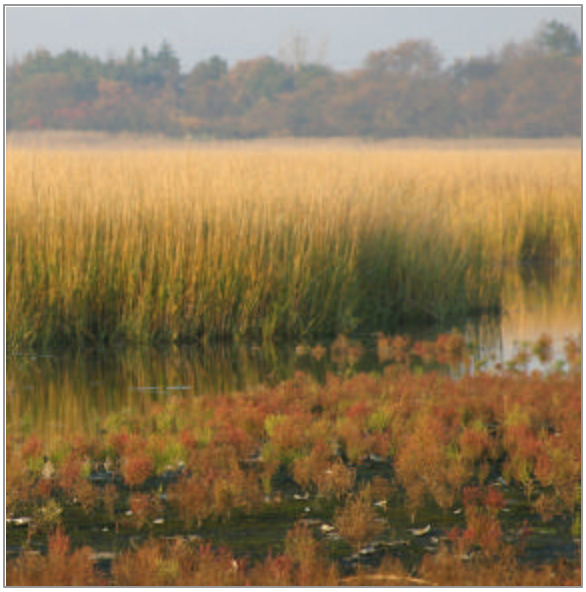
Chapter 4 - Ecology

4.1 THE JAMAICA BAY ECOSYSTEM

"Ecology is the study of how organisms interact with the living (biotic) and nonliving (abiotic) things that surround them" (ricegenomics.plbr. cornell.edu/glossary.htm). Ecological conditions within the Jamaica Bay watershed vary greatly between the non-urban areas (primarily within and surrounding the Jamaica Bay estuary), and the urban areas (including the majority of the upper watershed), reflecting the extreme differences in the composition of these landscapes.

The rich biodiversity that characterizes the Jamaica Bay estuarine ecosystem arises from a complex assemblage of open water, salt marsh and freshwater wetlands, shoreline, and upland habitat located immediately adjacent to some of the most densely populated land in the United States. Large numbers of migratory and resident birds, fish, and other organisms utilize these habitats as important feeding, breeding, and resting areas. The diversity of plants and animals found in the estuary is in part due to its unique position in the landscape (shielded from the open waters of the Atlantic by the Rockaway Spit and located along the Atlantic flyway bird migration route) and the legal protection given to the remaining natural areas. The Jamaica Bay estuary is located adjacent to other ecologically rich areas (the New York Bight of the mid-Atlantic and the Hudson–Raritan River estuaries) while its proximity to the ultra-urban development of New York City concentrates wildlife into the remaining available habitat, as does the landform of Long Island.



Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

In contrast to the ecological richness of the estuary, the upper 91,000 acre watershed of Jamaica Bay is comprised of the highly urban communities of Brooklyn and Queens, as well as a small portion of Nassau County. Three hundred years ago, the area north of Jamaica Bay harbored numerous freshwater wetlands and uplands with grassland, shrubland, and forest plant communities. Creeks meandered through large wetlands on their way to Jamaica Bay, providing extensive habitat for water birds. Most of the precipitation that reached the ground surface infiltrated into the soil or collected into natural stream channels. The mass of nutrients entering the Bay from the watershed was small and did not create water quality problems in the Bay.

In terms of total area, the urban environment is the dominant feature of the modern day landscape. Residential, commercial, industrial, and transportation infrastructure have replaced the native vegetation. In the last century, urban expansion has resulted in the filling of tidal salt marsh and freshwater wetlands; loss of all freshwater riparian habitat areas; and the loss of upland grassland, shrubland, and forest habitat. The Bay has been dredged for fill material used in shoreline development. Creeks have been channelized or routed through pipes, and shorelines have been hardened. Only a small portion of the precipitation infiltrates into the

TABLE 4.1.1 Primary References for the Ecology Section of Jamaica Bay

TITLE	AUTHOR	DATE
Jamaica Bay Marsh Islands Draft Integrated Ecosystem Restoration Project and Environmental Assessment	USACE	2005
Jamaica Bay Ecosystem Research and Restoration Team (JBERRT) Final Report	USACE	2002
Significant Habitat and Habitat Complexes of the New York Bight Watershed	USFWS	1997
Jamaica Bay Comprehensive Watershed Management Plan (Draft)	NYCDEP	1994
Buffer the Bay Revisited: An updated Report on Jamaica Bay's Open Shoreline and Uplands	Trust for Public Land and NYC Audubon Society	1992
Benthos Study: Jamaica Bay Wildlife Refuge, Gateway National Recreation Area	Franz and Harris	1985

ground; rather, it runs off roofs and streets into sewers, gathering pollutants, where it flows through pipes to Jamaica Bay. The movement of nutrients into the Bay is much greater now than in the past due to the growing human population. The associated waste materials end up in the treated sanitary sewer and stormwater systems and ultimately flow into tributaries of Jamaica Bay and the estuary itself.

The impact of urbanization has directly resulted in the ecologically degraded state of the Jamaica Bay watershed. It is important to note that many natural areas have not only been eliminated or damaged, but the processes which sustain healthy ecosystems have been significantly altered, thereby jeopardizing the long term functionality and sustainability of the Bay estuary and the upper watershed. The Ecological Model depicted in Figure 4.1.1 graphically represents the cause and effect of these anthropogenic alterations to the landscape.

The following sections use existing publications and studies to characterize the ecology of Jamaica Bay, including aquatic, wetland, shoreline, upland, and urban habitats. Following these general descriptions, more specific information on the composition, distribution, and condition of wildlife (including fish, macroinvertebrate, shellfish, finfish, bird, mammal, reptile, and amphibian communities), vegetation, and invasive species in the Jamaica Bay watershed is included.

4.2 AQUATIC ENVIRONMENT

In the Jamaica Bay watershed, the aquatic environment is composed of brackish or marine water areas (the tidally-influenced open water in the estuary) and freshwater features (such as lakes, ponds, and streams in the upper watershed).

As stated above and demonstrated upon examination of aerial photographs, it is readily apparent that the upper watershed is dominated by the dense urban grid of Brooklyn and Queens, and is almost completely devoid of surface waters. In fact, almost 100% of the freshwater tributaries to Jamaica Bay have been piped. Apart from several ponds in the upper watershed and two large freshwater ponds on Bay marsh islands, the freshwater ecological component of Jamaica Bay is a small fraction of its historical extent. Prior to urbanization, tributaries such as Fresh Creek, Paerdegat Creek, Bergen Creek, and Hassock Creek would run from the upper watershed, sometimes for many miles, before meeting tidal waters and opening into the estuary.

Freshwater ecosystems typically support a diverse array of macroinvertebrate, fish, and amphibian organisms, which in turn attract larger predators such as birds, reptiles, and mammals. The riparian ecosystems which surround these freshwater areas are also ecologically rich and diverse areas. As a result of the complete eradication of freshwater

channels in the watershed, these ecosystems and the associated biological communities have been almost completely extirpated. The few remaining ponds provide limited freshwater or riparian habitat for fish and wildlife, and are primarily artificial impoundments.

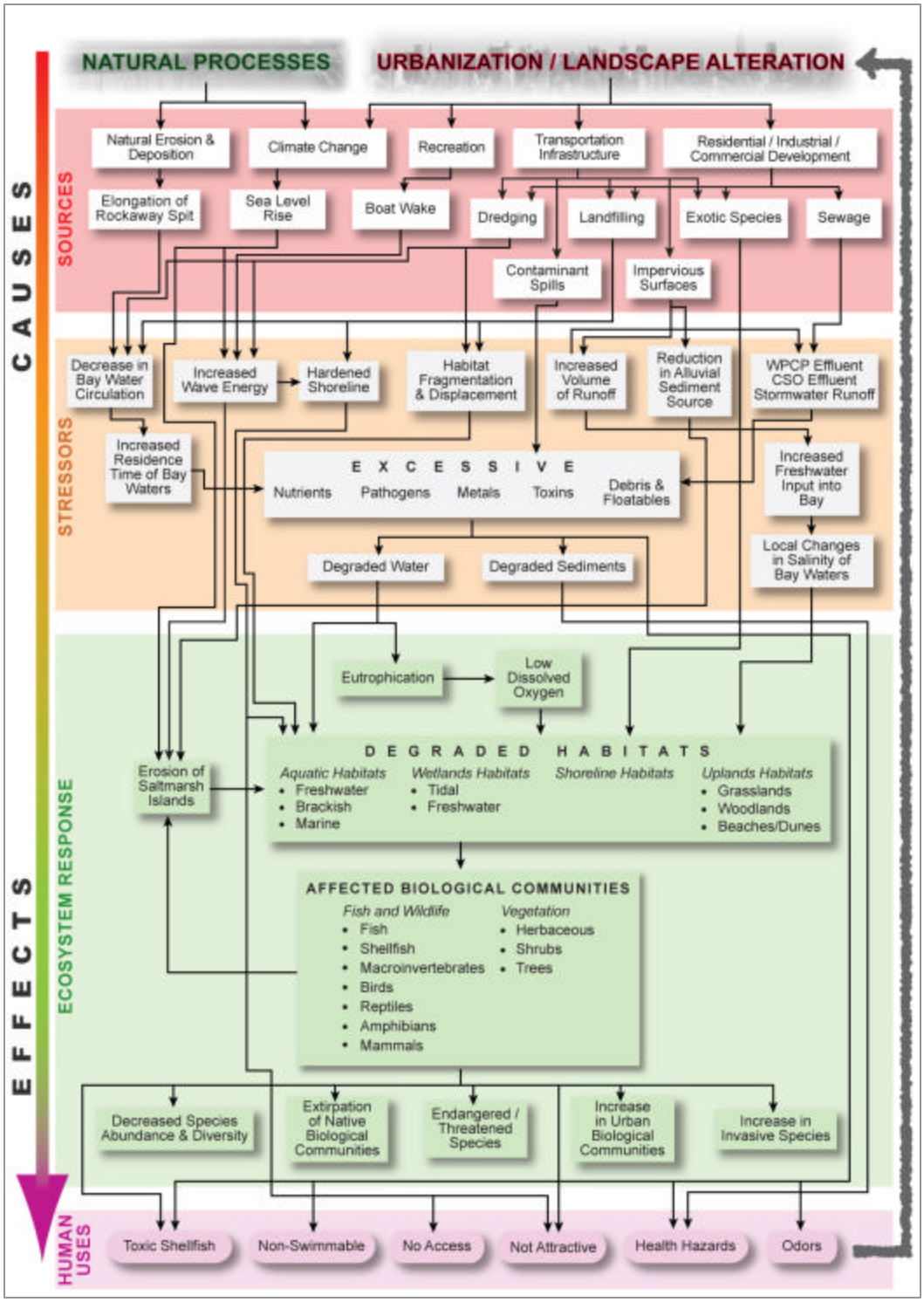


FIGURE 4.1.1 Jamaica Bay Watershed Ecosystem Model; Source: Biohabitats

The Jamaica Bay estuary is where these fresh waters now piped from the upland watershed into the tributaries and open waters meet salt water from the ocean. The majority of water in the Jamaica Bay estuary is brackish (a mixture of fresh water and sea water). Thus, the salinity of the Bay is intermediate between that of the fresh water flowing in tributary streams or out of sewer outfalls and the salt water of the ocean. Typically, fresh water flowing into the Bay has a salinity of less than one part per thousand, while ocean water has a salinity of about 34 parts per thousand (3.4%). Salinity in the Bay generally varies from about 23 to 27 parts per thousand (2.3% to 2/7%) (Gordon *et al.*, 2002). Fresh and salt water do not mix uniformly, thus distinct differences in Bay water salinity (stratification) in time and space occur throughout the Bay.

Return A Gift Pond, Floyd Bennett Field; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Jamaica Bay is a highly productive estuary. Historically, productivity had been limited by the availability of nitrogen. Today, ever increasing concentrations of readily available nitrogen in the Bay stimulates additional primary production. This includes the potential for stimulating the growth of aggressive non-native plants, phytoplankton and macro-algae "blooms." Nitrogen levels in the water of Jamaica Bay are elevated due to large volumes of treated sewage effluent from the WPCPs and episodic overflows from CSOs entering the Bay, mostly from the densely urbanized Brooklyn and Queens sub-watersheds. It is estimated that 36,600 pounds of total nitrogen are discharged to the Bay each day from WPCPs, which accounts for 95% of all nitrogen entering the Bay (NYCDEP, 2005).

