is highly susceptible to erosion. While much of the land loss occurring on many of the islands can be attributed to natural causes including wave erosion, storms effects, and sea level rise, there is concern that commuter boat wakes may be exacerbating natural shoreline erosion processes.

The Boston Harbor Islands Partnership is encouraged to endorse and support the need for research and monitoring evaluate the significance of the erosion issue upon park resources. Should boat wakes be found to be exacerbating natural erosion processes, the Boston Harbor Islands Partnership should work to identify particularly vulnerable / critical shorelines, and to develop science-based mitigation alternatives to address this important resource issue.

- ♦ **Consider implementing appropriate study recommendations from the intertidal biotic survey.**

In a water resources issues scoping session conducted in May, 2000, the "inadequacy of available baseline information" was listed as the most frequent concern (see Section III.a.). In particular, the lack of adequate baseline pertaining to intertidal resources (salt marshes, tidal flats, and rocky intertidal) was specifically noted by a large number of workshop participants.

In 2001, a study was initiated by the Boston Harbor Islands Partnership in order to provide the first comprehensive intertidal resources overview and assessment for the Boston Harbor Islands national park area (See Section II.d.1.). During its initial phase this study completed detailed maps and species lists for the substrata and biotic assemblages of 15 representative islands within the national park area (Bell et al., 2002). The authors also provided a number of recommendations for future inventory, monitoring, and research needs pertaining to the intertidal resources of the Boston Harbor Islands national park area (Bell et al., 2002). These include:

Inventory Activities

- consider baseline habitat mapping of Snake Island;
- continue to develop the comprehensive species list with particular emphasis on the benthic infauna and mudflats habitats;
- compare species richness of the Boston Harbor islands intertidal zone to other nearby areas (e.g. Nahant, Isle of Shoals, etc.) where there are sufficient data.

Monitoring Activities

- consider re-mapping of the intertidal habitats of the Boston Harbor Islands on a 5 – 10 year interval or after a major environmental or anthropomorphic event using field-based GIS techniques;
- consider quantitative species-level scale monitoring with a focus on high visitor use vs. low visitor use intertidal zones;
- consider quantitative species-level monitoring focused on invasive/non-native species of concern;
- consider quantitative species-level monitoring focused on overall patterns, trends, and health of the environment.

Research Activities

- encourage research regarding spatial analysis of intertidal habitats to address the question of the differences of intertidal resources between inner harbor and outer harbor islands;
- encourage research regarding the impact of boat wakes on habitat distribution and species composition of intertidal zones (Bell et al., in review).

The Boston Harbor Islands Partnership is encouraged to review the results of the intertidal biotic resources overview and assessment in light of the perceived baseline information requirements. Recommended future inventory, monitoring, and research activities should be considered, and where appropriate, incorporated into the Boston Harbor Islands national park area implementation plans.

♦ **Incorporate water and wastewater infrastructural planning considerations into Boston Harbor Islands national park area planning.**

Currently, drinking water and restroom facilities are available to park visitors only on Georges Island, Thompson Island, and Deer Island, with waterless composting / pump-out toilets also available on Bumpkin Island, Gallop's Island, Grape Island, Lovell Island, Peddocks Island and Worlds End. In addition, the discharge from the antiquated sewage system at Georges Island is in violation of State surface water discharge regulations and out of compliance with State Environmental Code (Title 5).

While the Boston Harbor Islands Partnership is currently focussing considerable attention on defining desired future conditions and appropriately managing anticipated visitor growth, infrastructural issues relating to the provision of safe and adequate drinking water and wastewater management are currently addressed only conceptually. The Boston Harbor Islands partnership is encouraged to incorporate planning specific to the provision of a safe and adequate drinking water supply and sustainable wastewater management alternatives more fully into current and future planning efforts.

- **Continue current Metropolitan District Commission seasonal recreational water quality monitoring program within the Boston Harbor Islands national park area.**

Both the swimming conditions and the aesthetics of the Boston Harbor beaches are better than they have been in decades. However, stormwater runoff and combined sewer overflows can still affect recreational water quality particularly after periods of heavy rainfall. Consequently, the MDC, in cooperation with the Massachusetts Water Resources Authority, maintains a robust seasonal recreational water quality monitoring program for Boston area beaches (see Section III.C.3.).

The Lovell Island Beach is currently the only designated swimming beach within the national park area. While the MDC has intermittently monitored recreational water quality at Lovell Beach since 1987, until recently, monitoring efforts have been irregular. During the last two summer recreational seasons (2000 and 2001), the MDC has instituted a regular weekly (Thursday) monitoring program for the *Enterococci* sewage indicator bacteria at the Lovell Island Beach. This monitoring program, as configured over the past two years conforms with EPA recreational water quality monitoring recommendations for marine waters (US EPA, 1986) and meets National Park Service requirements for recreational beach monitoring (NPS, 1999).

Over the past two summer seasons the weekly monitoring of recreational water quality at Lovell Island Beach has never exceeded recommended EPA criteria (Mark Doolittle, MDC, personal communication, 2002). However, because of the urban characteristics of stormwater discharge into Boston Harbor, and the relatively close proximity of the beach to wastewater discharges from Georges Island, it is recommended that the Boston Harbor Islands Partnership endorse the current MDC/MWRA recreational water quality monitoring program and work to assure its long-term continuation during the recreational season at the Lovell Island beach.

In addition, public recreational beach facilities are planned as part of the Spectacle Island remediation program. Recreational water quality monitoring, using the protocols currently used by the MDC/MWRA should be instituted at this beach facility when this area is opened to the public in 2003.