Landfilling activities combined with the dredging of the first "borrow pits" in the late 19th and early 20th centuries have profoundly altered the aquatic environment in the Jamaica Bay estuary. Prior to 1800, the estuary was shallow with an average depth of about 3 feet and a surface area of about 25,000 acres. The draining and filling of marsh and meadow lands, over the past 150 years, has reduced the size of the open water and wetlands in the Bay to about 13,000 acres (NYCDEP, 1994). Dredging and the removal of sand from the bottom of the Bay have increased the Bay's average depth to 16 feet, with a maximum depth of 40 feet in some shipping channels (NYCDEP, 1994) and more in Grassy Bay. Despite the reduction in surface area, the dredging of the Bay has increased the overall water volume by 350% (NYCDEP, 1994).

Borrow Pits

Borrow pits are deep areas of the Bay bottom that were dredged for fill material to expand the upland zone along shoreline wetlands for development. Floyd Bennett airfield and JFK airport were created from Bay dredge material as was the connection of several islands to the landward shorelines around the Bay.
Source: Biohabitats

Dissolved Oxygen in Water

Water is the universal solvent. Many different compounds dissolve in water, including oxygen, nutrients, and various pollutants. Dissolved oxygen (DO) gas is essential for most aquatic organisms, such as shellfish and finfish. Jamaica Bay's dissolved oxygen levels range from 3.5 – 18.5 milligrams/liter. At times, portions of the Bay are found to have DO levels below the 5.0 mg/l USEPA criteria for support of living organisms. Long periods of DO below 5 mg/L can harm larval life stages for many fish and shellfish species. Thus, maintaining adequate concentrations of dissolved oxygen is required to maintain healthy aquatic life in the Bay.
Source: Biohabitats

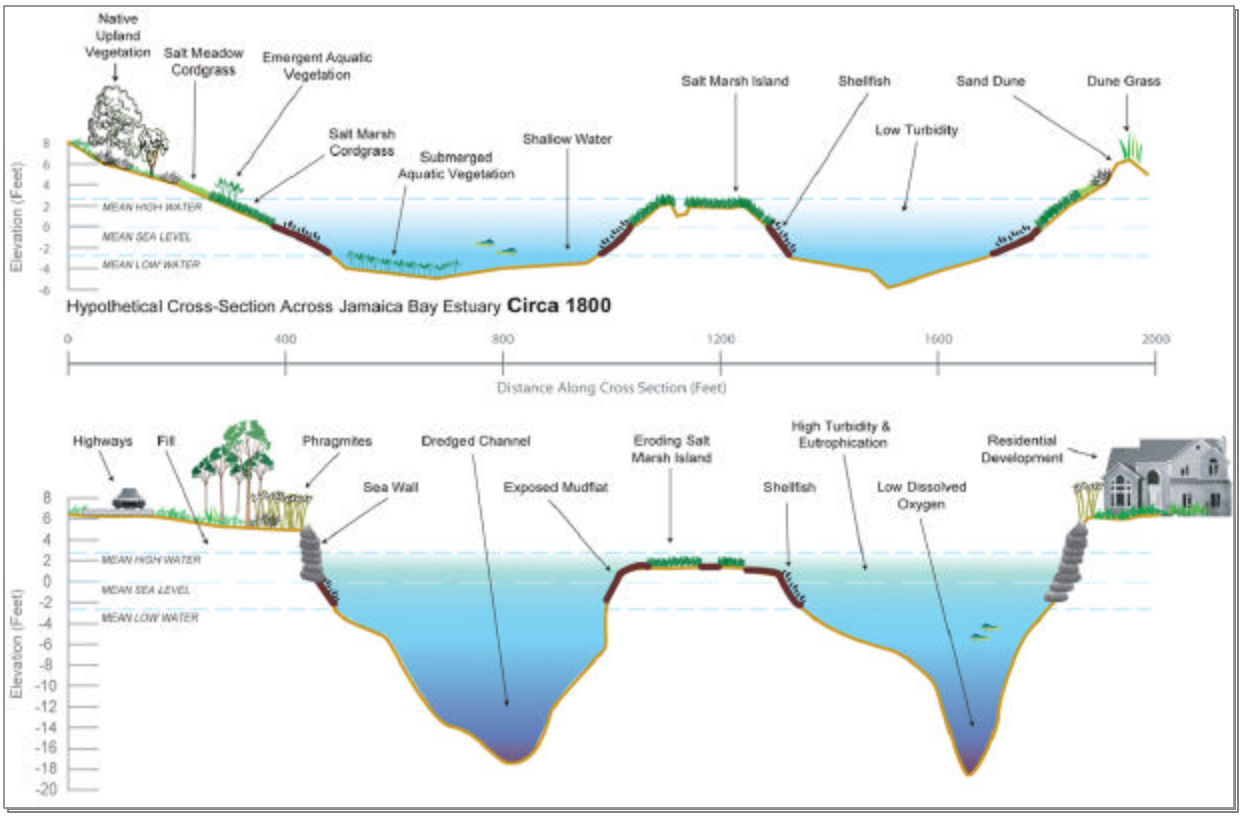


FIGURE 4.2.1 Changes in the Jamaica Bay Estuary from 1800 to 2000. Source: HydroQual, Inc.

The alteration of the bottom of the Bay has had many unintended effects, altering sediment transport dynamics and water quality. The deeper waters of the Bay may now act as a sediment sink, trapping sediment that formerly washed onto and was retained by salt marshes. Lack of sufficient sediment has been cited as a possible contributor to salt marsh disappearance (Gordon and Houghton, 2004). Combined with wave-induced erosion, these two factors may be having a synergistic effect on the rate of salt marsh loss in Jamaica Bay. The water in certain portions of the Bay now stratifies during the summer. Colder water stays on the bottom, and warmer water floats on top, with little mixing until water temperatures equilibrate. The addition of large amounts of nitrogen from WPCP and CSO stimulates the growth of aquatic plants, plankton and algae. A portion of this growth dies and settles into the lower stratified waters where it decomposes during the summer. The process of decomposition consumes much of the available dissolved oxygen. This nutrient-stimulated growth, death and decay results in a reduction of the concentration of oxygen in the bottom layers of the Bay, oxygen levels sometimes fall below the USEPA criterion for aquatic organisms (5.0 mg/L), a level at which the larvae and adults of certain fish and bottom dwelling invertebrate species become stressed and may not survive under long term exposure.

Tides are another key component of the Jamaica Bay estuary, with an average semidiurnal (two high, two low tides per day) tidal range of 5 feet (USFWS, 1997). Tidal currents move sediment and other materials around the Bay, mixing salt and fresh water. Salt water from the Atlantic Ocean continually replaces water in the Bay, flushing pollutants into the ocean where they are greatly diluted. Prior to large-scale dredging of the Bay, the 4.5 e-folding residence time of water in the northern regions of the Bay (or the time it takes 99% of the water to be cycled through to the

Submerged Aquatic Vegetation

The most common submerged aquatic vegetation (SAV) found in the coastal estuaries of New York, including Jamaica Bay, are eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*). Both of these plants provide valuable food for waterfowl and important habitat for many juvenile fish, crustaceans and mollusks. Today, SAV is rare in the Jamaica Bay estuary. Re-establishment of SAV is limited by reduced light availability, most likely from nutrient induced plankton blooms that result from treated and untreated sewage draining into the Bay. Other factors that have the potential to negatively affect SAV survival include increased wave action, introduced sediment, increased organic loading of the sediment, and mechanical damage from dredging and propeller scars.

ocean) was about 11 days. Now, the 4.5 e-folding residence time of water in the northern regions of the Bay is 33 days, due to changes in circulation patterns and the larger volume of water in the Bay from decades of dredging (NYCDEP, 1994).

Despite these severe alterations to historic physical properties of the freshwater, brackish, and marine water environments (Figure 4.2.1), macroinvertebrate, fish, and shellfish communities still live and thrive in the aquatic areas of the Jamaica Bay estuary. These particular communities and their utilization of aquatic habitat areas are discussed in greater detail in subsequent sections.

4.3 WETLANDS

If one were to ask a New Yorker what Jamaica Bay is, chances are good that he or she would reply "wetlands." Wetlands truly are the defining ecological feature of the Jamaica Bay watershed.

There are two wetland assemblages in the Jamaica Bay watershed, salt marshes and freshwater wetlands. Freshwater non-tidal wetlands are typically found in depressions where surface runoff or over bank flooding from streams or rivers collects for extended periods of time, or where ground water intersects the land surface. Historically, several types of freshwater wetlands occurred throughout the watershed, including deep marsh, shallow marsh, shrub swamps, lowland swamp forest, upland swamp forest, and wet meadow (Mockler, 1991).

Today, freshwater wetlands are very limited in extent, comprising less than 1% of their historic coverage in the Jamaica Bay watershed. Their disappearance can be directly attributed to urban

> *"If one way be better than another, that you may be sure is nature's way."*
>
> *– Aristotle*

development. During the construction of roads, buildings, and other infrastructure, fill and pavement replaced an undetermined acreage of freshwater wetlands. This occurred prior to the enactment of federal and state legislation which protects remaining wetlands areas from further encroachment.

Salt marsh wetlands occur along the Atlantic shoreline in estuaries which are protected from the full energy of the ocean. They occupy the vertical

zone between low and high tide as well as the less-frequently inundated areas above mean high water, consisting of three general zones of progressively higher elevation: mudflat, low marsh, and high marsh. Mudflats are unvegetated, appearing only at low tide as an important ecological transition between the vegetated marsh and sub-tidal waters. Low marsh occurs in the portion of the tidal zone where plant roots are covered twice daily by normal high tides and exposed twice daily by normal low tides. High marsh occurs just above the mean high tide elevation and is flooded only occasionally during major storms or during extreme (spring) high tides.

Smooth cordgrass or saltmarsh cordgrass (*Spartina alterniflora*) is the characteristic plant species of the low salt marsh. Green filamentous algae, although small and primitive, are also important and can contribute one-fourth of the photosynthesis in a New England salt marsh (Van Raalte and Valiela, 1976). Besides algae, few other plants can tolerate the harsh environmental conditions of the low marsh. Plants inhabiting the low marsh must contend with soils with no oxygen, highly saline water and soil, and alternating flooding and drying. However, life in the high marsh is not so severe for plants due to the lack of daily tidal inundation and flushing. Salt meadow cordgrass (*Spartina patens*) is the most abundant plant in the high marsh. Other common plant species of the high marsh include black grass (*Juncus gerardii*), salt grass (*Distichlis spicata*), marsh elder (*Iva frutescens*), and seaside goldenrod (*Solidago sempervirens*).

From a habitat standpoint, as well as an economic perspective, the Jamaica Bay salt marshes are critical for three groups of animals: shellfish, finfish, and waterfowl. Several species of invertebrates including fiddler crabs and ribbed mussels spend essentially all of their lives in the salt marsh. Numerous fish species spend all or part of their lives in or around the salt marsh. Mullet and menhaden feed and mature in shallow waters at high tide. Striped bass and shad pass by salt marshes from the ocean on their way to rivers to spawn. Large numbers of waterfowl and other

Wetlands Cleaning Water

Salt marshes naturally trap sediment and nutrients that help build the marsh and support its high level of productivity. Generally, nitrogen is considered one of the main limiting factors to plant primary productivity in coastal waters. In Jamaica Bay, nitrogen loading from human waste products has created an over-abundance of available nitrogen, leading to severely impaired water quality. Because of the low oxygen conditions in salt marsh sediments, some bacteria can convert nitrate forms of nitrogen to gaseous forms that are then released to the atmosphere. This process, called denitrification, is a part of a larger significant pathway whereby nitrogen from the water can be removed by wetlands. Additionally, the nutrient phosphorus and some metals attach readily to small particles, that when settled in salt marshes often become bound up in sediments, plant tissue and organic matter, effectively removing these pollutants from the aquatic system in a process called sequestration. Source: Biohabitats

Salt Marsh; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Salt Marsh Island Erosion

The New York State Department of Environmental Conservation estimates that since 1924, approximately 1,400 acres of tidal salt marsh has been lost from marsh islands in Jamaica Bay. The major losses on these islands have been identified as perimeter erosion, widening of tidal channels and expansion of interior tidal pools (USACE, 2005). In 2000, the National Park Service convened a Blue Ribbon Panel of eminent wetland ecologists to investigate the loss of the marsh islands. They concluded that numerous interrelated processes are responsible, including changes in sediment deposition, increased wave action, contamination of Bay waters, and sea level rise. These and other issues are currently being studied to better understand the mechanisms of degradation. The implications of the accelerating rate of salt marsh island loss are startling: Jamaica Bay could lose most of its salt marsh islands in the next several decades if these recent trends continue. Source: USACE, 2005

FIGURE 4.3.1 Historic Tidelands of the Jamaica Bay Estuary; Source: Regional Plan Association

birds use the salt marsh during their spring and fall migrations, and some stay for the summer to nest.

Several bird species nest in salt marshes, including clapper rail, marsh wrens, and sharp-tailed sparrow. These birds feed on insects, mollusks, and shellfish. Small rodents like the white-footed mouse search for small insects and seeds. Raccoons and mink patrol the salt marsh looking for crabs, mussels, and clams. Few large animals inhabit the salt marsh due to the difficulty of moving about on the marsh surface and the lack of other necessary habitat elements to support them. Wave energy and floodwaters from severe storms are dissipated on salt marshes, which can re-grow when damaged by storms. Salt marshes also provide a pleasing contrast to the developed areas that border the Bay as well as recreational opportunities for citizens of the Jamaica Bay watershed.

Prior to Euro-American settlement, it is estimated that there were about 16,000 acres of salt marsh in Jamaica Bay (USFWS, 1997, Figure 4.3.1). At first, salt marshes were used by the settlers as pasturelands for livestock. Later, as farming was replaced by manufacturing in the New York City region, salt marshes were filled with debris and then later developed. Large areas of salt marsh were filled with garbage and converted to landfills, which were subsequently converted to parks and commercial and other private uses. As of 1971, only about 4,000 acres of salt marsh remained in the Bay (National Academy of Sciences and National Board of Engineering 1971). Prior to 1974, salt marsh disappearance occurred primarily

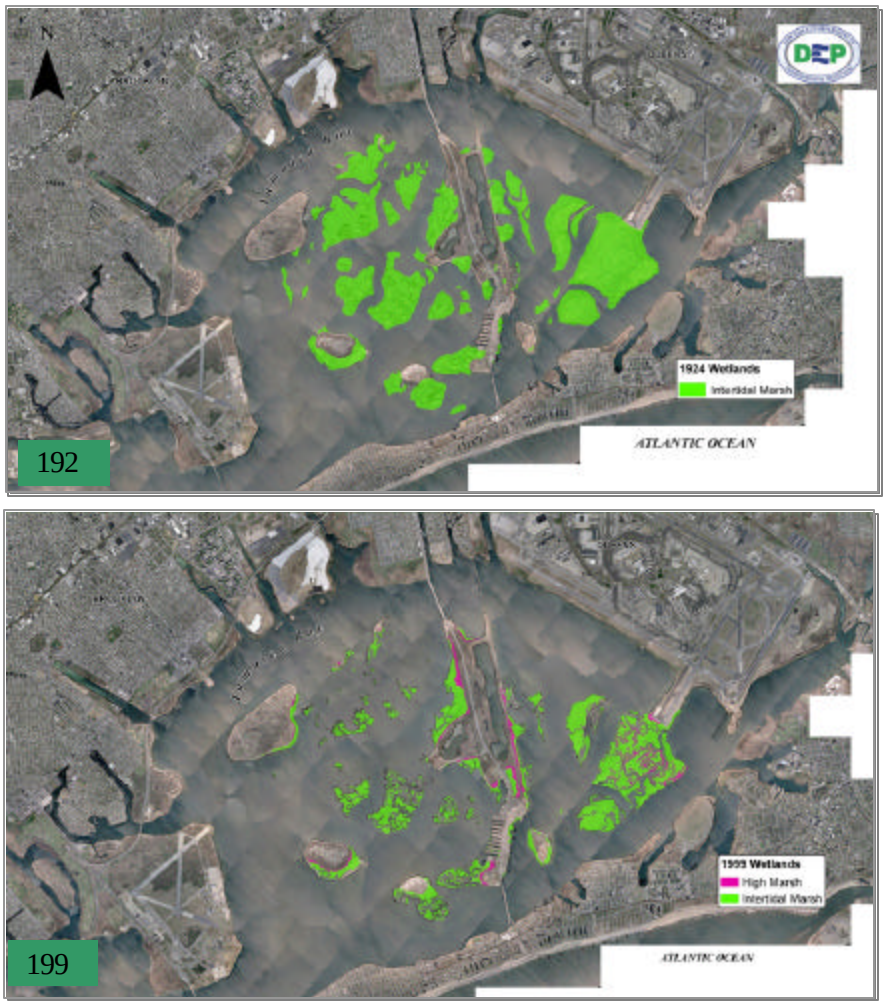


FIGURE 4.3.2 Wetland Loss in Jamaica Bay from 1924 to 1999; Source: NYCDEP

along the periphery of the Bay due to dredging, filling, and draining activities. Since 1974, the vast majority of salt marshes loss in the Bay is the result of marsh islands that are disappearing, not yet fully explained (see sidebar for more information). Figure 4.3.2 shows the changes in distribution of salt marsh islands in Jamaica Bay between 1924 and 1999 (NYCDEP, 2005). Based on aerial photographs, 780 acres of salt marsh were lost from 1924 to 1974, at an average rate of 0.4% per year (Hartig *et al.*, 2002). Analysis of 1974, 1994, and 1999 aerial photos showed that the rate of loss (44 acres/year) increased to 1.4% per year from 1974 – 1994 with 400 acres of salt marsh lost and further increased to 3.0% per year from 1994 – 1999 with 220 acres of salt marsh lost (Hartig *et al*., 2002) (Table 4.3.1).

Wetlands in Jamaica Bay that are not physically destroyed can be degraded directly and indirectly by human activities. Vacant areas of wetland are inviting places to dispose of junked cars, construction debris, and other refuse. Human disturbance creates an opening for invasive plant species that have the potential to suppress native vegetation and create monocultures that are considered less hospitable to wildlife than the

TABLE 4.3.1 Loss of Salt Marsh Islands in Jamaica Bay from 1900 to 1994; Source: USACE, 2005

	1900	1974		1994		
SALT MARSH ISLAND (SALT MARSH ZONE)	ACRES	ACRES	PERCENT REMAINING SINCE 1900	ACRES	PERCENT REMAINING SINCE 1974	PERCENT REMAINING SINCE 1900
Nestopol (Low)	36.6	5.7	16%	0.6	9%	2%
Jo Co (High and Low)	485.0	414.0	85%	374.0	90%	77%
Elders Point (Low)	120.0	93.0	77%	37.6	40%	31%
Fish Kill Hassocks (Low)	4.9	1.3	27%	0.05	4%	1%
Total Island Marshes (>15 Named Islands)	3,146	1,972	63%	1,572	80%	50%

native plants. In particular, purple loosestrife (*Lythrum salicaria*) is a threat to the remaining freshwater wetlands, while the common reed (*Phragmites australis*) forms dense stands in fresh to moderately saline wetlands, and is already well established around the estuary.

4.4 SEDIMENT QUALITY IN THE BAY

The sediments in Jamaica Bay have been impacted by the activities of man in the watershed. Not only the dredging and filling of the Bay but also the discharge of effluents from the WPCPs and the CSOs and wet weather flows have contributed to contaminants found in the Bay. A study conducted by the USEPA in 1998 compared sediment data from 1993/4 and 1998 (USEPA, 2003).

The discussion of sediment in Jamaica Bay involves a number of topics that can broadly be divided into two categories. The first category is sediment characteristics, which includes descriptions of the sediment and the quality of the sediment. The second category is the movement of sediments either naturally or due to human involvement, which includes sources and sinks of sediment as well as dredging and placement of sediment. This section of the report will discuss both categories.

Sediment Description

Limited data exists for sediment types in Jamaica Bay. The data that do exist tend to be dated. Feuerstein and Maddaus (1976) measured sediment fractions at 15 sites around Jamaica Bay and created isopleths for sand, silt and clay fractions. The western portion of the Bay from Cross Bay Boulevard to the Rockaway Inlet generally had greater than 80 percent sands. The isopleths are then tightly spaced toward Grassy Bay where the sand component is less than 40%. The western side of the Bay had a silt fraction of approximately 10% while Grassy Bay had 20 to 30% silt. Clay content in the Rockaway Inlet was less than 10 %, and was as high as 50% in Grassy Bay.

Franz and Harris (1985) also analyzed sediments in the Bay. On a Bay-wide basis, bottom sediments were described as "predominantly moderately to well sorted, nearly symmetrical to coarse skewed, mesokurtic to very leptokurtic, fine quartz sands" (a normal distribution is called mesokurtic; leptokurtic is a peaked distribution with thick tails). Some exceptions were noted near the Rockaway WPCP, North Channel Bridge and Barren Island. Muds were found in areas where flows were restricted. Very fine sand and mud covered by dense surface mats of amphipod tubes was found in Grassy Hassock Channel. Grassy Bay was covered with black sticky jelly-like muds. The mud fraction generally increased northwards in the western Bay and along the North Channel.

The Regional Environmental Monitoring and Assessment Program (REMAP) analyzed sediment type in 1993-94 and 1998 (Adams and Benyi, 2003). An area-weighted mean of sampling sites in Jamaica Bay found 30.3 percent silt-clay in 1993-94, and 37.5 percent silt-clay in 1998. The 1998 sampling classified 50 percent of Jamaica Bay as mud. More recently, the Norton Basin Borrow Pit Restoration Project conducted for the USACE and the NYSDEC (Barry A. Vittor and Assoc., 2002) conducted sampling in Norton Basin and Little Bay as well as Grass Hassock Channel and the Raunt. Samples collected in the Raunt were approximately 50 to 60 percent sand and 20 to 40 percent clay. Sediment samples in Grass Hassock Channel tended to be approximately 25 percent sand and 30 to 50 percent clay.

Salt Marsh; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

The nature of the bottom substrate at locations around the Bay is important. Different substrates provide different habitats and support different, sometimes interactive communities. Fishes and crustaceans often highly modify mud habitats exploiting the cohesive nature of the fine sediments and organic materials. Burrows of various sizes and configurations, as well as shallow depressions, greatly increase the complexity of such habitats. The mud bottom substrate provides habitat for shellfish and invertebrates, with some of the latter serving as prey for the finfish in the Bay.

Total Organic Carbon (TOC)

TOC provides a measure of how much organic material occurs in sediments. Decomposing salt marsh plants and upland runoff are the primary sources of organic carbon. Open water sites are generally farther away from these sources resulting in lower TOC concentrations than tidal creek habitats.

Franz and Harris (1985) collected TOC data for Jamaica Bay in the early 1980s. In this study they correlated the percent TOC with the condition of the sediment. Sediments with less than 0.5 percent TOC were characterized as clean yellow-brown to gray. Sediments with 0.5 to 1.0 percent TOC were described as dirty with black organics. TOC values greater than 1.0 percent were characterized as usually black, frothy mud and having a hydrogen sulfide (H_2S) (rotten eggs) odor.

Sediments with TOC content less than 0.5 percent were found in the western, central and southern portions of the Bay. The next category of sediments 0.5 to 1.0 percent TOC were found at Nova Scotia Bar, outside of Mill Basin and Paerdegat Basin, near JoCo Marsh and on the western side of Rulers Bar Hassock (sometimes referred to as the Broad Channel Community). Sediments with TOC levels of 1.0 to 3.0 percent were measured outside of Fresh Creek and Spring Creek, in the areas around Grassy Bay and Grass Hassock Channel. The highest TOC content (> 3.0 percent) was found in Grassy Bay, the area to the southeast of Grassy Bay next to the

JFK Airport runway extension, in Fresh and Hendrix Creeks, and near the area around Broad Channel, which was unsewered at the time.

The REMAP program measured TOC in Jamaica Bay during 1998. While the area weighted mean of TOC in Jamaica Bay was 2.6 percent, nearly 40 percent of the Bay had TOC measurements less than 0.5 percent. Another nearly 40 percent of the Bay had TOC measurements greater than 3.5 percent (Adams and Benyi, 2003). Hyland *et al.* (2000) found that extreme concentrations of TOC can have adverse effects on benthic communities; TOC levels below 0.5 mg/g (0.05%) and above 30 mg/g (3.0%) were related to decreased benthic abundance and biomass. The National Coastal Assessment Program (USEPA, in review) has used TOC concentrations of below 2% and above 5% to indicate fair or poor sediment quality.