- **Assess needs and establish priorities for the completion of necessary environmental audits**

Environmental issues affecting the Boston Harbor islands have been influenced by their relatively eclectic land use over more than 350 years. In 1993, the Commonwealth of Massachusetts implemented Executive Order 350, known as the “Clean State Initiative” under which state-owned properties were to be self-audited for compliance with current environmental regulations. In response to this initiative, 16 of the state-owned (DEM or MDC) Boston Harbor islands have completed environmental audits and initiated necessary remediation activities. While environmental audits may not be necessary for all of the national park area, they are likely warranted for a number of additional non-state owned islands which have received the most intensive land use.

The Boston Harbor Islands Partnership is encouraged to review results of the environmental audits and remediation activities undertaken to date (see Section III.d.3.) and assess the needs and recommended priorities for the completion of environmental audits where they may be deemed appropriate.

- **Endorse The Trustees Of Reservations (TTOR) wetland restoration activities at Damde Meadows and support activities to identify additional opportunities for potential wetland restoration**

Prior to European settlement in the 1600s, Damde Meadows was a typical New England salt marsh located which extended from Martins Cove to the Weir River between Cushing Neck and Planter's Hill. It is generally believed that early colonists constructed small stone dams at both ends of the salt marsh, eliminating tidal flow and allowing that the marsh be managed for the production of salt hay. Sometime around 1890, a more substantial dam was constructed, and the meadow utilized for salt hay production into the 1940s. Over the past 5 years The Trustees of Reservations has consulted with a number of wetland ecologists, botanists, and wildlife biologists who have concluded that the Damde Meadow is a good candidate for salt marsh restoration. The Trustees of Reservations plan to undertake restoration activities in the near future (J. Andrew Walsh, TTOR, personal communication, 2002).

The Boston Harbor Islands Partnership is encouraged to endorse the wetland restoration activities at Damde Meadows and to support activities to identify additional potential opportunities for wetlands restoration throughout the national park area.

- **Enhance awareness of invasive species issues and concerns**

The accidental or intentional introduction of non-indigenous species into ecosystems throughout the world is a global concern (see Section If.). Frequent sources of introduced species to estuarine systems may occur as a result of ship ballast discharge, introduction of species via hull fouling, inadvertent transfers coincident with mariculture expansion, as a consequence of the worldwide expansion of the aquarium trade, and via the improper distribution and handling of nonindigenous organisms used for educational and research purposes (US Environmental Protection Agency, 2000; Massachusetts Office of Coastal Zone Management, 2002).

While it is beyond the abilities of the Boston Harbor Islands Partnership to address the invasive species issues alone, there is a tremendous educational opportunity to enhance the awareness of regional (e.g. Massachusetts Aquatic Invasive Species Management Plan) and national efforts to address this important environmental issue. The Boston Harbor Islands Partnership is encouraged to take advantage of the extensive local knowledge concerning this invasive and consider working with the Massachusetts Aquatic Invasive Species Working Group to sponsor a brochure / environmental education program pertaining to the extent and effects of non-indigenous species within the national park area.

- **Facilitate the exchange of sensitive resource information for incorporation into spill contingency planning activities**

  Because of its location, the probability of a major oil or hazardous substances spill occurring in the vicinity of the Boston Harbor Islands national park area is extremely high. Should a major spill event occur, response activities in the vicinity of the national park area would occur in accordance with procedures outlined in the Plymouth to Salisbury (MA) Area Contingency Plan (see Section III.d.4.). Important components of this plan are the Priority Protection Maps. These maps endeavor to identify "high priority areas" including sensitive natural resource areas, which will receive consideration for protection before lower priority areas in the event of a major spill. While the current Priority Protection Maps for Boston Harbor look appropriate, the Boston Harbor Islands Partnership is encouraged to take part in the periodic review of these maps and to provide enhanced resource information made available from the natural resource inventories currently being conducted in the national park area.

- **Commission a study to evaluate the maintenance needs of seawalls and rip-rap and to determine the impact of these structures on geomorphic processes**

  Many of the Boston Harbor islands have some sections of coastal embankment that have been armored over the centuries to control shoreline erosion. While some of these seawalls protect important historical and coastal features, they may also interfere with natural coastal processes including the movement of sand along the coast. Sections of seawalls on several islands have been eroding away over recent years. The Boston Harbor Island Partnership is encouraged to support a study of both the geomorphic impact and maintenance needs of these structures and to use this information in developing alternative strategies for addressing these needs.

- **Incorporate water-related recommendations into the Boston Harbor Islands national park area strategic plan**

  While based upon the broad general policies for managing the national park area delineated in the Boston Harbor Islands national park area (draft) General Management Plan (National Park Service, 2000), the national park area's strategic plan (Boston Harbor Islands Partnership / National Park Service, 2000) is intended to establish the Boston Harbor Islands Partnership's agenda for joint action over the upcoming five-year planning horizon.

  The major natural resource-related focus of the current strategic plan (2001 – 2005) is to launch necessary inventory and monitoring activities to better understand the nature and condition of the park environment (Boston Harbor Islands Partnership / National Park Service, 2000). Activities will include the completion of essential natural resource inventories, the initiation of "vital signs" monitoring of ecosystem health, and a continuation of environmental remediation activities identified as part of the Clean State Initiative.

  The Boston Harbor Islands Partnership is encouraged to use the "strategic plan" as the platform for establishing implementation priorities as warranted for water-related activities identified in this Boston Harbor Islands National Park Area Water Resources Scoping Report and other planning activities.

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