Priority Pollutants

A review of Zeppie (1977), Ramondetta and Harris (1978), Seiger and Tanacredi (1979), Staubitz and Wolcott (1985), Franz and Harris (1985), Bopp *et al.* (1993), and Adams *et al.* (1996) shows that a number of trace and heavy metals and priority pollutants have been found in the sediments of Jamaica Bay. These include cadmium, chromium, copper, iron, lead, mercury, nickel and zinc, as well as chlordane, DDD, DDT, dieldrin, heptachlor, polynuclear aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs). In general, these contaminants were found in proximity to the outfalls of WPCPs, CSOs, and storm sewers, or near landfills. Contaminants were also found to be highly correlated with the total organic content of the sediment. As such, the most highly contaminated areas were found along the northern and eastern portions of the Bay, especially Grassy Bay, and also on the northeastern side of Nova Scotia Bar. The Brookhaven National Lab has created contour maps of the REMAP data that can be found at: *http://www.bnl.gov/wrdadcon/publications/image/status_jpg.htm*

REMAP also evaluated the biological effects of toxics in the sediment. The Effects Range-Low (ERL) value is the concentration at which adverse biological effects begin to be seen. The Effects Range-Medium (ERM) is the concentration that is usually associated with adverse biological effects (Adams and Benyi, 2003). New York State has adopted the use of some ERLs and ERMs for Sediment Guidance Criteria (NYSDEC, 1999). The REMAP data shows that mercury, chlordane, and high molecular weight PAHs exceeded ERMs in portions of Jamaica Bay.

Prior to the 1972 Federal Clean Water Act, many industries released toxic contaminants into local waterways as unregulated point sources of pollution (USACE, 2004). As a result of that legislation, most point sources have been identified and many of them remediated. Currently, non-point source dissolved pollutants and pollutants that adhere to sediment enter the Bay at storm, sanitary, and combined sewer outfalls. The National Oceanic and Atmospheric Administration (NOAA) ranks sediment samples collected in the late 1980s in Jamaica Bay as being within the top 20 most polluted nationally (out of 110 sites) (NOAA, 1988). Additionally, sediments collected in the 1990s were found to have some of the highest toxicity levels in the New York harbor area (Adams *et al.*, 1998).

Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Researchers have also found that contaminant levels in the sediments have been declining since the 1960s and 1970s. According to Franz and Harris (1985), their metals data showed a significant decrease in the metals concentrations

when compared to data collected by Ramondetta and Harris (1978) a decade earlier. Bopp *et al.* (1993) found that metals concentrations decreased by approximately 50 percent from the mid-1960s to the mid-1980s, and that PCBs, chlordane, and DDT-related compounds had decreased by a factor of five between the late 1960s and late 1980s. Bopp hypothesized that improvements in wastewater treatment, and regulations related to the use and release of certain compounds, was the cause for this decline. The NYCDEP (2005) reported that influent loading of metals to WPCPs in NYC during 2003 declined to 29 percent of the loadings received in 1973. The REMAP found chlordane concentrations had a statistically significant decrease between 1993-94 and 1998 in Jamaica Bay.

Sediment samples were analyzed for PAHs, pesticides, metals, PCBs, dioxin and furan congeners, and TOC. Of the 47 parameters analyzed, it was found that concentrations for the majority had decreased from 1993/4 to 1998. Concentrations for the metals (arsenic, chromium, manganese, mercury, and nickel), and for the PAH perylene, were found to have increased. Generally, sediment quality data throughout the Bay are limited, as are evaluations of historic sediment quality.

While sediment conditions in Jamaica Bay appear to be improving, areas in the Bay are still problematic. Adams *et al.* (1996) reported that 14 percent of Jamaica Bay's sediments are highly toxic and 25 percent of the Bay's sediment is toxic (inclusive of highly toxic) to *Ampelisca abdita*, a polycheate worm, and that 50 percent of the Bay's sediments were toxic using the Microtox assay (which measures toxicity to a bacterium). Adams and Benyi (2003) found 20 percent of Jamaica Bay's sediment to be highly toxic and 32 percent to be toxic based on data collected during 1998.

Sediment Balance

The movement of sediment within Jamaica Bay has become an important issue with regard to marsh loss. Some theorize that marshes can no longer keep pace with sea level rise because sediments do not reach the marshes in enough quantities. Zeppie (1977) measured sediment deposition rates in the marshes at 0.8 cm/yr and sandy channels at 0.5 cm/yr. This rate is well above the 0.29 cm/yr attributed to sea level rise in some references. However, confirmation of this rate at the present, 30 years later, may be advisable as a factor in decision making, due to changes in contributing variables in and around the Bay.

Sediment sources from the land have been reduced due to urbanization and the paving over of the watershed. Approximately 12,000 acres of marshland that surrounded Jamaica Bay have been filled (JBESG, 1971). Those sediments that do enter the Bay tend to settle out in the deeper areas of the Bay where current velocities are lower. Bopp *et al.* (1993) examined two sediment cores taken from Grassy Bay, one in 1982 the other in 1988. Sedimentation rates in Grassy Bay were estimated to be 1.4 cm/yr from the mid-1960s to the late 1980s, and 1.6 cm/yr between the mid-1950s and late 1980s. These deeper areas were artificially created for shipping lanes and by the removal of material for landfilling. It has been estimated that 125 million cubic yards of material have been dredged since the early 1900s to create shipping channels and to provide fill for use in other portions of the Bay, such as the creation of JFK Airport, Floyd Bennett Field, and Broad Channel Island. It has also been estimated that 70 percent of the current volume of Jamaica Bay is the result of man made changes (JBESG, 1971).

Under pre-urbanized conditions, sediments would have entered the Bay via the tributaries that surround the Bay. Currently, sediments enter the Bay via the WPCPs, which are designed to remove suspended solids from wastewater, and from CSOs and storm sewers, which discharge into tributaries where much of the sediment settles out. The extension of the Rockaway Peninsula westward from about the location of Jacob Riis Park to its present location has altered flows and restricted the import of sediments from the Lower Harbor.

Modeling conducted by HydroQual (2006) suggests that the changes to the bathymetry of the

Bay have changed the shear stress on the bottom sediments, thereby changing the way sediments are distributed within the Bay. Currently, current velocities are strong through the Rockaway Inlet, as well as the North Channel and Beach Channel up to about Cross Bay Boulevard. Here the currents are restricted by the narrow channels, and bottom shear stress significantly declines in the eastern portion of the Bay, which is a depositional zone. Marsh areas in the western portions of the Bay experience some high shear stresses, but on average would appear to be depositional areas. If all of the deep areas of Jamaica Bay were filled to 8 ft below mean low water (MLW), the shear stress in the bottom sediments would change within the Bay. In this case, the shear stress in the channels increases, but in the western marsh areas the shear stress is smaller, which might allow more deposition. The eastern portion of the Bay remains a depositional zone. Based on these results it appears that modifications to the geometry of the Bay have contributed to changes in the sediment distribution in the Bay.

4.5 SHORELINE

Shorelines occur where the Jamaica Bay estuary meets land. In this context, a "shoreline" refers to a narrow strip of land that is located immediately above the mean high tide forming a zone interfacing with adjacent uplands. The shoreline environment includes the upper extent of wetlands areas, unvegetated sandy areas or dunes, vegetated uplands, and the built environment that abuts the Bay and its tributary creeks and basins (Figure 4.5.1).

Jamaica Bay has extensive shoreline habitat around the Bay's periphery, on larger islands in the central Bay, and along its tributary creek channels. Historically, much of the shoreline of the Bay was fringed with salt marsh wetlands, although there were also unvegetated areas dominated mostly by sands. Shoreline wetlands dissipate wave energy from adjacent waters. Prior to the dredging that deepened much of the Bay, most of the shoreline was subject to low-energy waves due to the shallow water in the Bay and lower wave height. With the dredging of the Bay and attendant increase in wave height, some shorelines now experience more erosive wave energy.

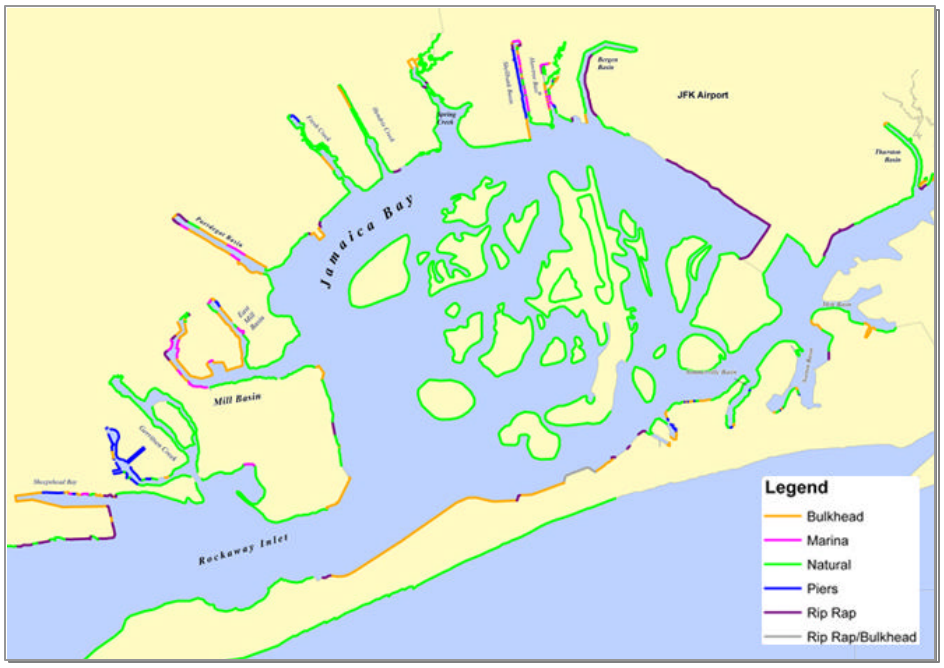


FIGURE 4.5.1 Natural and Artificial Shoreline Habitat Areas in the Jamaica Bay Estuary: Source: NYCDEP

TABLE 4.5.1 Shoreline Area Soils

SOIL TYPE	SOIL DESCRIPTION
Beaches (5)	Nearly level to gently sloping areas of sand or sand and gravel adjacent to the Atlantic Ocean and Jamaica Bay, inundated by saltwater twice each day at high tide. Frequently reworked by wave and wind action, these areas do not support vegetation.
Ipswich-Pawcatuck-Matunuck mucky peats, 0-3 percent slopes (6)	Low lying areas of tidal marsh that are inundated by salt water twice each day at high tide, with a mixture of very poorly drained soils which vary in the thickness of organic materials over sand.
Pavement & buildings, wet substratum-Bigapple-Verrazano complex, 0-8 percent slopes (92)	Nearly level to gently sloping urbanized areas where sandy dredged materials and loamy fill have been placed over swamp, tidal marsh, or water; a mixture of sandy and loamy-capped anthropogenic soils, with up to 80 percent impervious pavement and buildings covering the surface; located along coastal waterways in Staten Island, Brooklyn, and Queens.
Greatkills-Freshkills complex, 3-25 percent slopes (98)	Gently sloping to moderately steep areas where household landfill material is capped by loamy fill of variable thickness.
Bigapple-Fortress complex, 0-8 percent slopes (99)	Nearly level to gently sloping areas that have been filled with sandy dredged materials; a mixture of well drained and moderately well drained anthropogenic soils; located along coastal waterways.
Inwood-Laguardia-Ebbets complex, 0-8 percent slopes (100)	Nearly level to gently sloping areas that have been filled with a mixture of natural soil materials and construction debris; a mixture of anthropogenic soils which vary in coarse fragment content.
Hooksan-Verrazano-Pavement & buildings complex, 0-8 percent slopes (242)	Nearly level to gently sloping areas of dunes that have been partially cut and filled, mostly for parkland and light residential use; a mixture of sandy soils and loamy-capped anthropogenic soils with more than 15 percent impervious pavement and buildings covering the surface; located on Coney Island and the Rockaway peninsula.

Sea Level Rise and Shoreline Erosion

Global warming causes the volume of water in the oceans to expand and it promotes melting of the polar ice caps. These and other factors contribute to sea level rise, which is occurring locally at a rate of about 2.2 mm per year (Hartig *et al.*, 2002). In addition, climate change models project a higher frequency and intensity of storm events as a result of global warming trends. Rising ocean levels combined with augmented storm surges may lead to an increased risk of salt marsh wetland erosion and the destruction of developed infrastructure around the periphery of the Bay. The armoring of shorelines prevents the natural landward migration of wetlands during sea-level rise, a process that normally allows tidal wetlands keep pace with long-term changes in climate and ocean levels. Moreover, hardened shorelines reflect wave energy back into the interior of the estuary, leading to further erosion potential for the vulnerable salt marsh islands.

Shorelines provide important animal habitat, especially for birds that use the areas for feeding. Four species listed as threatened or endangered by the State of New York use shoreline habitat in Jamaica Bay: piping plover, common tern, least tern, and roseate tern (NYCDEP, 1994). These areas function as critical habitat for horseshoe crabs and diamondback terrapins that use unvegetated open shorelines to lay their eggs. Shorelines are also important for recreational uses such as fishing and bird watching.

Shorelines have been altered by human activities perhaps more than any other portion of the Bay. Consequently, the remaining natural remnants are particularly important. During the first half of the 20th Century, many shoreline wetlands around the periphery of the Bay were drained and filled while creeks were straightened and channelized. Land uses along shorelines now include landfills, parks,

sewage treatment plants, highways, airports and residential subdivisions. Many shorelines have been hardened with bulkheads to protect infrastructure on the landward side. Bulkheading a shoreline prevents the natural landward migration of salt marshes, and removes essential habitat for many wildlife communities.

The shoreline area soils are most commonly characterized by the soil types as described in the New York City Reconnaissance Soil Survey in Table 4.5.1 (USDA, 2005b).

4.6 UPLANDS

Uplands are characterized as those land areas that are rarely or never inundated by standing water. Broadly defined, uplands include all environs with the exception of aquatic, wetland and subterranean communities. As a result of the dry, productive soils, upland landscapes tend to be the most desirable places for human habitation and agriculture. Since the early days of Euro-American settlement and continuing through the 20th Century, the large majority of uplands in the Jamaica Bay watershed were cleared of native vegetation and converted to land uses such as pasture, landfills, and ultimately the built urban environment. As a part of the urban core of New York City, all upland areas in the Jamaica Bay watershed have been at least nominally impacted by human disturbance, although there are a few locations where traces of the native upland landscape still exists. These undeveloped areas harbor assemblages of grasses, low herbaceous vegetation, shrubs and trees.

The vegetation growing on uplands is essentially a "living filter" for both surface and subsurface water leaving upslope areas. Soil sediment and water borne pollutants are trapped, modified or used by vegetation for growth, reducing their effects on adjacent waterbodies and their aquatic systems. The root structures of upland vegetation break up compacted soil allowing for greater infiltration and retention of surface runoff.

Upland areas are essential for a large number of terrestrial plant and animal communities, which

"Grass grows by inches but it's killed by feet."

– George Thoma

Floyd Bennett Grasslands; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Historic Grasslands on Long Island

Before the Dutch settled the New York City region, the upland areas of the Jamaica Bay watershed were part of a larger grassland complex that included vast areas of Long Island. Historically, this region was thought to contain some of the largest contiguous grassland habitats east of the Mississippi River (Drennan, 1981).

utilize the complex array of grassland, shrub, woodland, and dune habitats. There are only a few such areas in the watershed which retain valuable terrestrial habitat function for resident and migratory wildlife. Most of these areas are currently protected and under public ownership: the Jamaica Bay Wildlife Refuge, a unit of GNRA, which encompasses the interior of the estuary, including upland areas on Canarsie Pol, Ruffle Bar, and Rulers Bar Hassock; Floyd Bennett Field, under the jurisdiction of GNRA; NYCDEP managed landfills on the perimeter of the estuary; NYCDPR open space areas; and selected areas within JFK Airport.

Grasslands; Source: NYCDEP

Floyd Bennett Field is a former airfield that includes upland and shoreline habitat created by the historic filling of salt marsh in Jamaica Bay. Decommissioned in 1950, the land became a home for grassland and open-country birds until recent decades when shrub and forest species began to predominate. Significantly, about 57 hectares (140 acres) of this area has been restored to grassland and maintained through clearing, mowing and burning to support several bird species particular to this habitat type. Additionally, 54 species of butterflies and skippers have been recorded at the Wildlife Refuge and surrounding uplands (USFWS, 1997).

A coastal uplands beach and dune system exists on the bayside interior of the Rockaway Point / Breezy Point tip of the Rockaway Beach peninsula. This area supports high concentrations of nesting birds including small numbers of breeding pairs of the federally listed threatened piping plover (USFWS, 1997). Breezy Point also supports the state-listed rare Schweinitz's flatsedge on the Bay side of the barrier. Some islands in the Bay support upland communities that include open field, shrub thicket, emerging woodlands, and beach grass dunes (NYSDOS, 1992).

Areas away from the immediate shoreline (*i.e.* greater than 1/4 mile) of the Bay are generally characterized as "urban" soils or those areas where the soil has been covered by pavement and/or buildings. In the New York City area of the watershed, the soil classifications are differentiated mainly by the degree of slope and the underlying soil materials (USDA, 2005b). Soils within the watershed are generally described as follows in Table 4.6.1.

TABLE 4.6.1 Urban Soils Within New York City Portion

SOIL TYPE	SOIL DESCRIPTION
Pavement & buildings, postglacial substratum, 0-5 percent slopes (1)	Nearly level to gently sloping, highly urbanized areas with more than 80 percent of the surface covered by impervious pavement and buildings, over dunes and dune sand, generally located in urban centers.
Pavement & buildings, wet substratum, 0-5 percent slopes (4)	Nearly level to gently sloping, highly urbanized areas with more than 80 percent of the surface covered by impervious pavement and buildings, over filled swamp, tidal marsh, or water, generally located in urban centers.
Freshkills, geotextile liner substratum-Klienkill sandy loams, 3-25 percent slopes (123)	Gently sloping to moderately steep areas where household landfill material is capped with either a geotextile or a clay liner.
Pavement & buildings-Hooksan-Verrazano complex, 0-8 percent slopes (208)	Nearly level to gently sloping urbanized areas of sandy sediments that have been substantially cut and filled mostly for residential use; a mixture of sandy soils and loamy-capped anthropogenic soils, with 50 to 80 percent of the surface covered by impervious pavement and buildings; located along the southern shorelines of Brooklyn and Queens.

4.7 URBAN ECOLOGY

The tidal waters, shoreline, and immediate upland buffers of Jamaica Bay have been the focus of numerous ecological studies, as well as management and policy recommendations. Indeed, these areas harbor the majority of the remaining fish and wildlife habitat and communities that still exist in the watershed. Often overlooked is the Bay's human built environment, the urban zone known as New York City and Nassau County.

Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Urban ecosystems often amplify common, long held concepts in ecology, such as disturbance, species invasions and extinctions, and habitat fragmentation. The air, water, and soils of urban environments are highly modified, impacted physically and chemically by human activity. The impacts these alterations have on plant and animal species composition become greater with increasing urban area and proximity to the city center (Sukopp, 1998).

The city's urban environment is in fact a "new" ecosystem (Kangas, 2004). The notion of an urban ecosystem implies that humans are a part of the system and not separate from it as it has been traditionally thought. The human controls on the urban ecosystem strongly influence the structure and dynamics of plant and animal communities, often in different ways when compared to natural ecosystems (Rebele, 1994). Cities have different climate characteristics than surrounding natural areas with the urban heat island affecting plant growth seasons and survivability while wind patterns are also influenced by surface structures. The covering of soils with concrete and asphalt decreases ground water infiltration while increasing soil compaction. This is ecologically significant as polluted water and sediments are then shunted away through storm sewers to natural waterbodies without the cleansing benefit of filtration through the ground and ground water recharge.

In an urban environment, living plants do not form the dominant food base, with human and animal consumers in highly urbanized areas requiring food energy imports on a scale many times greater than those supplied by natural systems (Odum, 1983). Energy cycling is not complete within the urban environment (Sukopp, 1998), as natural decomposer connections with waste streams are limited by landfills and cut off by incinerators.

While the majority of wetland and upland areas of the Jamaica Bay watershed have been highly developed into the human built environment, concrete and asphalt occasionally give way to sparsely vegetated developed areas such as small city parks, tree-lined streets, backyards and abandoned lots. Interestingly, graveyards and landfills provide some of the largest "open" spaces in the watershed. While the built environment provides marginally valuable and fragmented habitat, these areas are still voluntarily colonized by hearty vegetation and utilized by some species of wildlife adapted to contact with the built human environment. Most of these areas, if not

Forests in New York City?

Although highly populated, New York City's five boroughs still collectively host almost 5,000 acres of forested areas (Luttenberg *et al.*, 1993), which accounts for about 2.6% of the total area of New York City. A study examining 100 years of woody plants in the New York metropolitan region found that non-native invasive species are spreading rapidly while native species are in slight decline (Clements and Moore, 2005), a common trend in many urban areas.

abandoned, are highly managed with intentionally introduced native and non-native vegetation. Unintended invasive species such as the ubiquitous tree of heaven are often found in urban environments as well.

TABLE 4.7.1 Common Urban Wildlife and Vegetation Found at Jamaica Bay

COMMON NAME	SCIENTIFIC NAME	TYPE
Norway maple	*Acer platanoides L.*	Exotic
Tree of heaven	*Ailanthus altissima*	Exotic
Ginkgo	*Ginkgo biloba*	Exotic
Black cherry	*Malacosoma americanum*	Native
Grey squirrel	*Sciurus carolinensis*	Native
Black rat	*Rattus rattus*	Exotic
Norway rat	*Rattus norvegicus*	Exotic
Ferel cat	*Felis silvestris*	Domesticated
Ferel dog	*Canis familiaris*	Domesticated
Rock pigeon	*Columba liva*	Domesticated
European starling	*Sturnus vulgaris*	Exotic
Common grackle	*Quiscalus quiscula*	Native
Herring gull	*Larus argentatus*	Native
Ring-billed gull	*Larus delawarens*	Native

4.8 VEGETATION

The distinctive vegetation found in the Jamaica Bay estuary and the greater watershed is one of the defining features of the landscape. Plant species are distributed throughout the watershed according to their physiological preferences for environmental factors such as salinity, soil moisture, sunlight, temperature, and nutrients. Ecologists have long noticed that certain plant species tend to grow together, presumably because they share physiologic adaptations to similar environmental conditions. We refer to these broadly defined assemblages of plant species as plant communities.

While extensive vegetation studies have been conducted in the GNRA and adjacent upland buffers, Jamaica Bay is lacking a comprehensive survey of the composition, location, and condition of plant communities in the urbanized areas of watershed. However, Luttenberg *et al.* (1993) list the native plant species that can be expected for New York City and vicinity. The following information relies heavily on the community descriptions in Lutterberg *et al.* (1993) and is augmented by data from studies on specific plant

communities in the watershed. Also, as part of its New York Metropolitan Flora Project, the Brooklyn Botanical Gardens has prepared a "Metropolitan Plants Encyclopedia." It "…consists of a series of comprehensive pages on the plants of the New York metropolitan region. For each family, genus, and species in the area there are one or more pages with photos, distribution maps, descriptions, ecological information, references…" and additional information that is being gathered and added periodically (Brooklyn Botanical Garden, 2007).

Sea Lettuce

Sea lettuce, (*Ulva latuca*), is a unique form of vegetation that is actually a macro-algae. It forms dense layers in the shallows of Jamaica Bay and is sometimes seen on mudflats at low tide or washed up on shore from storms. Source: Biohabitats

Sea Beach Amaranth; Source: Newsday, Inc., 2006

Sea Beach Amaranth

Sea Beach Amaranth is a rare plant that grows in beach-dune areas. For years it was thought to be extirpated from New York State, until it was found again in 1990. It is found along sandy beaches of the Atlantic coast, where it grows on the shifting sands between dunes and the high tide mark. Construction of beach stabilization structures that stop the natural movement of sand has degraded much sea beach amaranth habitat.

Herbaceous communities

Wetland herbaceous communities include low salt marsh, high salt marsh, deep freshwater emergent marsh, and shallow freshwater emergent marsh. Salt marsh occurs in sheltered tidal areas. Smooth cordgrass or saltmarsh cordgrass (*Spartina alterniflora*) is the characteristic plant species of the low salt marsh. Few other plant species are adapted to grow in the low marsh because of the harsh environmental conditions associated with fluctuating salinity and alternating wetting and drying.

Salt meadow cordgrass (*Spartina patens*) is the most abundant plant in the high salt marsh, which occurs above the mean high tide to the upper limit of the spring high tide. Other common plant species of the high marsh include black grass (*Juncus gerardii*), salt grass (*Distichlis spicata*), marsh elder (*Iva frutescens*), and glasswort (*Salicornia* spp.). The high marsh is also laced with wildflowers such as salt marsh aster (*Aster tenuifolius*), sea lavender (*Limonium carolinianum*), and seaside goldenrod (*Solidago sempervirens*) (Mack, 1990).

Freshwater marshes are dominated by emergent herbaceous vegetation, plants that are rooted under water and whose leaves extend into the air. Deep emergent marshes, with standing water to a maximum depth of about 2 feet, hosts pickerelweed (*Pontederia cordata*), cattails (*Typha latifolia* and *T. angustifolia*), bullrush (*Scirpus validus*), arrow arum (*Peltandra virginica*), and other emergent wetland plant species. Shallow emergent marshes typically have standing water to a maximum depth of about one foot and harbor sedges (*Carex* spp.), rushes

(*Juncus* spp.), water plantain (*Alisma* spp.), and common threesquare (*Scripus pungens*), among others.

Upland herbaceous communities include maritime beach/dunes, maritime grassland, and oak opening. Oak openings probably no longer occur in the Jamaica Bay area. The maritime beach/dune community is dominated by salt-tolerant grasses and low shrubs occurring on beaches and dunes at Breezy Point/Fort Tilden, Plumb Beach, Bayswater Park, and Arverne (EIS, 2001). The main plant species found in this community are beachgrass (*Ammophilia breviligulata*), northern bayberry (*Myrica pensylvanica*), sea beach knotweed (*Polygonum glaucum*), Schweinitz's flatsedge (*Cyperus schweinitzii*), seaside goldenrod, sea rockets (*Cakile* spp.), and salt spray rose (*Rosa rugosa*).

Goldenrod; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Several endangered, threatened, rare or plant species of concern occur in the beach/ dunes community. They include sea beach amaranth (*Amaranthus pumilus*), seabeach knotweed, sea blite (*Suaeda maritima*), Houghton's umbrella-sedge (*Cyperus squarrosus*), blunt spikerush (*Eleocharis obtusa*), Schweintitz's flatsedge, and retrose flatsedge (*Cyperus retrorsus*). The piping plover, common tern, and little tern are rare bird species that nest in this community.

Sea Lavender; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

The Jamaica Bay watershed harbors maritime grassland at JFK Airport, Floyd Bennett Field and on islands in the center of the Bay where upland areas exist. These grasslands often harbor high floristic diversity (Luttenberg *et al.* 1993). Common plant species include beachgrass, broomsedge (*Andropogon virginicus*), switchgrass (*Panicum virgatum*), little bluestem (*Schizachyrium scoparium*), and seaside goldenrod, plus northern barberry and shining sumac (*Rhus copallinum*) (Nancy, 2001). A study conducted in the mid-1980s indicated that expansion of northern bayberry has caused the decline of maritime grasslands around Jamaica Bay (Rogers *et al.*, 1985).

Shrub communities

Shrub communities include wetland (shrub swamp) and upland (maritime shrubland and successional shrubland) assemblages. The shrub swamp community occurs in areas of seasonal standing water. The common plant species include buttonbush (*Cephalanthus occidentalis*), elderberry (*Sambucus canadensis*), and alder (*Alnus serrulata*). These shrubs provide nesting cover for birds like the yellow warbler and the swamp sparrow.

Maritime shrubland is similar to maritime grassland, but has higher shrub species diversity plus several tree species, such as red cedar (*Juniperus virginiana*) and pitch pine (*Pinus rigida*). The successional shrubland community is a product of human alteration, occurring on sites that have been cleared or otherwise highly disturbed. A variety of shrubs and herbaceous species invade such disturbed sites. Common shrubs include grey birch (*Betula populifolia*), autumn olive (*Elaeagnus umbellata*), hackberry (*Celtis occidentalis*), and black cherry (*Prunus serotina*). Despite their history of disturbance, successional shrublands provide important nesting habitat for numerous songbird species.

Tree communities

New York City harbors five distinct tree communities: floodplain forest and red maple-hardwood swamp communities in wetland areas and Appalachian oak-hickory forest, rich mesopyhtic forest and successional mixed hardwoods in upland areas. Although the vast majority of forest has been cut and built upon long ago, almost 5,000 acres of forest still exists throughout the City's five boroughs today (Luttenberg *et al.* 1993).

Floodplain forest, red maple-hardwood swamp, Appalachian oak-hickory forest and rich mesophytic forest were all representative forest types historically found in the New York City metropolitan area. However, these forest communities probably exist today only in small remnant patches, if at all, while the successional mixed hardwoods community is most likely to be represented. The successional mixed hardwoods community is found on disturbed sites, including most areas of Jamaica Bay that do contain some patches of forested land, such as Floyd Bennett Field.

4.9 WILDLIFE

The Jamaica Bay watershed is distinctly divided into densely urbanized and functional natural areas that are relatively undisturbed by humans. The upper watershed is home to wildlife typical to dense urban environments, including domesticated animals, rodents and birds that thrive in a human-dominated ecosystem, as well as a host of insects that co-exist in the human landscape. Despite the developed watershed, the Jamaica Bay estuary is rich in fish and wildlife communities, hosting a large diversity and population of resident and migratory species.

Jamaica Bay exhibits very high levels of primary productivity, typical of estuarine systems. The pulsed tidal mixing of marine and fresh waters and the diversity of habitat types ensure that there is an abundance of basic food sources and living conditions available for important fish, bird and other wildlife populations. The significance of the estuary as a valuable habitat area is reflected by the protected status it receives. The NYSDOS has designated the Bay as a Significant Coastal Fish and Wildlife Habitat. The NPS created the Jamaica Bay Wildlife Refuge and the Bay area as a whole is recognized by the U.S. Fish and Wildlife Service (USFWS) as a regionally valuable habitat for migrating birds along the Atlantic Flyway.

Marine, estuarine, migratory, and anadromous fish species all utilize the Bay, areas of which have been recognized by NOAA's National Marine Fisheries Service (NMFS) as being Essential Fish Habitat for numerous species. The estuary is also recognized as essential habitat for communities of mammals, reptiles, amphibians and invertebrates, who use the Bay environment for shelter, a food-source, breeding ground, and nursery resource.

These distinct wildlife communities are further described in the following sections.

Benthic Macroinvertebrates as Biological Indicators

Benthic macroinvertebrates are often used as biological indicators of site specific ecological health and water quality impairment. In estuaries like Jamaica Bay, the amphipods have proven to be particularly sensitive to pollutants while some polychaete worms are considered the most tolerant organisms to environmental degradation. The variability of the total numbers of macroinvertebrate and the number of species found at different sites in the Bay can be measured and used as indicators of excessive organic loading from sewage and sediment contamination by toxic heavy metals and hydrocarbons.

Macroinvertebrates

Invertebrate organisms that are large enough to be retained on a 0.5 millimeter (mm) screen are termed macroinvertebrates. The Bay bottom and the emerging substrate of the Jamaica Bay estuary provides habitat for a large and diverse benthic macroinvertebrate community. In Jamaica Bay, as in other aquatic systems, this group of organisms are understood to mean those species living in (infauna), on or near the bottom (epibenthic) of aquatic environments for some part or all of their life history. While terrestrial macroinvertebrates such as butterflies are also ecologically significant, the focus of this section will be on aquatic macroinvertebrates, reflecting the focus of research efforts in this area.

Horseshoe Crab; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

The relative abundance of most aquatic macroinvertebrate species is related to bottom sediment composition. Generally, stable coarse substrates such as rock jetties and submerged shell reefs support diverse assemblages which include many filter feeders. Stable soft bottoms (muddy sands) also have a relatively high diversity of macroinvertebrate species, with a mixture of mobile and stationary forms of deposit and filter feeding organisms. Conversely, muddy substrates are rich in deposit feeders and generally poor in filter feeders, with an overall lower diversity than muddy sands.

Mudsnails; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

The eastern and northern portions of Jamaica Bay are typically characterized by muddy to finer grained sandy substrates while the western and southern sections of the Bay have fine to medium sandy bottom types (USFWS, 1997). A comprehensive survey of the subtidal macrobenthos of Jamaica Bay completed in 1983 found a total of 121 species (Franz and Harris, 1985). The high diversity of species in the Bay was considered to be reflective of the wide range of sediment types.

Many of the benthic macroinvertebrates in Jamaica Bay (table 1.4.4) often go unnoticed as they are generally small, opportunistically feeding infaunal species living inside the bottom substrates of tidal environments. Included among these are the polychaete worms, which are the dominant taxon in terms of numbers of species, and the amphipods (Franz and Harris, 1985). These invertebrates usually have multiple reproductions per year which gives them a capacity for rapid colonization of suitable habitat making them important components in the diets of fish and shorebirds.

Rock piles, piers and jetties in the inlet support a fairly diverse community of marine epibenthic colonial invertebrates such as sponges, bryzoans, hydroids, anemones, tunicates, and others. Meiofauna are a part of the very small (micro)invertebrates that inhabit algae, rock fissures, and the surface layers of the muddy bay bottom. While this class of organisms is important ecologically, they have not been studied in Jamaica Bay.

Franz and Harris (1985) found that subtidal benthic macroinvertebrate assemblages were stable in terms of species composition and that the diversity and abundance of macrobenthos in the

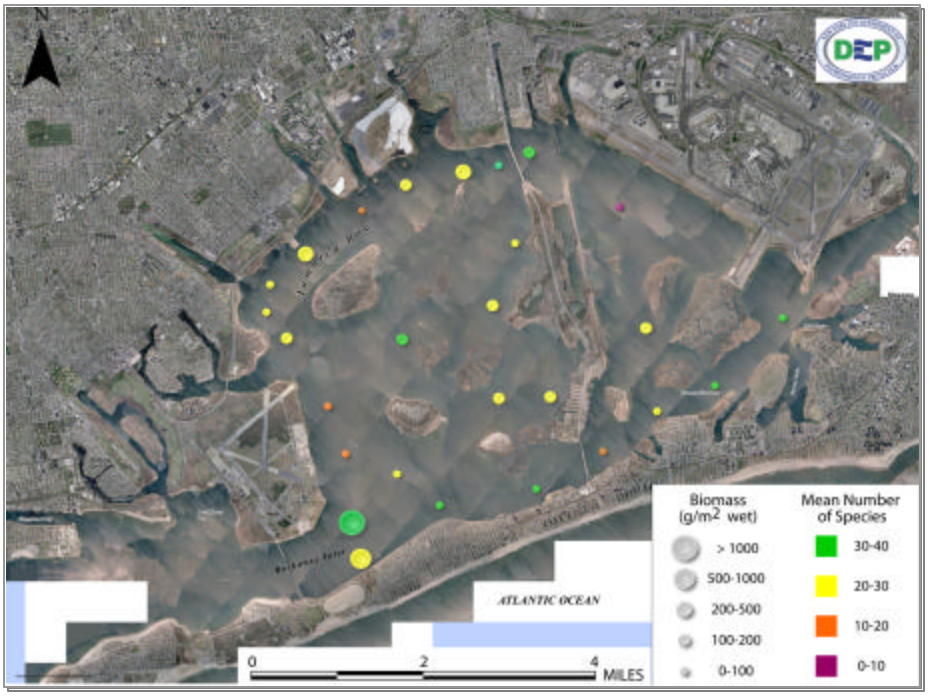


FIGURE 4.9.1 Macroinvertebrate Biomass and Species Abundance at Different Sampling Locations in Jamaica Bay; Source: Franz and Harris, 1995

Bay were comparable to other relatively healthy estuaries. A 1995 survey of Jamaica Bay intertidal benthic habitats by Iocco *et al.* (2000) found the dominant species collected were similar to those of Franz and Harris (1985). This is important because a stable and relatively diverse benthic community provides a range of pathways for energy in the form of nutrients to move up the food chain to a greater diversity of shellfish, fish and birds.

A map of macroinvertebrate biomass (living weight) and the number of species found at each Franz and Harris (1985) sampling station is found in Figure 4.9.1.

TABLE 4.9.1 Common Macroinvertebrates Found at Jamaica Bay

COMMON NAME	SCIENTIFIC NAME
Polycheate worm	*Streblospio benedicti*
Amphipod	*Ampelisca abdita*
Mud crab	*Neopanope texana*
Mud snail	*Ilyanassa obsoleta*
Slipper limpet	*Crepidula fornicate*
Shrimp	*Crangon septemspinosus*
Gem clam	*Gemma gemma*

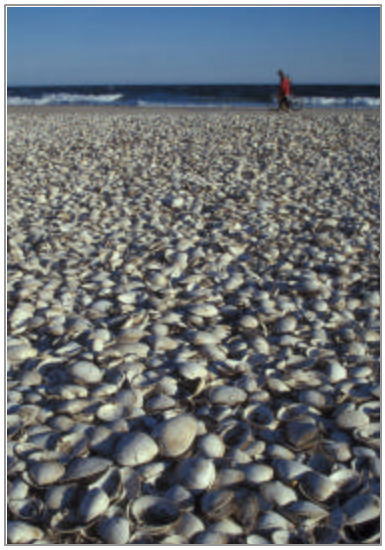
Shellfish

The Jamaica Bay estuary supports several species of shellfish including clams, mussels, oysters, and crabs (Table 4.9.2). Many shellfish are filter-feeding bivalves and, while processing water to obtain food, they also ingest and accumulate pollutants released from human sources, effectively cleaning the water. However, shellfish such as oysters and clams in the Jamaica Bay estuary have long become too contaminated for human consumption. This is due to both contamination by pathogens and bioconcentration of environmental contaminants by the filter feeding shellfish.

Jamaica Bay once supported an important shellfish industry at the beginning of the 20th Century. The American, or eastern, oyster (*Crassostrea virginica*) once dominated the local fishing economy, although today it is found in greatly reduced numbers and concentrations as a result of extensive dredging and filling of bottom habitat (Franz and Harris, 1985). In 1921 the shellfishery was closed by the City's Health Department due to pollution from untreated sewage (Seitz and Miller, 2003). While the fishery remains closed to this day, the USFWS (1997) reported several dominant

shellfish species are still found in the Bay. Ironically, the closure of the fishery has enabled some shellfish populations to maintain their presence in the Bay, despite decades of habitat destruction from dredging and frequent reports of illegal harvesting.

The Atlantic ribbed mussel (*Geukensia demissa*) may be found in extremely high densities and is common on Jamaica Bay mudflats and salt marshes (USACE, 2005). These mussels are thought to aid in the process of wetland creation and stabilization; the increases in micro-elevation caused by their tightly clustered growths may help in the retention of sediment, water, and organic material, allowing colonizing plants to take root (Rice and Gibbs, 1995). Conversely, D. R. Franz, a researcher at Brooklyn College, investigated the idea that small berms created by ribbed mussels causes localized ponding that leads to the death of saltmarsh cordgrass and consequently salt marsh loss (Franz, 1982). Despite these conflicting theories, it is understood that the species is a major faunal biomass component in the Bay, potentially filtering large volumes of water daily (USFWS, 1997). The blue mussel (*Mytilus edulis*) almost exclusively found attached to piers, jetties and other structures, comprises a smaller proportion of the mussel population (USFWS, 1997).



Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Jamaica Bay is host to an abundance of horseshoe crabs. These crabs spend their lives in subtidal waters but require low-energy intertidal beaches with enough dissolved oxygen to lay their eggs (USACE, 2002). Expansive mudflats and remaining non-hardened shoreline areas function as important breeding areas for the crab, in turn providing vital foraging areas for migrating shorebirds that feed on horseshoe crab eggs in the late spring. It is believed that horseshoe crab spawning in the Bay as a whole is more limited by suitable habitat availability rather than water quality (USACE, 2002). The blue crab is

TABLE 4.9.2 Common Shellfish Found at Jamaica Bay

COMMON NAME	SCIENTIFIC NAME
Hard-shelled clam / northern quahog	*Mercenaria mercenaria*
Soft clam	*Mya arenaria*
Blue mussel	*Mytilus edulis*
American / eastern oyster	*Crassostrea virginica*
Blue crab	*Callinectes sapidus*
Horseshoe crab	*Limulus polyphemus*
Atlantic ribbed mussel	*Geukensia demissa*

Jamaica Bay's Oyster Fishery

At the turn of the 20th Century, 266 oyster boats operated from Canarsie, in Brooklyn. At its peak, Jamaica Bay is said to have produced up to 700,000 bushels of oysters per year (Franz, 1982). The Bay developed a reputation for shell fishing, with the Rockaway Oyster being especially popular. In 1906, an estimated four hundred fifty thousand tons of oysters and clams, valued at $2 million, were harvested. By 1917, sewage treatment plants in Queens and Brooklyn were discharging an average of fifty million gallons of inadequately treated waste into the Bay each day, poisoning clams, oysters, and ultimately people. The water became so polluted that in 1921 the City Department of Health abolished shell fishing in Jamaica Bay altogether, destroying both a major industry and a way of life (Seitz and Miller 2003).

TABLE 4.9.3 Common Fish Found at Jamaica Bay

COMMON NAME	SCIENTIFIC NAME
Atlantic silverside	*Menidia menidia*
Striped killifish	*Fundulus majalis*
Winter flounder	*Pseudopleuronectes americanus*
Atlantic menhaden	*Brevoortia tyrannus*
Bluefish	*Pomatomus saltatrix*
Striped bass	*Morone saxatilis*
Striped mullet	*Mugil cephalus*

another important shellfish species that utilizes the Bay for significant parts of its life cycle (Franz and Harris, 1985).

Fish

Highly productive estuaries like Jamaica Bay serve as important nursery areas and feeding grounds for marine, estuarine, migratory, and anadromous fish species (USFWS, 1997). The area supports some of the greatest numbers of fish species in the New York estuary system (Table 4.9.3), with up to 82% of individual species coming from the Atlantic to utilize the estuary for feeding, breeding and nursery habitat (Woodhead, 1991). During their initial life stages, juvenile fishes utilize salt marsh fringes and nearshore areas of higher turbidity as cover from predators and as productive feeding habitat.

Studies conducted to identify the dominant fish in Jamaica Bay found approximately 100 species with juveniles representing the dominant age group (USACE, 2005), confirming the Bay's importance as a nursery for fish. The juvenile Atlantic silverside (*Menidia menidia*) was found to be the most prevalent species caught while seining shallow water areas (USACE, 2002). Killifish (*Fundulus* sp.) species were the second most prevalent nearshore and fringe marsh fish species found in Jamaica Bay. These small, omnivorous, foraging fish species are important food sources for young predatory fish and wading birds.

Other fish species that have been found to utilize the shallow nearshore and salt marsh areas as nursery habitat include alewife herring (*Alosa pseudoharengus*), striped mullet (*Mugil curema*), and winter flounder (*Pleuronectes americanus*). Also regularly found are the Atlantic menhaden (*Brevoortia tyrannus*), bluefish (*Pomatomus saltatrix*), and striped bass (*Morone saxatilis*) (USACE, 2002). These three species of fish are of significant ecological and economic importance. Menhaden form a critical feeding link between plankton and two top predators in the Bay, striped bass and bluefish. Open-water trawls conducted in the Bay found that the winter flounder and summer flounder (*Paralichthys dentatus*) were the first and second most abundant species collected, respectively (USACE, 2002).

Birds

The Jamaica Bay watershed's varied geography provides diverse habitat for a large and varied number of bird species (Table 4.9.4). In addition to providing habitat for numerous permanent residents, the estuary is critical feeding, resting and breeding grounds for many migrating species along the Atlantic Flyway during the spring and especially in the fall (USACE, 2005). The Bay is providentially located at the crossroads of two migratory pathways for waterfowl. These Jamaica Bay-specific species may be classified into ten major groups: diving ducks, dabbling ducks, Brant geese, non-Brant geese,

Clapper Rail; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

ibis, herons and egrets, gulls, terns, skimmers, and shorebirds (Burger, 1982). Raptors and land birds are also significant in the upland watershed.

Migratory shorebirds that utilize Jamaica Bay estuary for breeding habitat include: killdeer (*Charadrius vociferous*), American oystercatcher (*Haematopus palliates*), willet (*Catoptrophorus semipalmatus*), spotted sandpiper (*Actitus macularia*), and American woodcock (*Scolopax minor*). Other birds known to nest on Bay islands are the common tern (*Sterna hirundo*), laughing gull (*Larus atricilla*), osprey (*Pandion haliaetus*), and clapper rail (*Rallus longirostris*) (USFWS, 1997). Additionally, Veit *et al*. (2002) identified six species including the clapper rail, willet, Forster's tern (*Sterna forsteri*), salt marsh sharp-tailed sparrow (*Ammodramus caudacutus*), seaside sparrow (*Ammodramus maritimus*), and boat-tailed grackle (*Quiscalus major*) that are salt marsh-dependent for their entire breeding season.

Intertidal habitats such as mudflats, salt marsh, and sandy shorelines are important feeding areas for the 22 species of shorebirds currently found in the Jamaica Bay estuary (Viet *et al.*, 2002). Shallow water areas also provide fishing habitat for wading birds including nine species of herons (USACE, 2002). Historically, 44 species of shorebirds had been identified in the Bay area. The dramatic reduction in the numbers of species of shorebirds is likely related to the destruction of their habitats in the Bay and throughout their migratory ranges.

Migratory waterfowl species such as the black duck (*Anas rubripes*), snow goose (*Chen caerulescens*) and Atlantic brant (*Branta bernicla*) use the open water areas of Jamaica Bay in the winter to congregate and feed during migration periods. Other, year-round "resident" species of

TABLE 4.9.4 Common Birds Found at Jamaica Bay

COMMON NAME	SCIENTIFIC NAME
Killdeer	*Charadrius vociferus*
Greater yellowlegs	*Tringa melanoleuca*
Osprey	*Pandion haligetus*
American brant	*Branta bernicla*
Herring gull	*Larus argentatus*
Great blue heron	*Ardea herodias*
Barn swallow	*Hirundo rustica*

TABLE 4.9.5 Birds at Risk in Jamaica Bay

LISTED	COMMON NAME	SCIENTIFIC NAME
Federally Endangered	Roseate tern Peregrine falcon	*Sterna dougallii* *Falco peregrinus*
Federally Threatened	Piping plover	*Charadrius melodus*
NYS Endangered	Least tern	*Sterna antillarum*
NYS Threatened	Northern harrier Osprey Common tern	*Circus cyaneus* *Pandion haliaetus* *Sterna hirundo*
NYS Species of Concern	Least bittern Cooper's hawk Upland sandpipier Short-eared owl Common barn owl Grasshopper sparrow	*Ixobrychus exilis* *Accipiter cooperii* *Bartramia longicauda* *Asio flammeus* *Tyto alba* *Ammodramus savannarum*

Jamaica Bay's Importance as Bird Habitat

An avian abundance study found 326 species of birds that use the Jamaica Bay Wildlife Refuge including confirmed breeding by 62 species (Mack and Feller, 1995; USFWS, 1997). The USFWS estimates that nearly 20% of North America's bird species migrate through or breed in the Jamaica Bay area (USACE, 2004).

waterfowl are the Canada goose (*Branta canadensis*) and mallard (*Anas platyrhynchos*) (USACE, 2005).

The Jamaica Bay estuary provides feeding and nesting habitat for the federally-listed endangered roseate tern (*Sterna dougallii dougallii*), and federally-listed threatened piping plover (*Charadrius melodus*), common tern, pied-billed grebe (*Podylimbus podiceps*), peregrine falcon (*Falco peregrinus*), and northern harrier (*Circus cyaneus*) (USACE, 2005; Mack and Feller, 1995) (Table 4.9.5). The salt marsh islands of the Bay are used by numerous heron and colonial waterbird species as a rookery.

Great Egret; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Impairments to migratory and resident bird populations in Jamaica Bay include habitat destruction and degradation through water pollution, noise, boat traffic, contaminated food sources and oil spills. Predation by introduced and nuisance species such as rats, feral cats, raccoons and gulls create problems for breeding bird populations. In earlier times, hunting, which is no longer allowed in the Bay, impacted some migratory bird species locally (Brody, 1998; West-Valle *et al.*, 1992). The loss of wetland habitat has significantly impacted some bird populations that require these areas for nesting and feeding.

Upland grasslands and scrub/shrub areas are also important bird nesting, cover and feeding habitat for a variety of neotropical migrant land-birds, raptors and a species of shorebird, the upland sandpiper (*Bartramia longicauda*). Habitat for these birds has been significantly diminished and degraded over time. The most numerous neotropical migrant is the barn swallow (*Hirundo rustica*), making up almost 50% of all birds in this group at some locations. Also often sighted are the willow flycatcher (*Empidonax traillii*) and yellow warbler (*Dendroica petechia*), both common breeders in the Jamaica Bay area.

Greater Yellowlegs; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

The rise in gull populations such as the herring gull (*Larus argentatus*), was likely due to nearby landfills providing a nearly unlimited food source. These birds can adversely affect the diversity and abundance of colonial waterfowl and shorebirds as they are known to raid nests and generally harass other birds (West-Valle *et al.*, 1992). Gull populations have been declining, due to recent landfill closings; however, they still comprise a significant portion of the bird population that causes major disruptions at JFK Airport (USNPS, 1999). The JFK complex is

TABLE 4.9.6 Common Mammals Found at Jamaica Bay

COMMON NAME	SCIENTIFIC NAME
Feral dog	*Canis familiaris*
Feral cat	*Felis silvestris*
Black rat	*Rattus rattus*
Raccoon	*Procyon lotor*
Gray squirrel	*Sciurus carolinensis*
House mouse	*Mus musculus*
Muskrat	*Odantra zibethicus*
Brown bat	*Myotis lucifungus*

located next to the Bay, causing conflict between goals of human safety and wildlife protection. Aircraft–bird collisions have led to the active management of gulls through habitat disruptions and shootings (USNPS, 1999). Two upland nesting birds found at JFK Airport and Floyd Bennett Field are the upland sandpiper (*Bartramia longicauda*) and the grasshopper sparrow (*Ammodramus savannarum*), both species of concern (NYSDOS, 1992).

Black Squirrel; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Despite continued stressors on bird populations and their habitat, there has been a noted increase in the numbers of ibises, egrets, herons, cormorants, and ospreys in the past few decades. Biologists attribute these increases to the effectiveness of the 1972 Clean Water Act (Brody, 1998).

Loss of Mammals

Almost 80% of the native mammals that historically inhabited the Jamaica Bay watershed have been extirpated as a result of centuries of human development of the region (USNPS, 2006). Elk, deer, and bear have given way to those animals that have adapted to near the urban environment (Black, 1981). Raccoon populations are now considered a nuisance due to their overabundance, which threatens the survival of native ground nesting bird species (USNPS, 2006).

Terrapin; Source: NYCDEP

Sea Turtles in Jamaica Bay

Several species of sea turtle have been observed in Jamaica Bay. These include the federally listed and endangered Kemp's ridley (*Lepidochelys kempii*) and leatherback turtles (*Dermochelys coriacea*). Several species are New York State listed and considered threatened, including the loggerhead (*Caretta caretta*), which is also listed as federally threatened, and green turtles (*Chelonia mydas*) (USACE, 2002).

Mammals

Although not rare in the greater bioregion, most mammals are rare in the urban core of the Jamaica Bay Watershed. The most typical mammal species observed in surveys (Table 4.9.6) consist of feral dogs and cats, rats and a mole and vole species found along shorelines and in adjacent grasslands (USFWS, 1997; USACE, 2002). Small rodents such as mice and voles are an important food base for the hawks and owls that frequent the Bay area. Raccoons are not uncommon but in large numbers can be considered a nuisance along with the undesired rat population. In addition, the opossum, cottontail rabbit, grey squirrel and several species of bat are also commonly identified in the Jamaica Bay watershed (USFWS, 1997; USACE, 2002).

The muskrat is the only mammal that makes the salt marsh its permanent home and whose presence is indicative of a healthy marsh ecosystem (Mack and Feller, 1990). Four species of bats, including the hoary bat and little brown myotis have also been identified in the Jamaica Bay watershed (USFWS, 1997). Several marine mammals are known to occasionally visit Jamaica Bay including the bottlenose dolphin (*Tursiops truncates*) and harbor seal (*Phoca vitulina*).

Reptiles / Amphibians

Several species of snakes, frogs, toads, salamanders and turtles live in the Jamaica Bay estuary and the greater watershed (Table 4.9.7). Extensive alteration of the historic landscape has impacted vital habitat and greatly reduced reptilian

/ amphibian diversity and abundance. There are plans to re-introduce several species to the Bay's wildlife refuge (USFWS, 1997). Many of the reptiles and amphibians are found in the vicinity of freshwater pools and stormwater outfalls due to physiological dependence on these remaining shallow freshwater areas for all or part of their life histories. The diamondback terrapin is an exception as it is adapted to a wide range of salinities, ranging the marine waters of the Bay and brackish waters of the tidal creeks for foraging and nesting. Their habitat includes both shallow waters and sparsely vegetated and sandy shorelines (USACE, 2002), which the terrapins utilize to lay eggs and sun themselves (Mack and Feller, 1990).

Invasive Species

Many plant and animal species in the Jamaica Bay watershed are living and reproducing outside of their native ranges. These non-native, exotic organisms are generally considered to be invasive species, although some native species may also be considered invasive. Many invasive organisms were deliberately brought to the region for food, fiber, landscaping purposes, or for the pet trade, while others arrived as contaminants in shipments of grain, in ballast water of ships, or as packing material. It is estimated that approximately 5,000 plant species introduced in the United States have escaped into the natural environment (Pimentel *et al.*, 2000). A small subset of these species actively and aggressively colonize new areas and pose risks to native ecosystems.

Along with habitat destruction and fragmentation, invasive species collectively rank as one of the top global threats to biological diversity in natural areas (Randall, 1995). They can affect multiple

TABLE 4.9.7. Common Reptiles and Amphibians Found at Jamaica Bay

COMMON NAME	SCIENTIFIC NAME
Northern brown snake	Storeria dekayi
Northern black racer	Coluber constrictor
Snapping turtle	Chelydra serpentine
Fowler's toad	Bufo fowleri
Green frog	Rans clamitans
Redback salamander	Plethodon cinereus
Bullfrog	Rana catesbeiana

Native vs. Non-Native vs. Invasive

Native species are identified as species that existed in a landscape prior to colonization or agriculture. Non-native and exotic species have been identified as species that have been introduced to an ecosystem by humans, either intentionally or non-intentionally. An invasive species can be identified as having the ability to thrive under adverse conditions. Invasive species can be native or non-native. Their ability to out-compete native organisms for limited sunlight, nutrients and space disrupts the natural balance of an ecosystem. Jamaica Bay is an excellent location for invasive species to find a home due to the high level of disturbance from land alteration and development, and an abundant seed-bank of exotic plants in residential gardens. (Biohabitats, Inc)

Common Reed

Common Reed can form monocultures in wetlands and crowd out native plants.

levels of biological organization (species, communities, ecosystems, and landscapes). These impacts include changes in ecosystem structure and function, species extinctions, species declines, and changes in community composition. The most fundamental effects are alterations of ecosystem structure and function. Problems that arise from invasive species are sometimes permanent (at least in human time scales) and may be the most pervasive influence on biological diversity in many systems (Coblenz, 1990). The Gateway National Wildlife Refuge has a goal to surpass or eradicate exotic invasive species in selected areas to ensure pockets of high biodiversity.

The most significant invasive plant species found in the wetter portions of the Jamaica Bay watershed is common reed (*Phragmites australis*). This species produces large quantities of seeds and also spreads vegetatively by sprouting new growth from its roots. *Phragmites* has a native form although the non-native form is much more aggressive, readily invading disturbed, wet areas such as degraded wetlands, roadside ditches, and even piles of dredged material. While it is typically found in areas of standing fresh water, it can tolerate moderate salinities (up to 18 ppt) and forms dense monocultural stands, suppressing and killing native vegetation (Byer *et al.* 2004).

Phragmites; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Purple loosestrife (*Lythrum salicaria*) is a very attractive freshwater wetland plant imported from Europe as an ornamental in the late 19th century. It can take over freshwater marshes and crowd out native plant species, drastically altering wetland composition and structure. This plant has spread throughout the US in freshwater wetland habitats, especially throughout the Northeastern states. It is of no threat to waters with any salinity. Because Jamaica Bay has so few remaining freshwater wetlands areas, it is currently not threatened by purple loosestrife, but it is worth noting that any freshwater restoration efforts in the watershed will have to contend with this plant.

The Jamaica Bay watershed currently has substantial populations of invasive shrubs and trees, including tree of heaven (*Ailanthus altissima*), Oriental bittersweet (*Celastrus orbiculatus*), Japanese knotweed (*Polygonum cuspidatum*), Japanese barberry (*Berberis thunbergii*), and autumn olive (*Eleagnus umbellata*). These species rapidly invade remnant patches of native forest. Garlic mustard (*Alliaria petiolata*) is an herbaceous perennial that rapidly invades shrublands, woodlands, and forests. All of these species tend to crowd out native plant species and compromise wildlife habitat.

The Jamaica Bay watershed harbors a number of invasive, non-native animal species, including Norway rat (*Rattus norvegicus*), black rat (*Rattus rattus*), feral cat (*Felis silvestris*), and feral dog (*Canis familiaris*). Feral and house cats are estimated to kill over one billion birds annually in the U.S. (Stallcup, 1991). The mute swan (*Cyngus olor*) is a European species of waterfowl that is territorially aggressive and threatens nesting native waterfowl (Mockler, 1991).

Two native mammals have successfully exploited their proximity to the human environment and become invasive nuisance species. The opossum (*Didephis virginiana*) and the raccoon (*Procyon lotor*) have been targeted for further research by the NPS at Jamaica Bay. These animals are considered nuisances in the area due to their large numbers, with raccoons threatening the eggs of reproducing terrapins and birds around Jamaica Bay.

The ribbed mussel (*Geukensia demissa*) is a native invasive invertebrate that can achieve densities up to 10,000 individuals per square meter in Jamaica Bay (Cohen, 2005). Researchers have speculated that berms formed by large numbers of ribbed mussels create ponds of salt water on top of salt marsh islands, leading to salt marsh cordgrass death and the further erosion of salt marsh islands (Franz and Friedman, 2004).

4.10 CURRENT ECOLOGICAL RESTORATION EFFORTS IN JAMAICA BAY

In the last century there has been a growing recognition of water quality, ecosystem, and human use impairments, and an awareness that the rate of degradation is linked with population growth and development in the Jamaica Bay watershed. In response, regulatory agencies in New York City, New York State and the federal government with vested interests in the environmental health of Jamaica Bay have begun to implement programs to curb known and anticipated environmental impacts. Most of this work has been driven by local, state, and federal legislation geared towards environmental preservation and improvement in conjunction with local non-governmental organizations' interest in environmental health and a greater public awareness of and interest in ecological sciences.

Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

At first, many of these efforts were focused on improving water quality in Jamaica Bay, with the recognition that the impaired shellfisheries were the result of untreated urban sewage and industrial contamination. Later, as the ecological sciences became better understood, a heightened awareness of the importance and value of wetlands and their relevance as vital fish and wildlife habitat spurned an interest in halting landfilling operations and restoring remaining wetland areas. Unfortunately, water quality conditions in the Bay were severely degraded, most of the valuable upland and shoreline habitat areas were already gone, lost to urban infrastructure, and more than 75% of the wetlands had disappeared.

Currently, there are multiple agencies working to improve water quality in the Jamaica Bay estuary and conserve and restore critical habitat areas. Much has been accomplished, including an enormous effort to improve environmental data collection and research and the integration of the resulting information into ongoing mitigation programs. Habitat restoration/conservation efforts include mitigating landfills, restoring wetlands,

> *"The solution seems to lie in giving local communities control over local resources so that they have the right and responsibility to rebuild nature's economy and, through it, their sustenance."*
>
> *- Dr. Vandana Shiva*

managing threatened or endangered fish and wildlife, and addressing exotic species.

A number of sites have been acquired and are afforded protection as designated New York State Parks or New York City Parks. The New York City parks include Dubos Point, Norton Basin, Brandt's Point, Four Sparrows Marsh, Spring

Vernam/Barbados Peninsula; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Creek, much of Fresh Creek, Conch Point, Paerdegat Basin, the Vernam Barbadoes Peninsula (locally Terrapin Point) and Bayswater State Park. However, some areas have been lost to development, such as the Vandalia Dunes. According to the RPA (2003), "Land preservation in Jamaica Bay, with a few exceptions such as some Arverne/Edgemere watershed sites, is virtually complete…" In addition, a number of significant restoration projects have been implemented by the NYCDEP including the Pennsylvania Avenue and Fountain Avenue Landfills and Idlewild Park projects; by the New York City Department of Park and Recreation (NYCDPR) National Resources Group (NRG) at Dubos Point Wildlife Sanctuary, Four Sparrow Marsh, Fresh Creek, Spring Creek and Marine Park; and the NPS's Big Egg Marsh project. The most substantial project, which has recently been initiated, is the USACE's 60-acre Elder's Point marsh island restoration. Additional information on these restorations is provided below.

Over the course of the past 20 years a large number of other acquisition and restoration sites have been identified throughout Jamaica Bay by a variety of knowledgeable federal, state, city and non-governmental entities. Various reports have considered a range of sites and over time they seem to encompass the same sites that were previously considered. This is not unexpected since there are limited opportunities for identifying new sites within the confines of the Jamaica Bay waterfront. Non-governmental organizations have also played a very important role in identifying land acquisition and restoration sites, most notably the Jamaica Bay Ecowatchers, Tree Branch Network, American Littoral Society and the New York City Audubon Society.

NYCDEP is actively restoring and designing complex environmental restoration projects along the perimeter of Jamaica Bay that will provide substantial wildlife habitat and stormwater quality benefits. Some restorations may not appear to cover large land areas; however, it is important to note that the cumulative incremental improvements and spatial distribution associated with each of these projects adds significantly more ecological value than if they were simply isolated restorations with little geographic connectivity. In addition to the substantial ecological benefits

Bayswater State Park; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

provided, some projects are associated with infrastructure improvement projects that are designed to further remediate the harmful effects of past landfilling activities, provide for the capture and treatment of CSOs and provide effective stormwater management to alleviate street flooding within several communities in the southeast section of the watershed. Each of these restorations were developed using appropriate

specifications and designs that incorporate the latest ecological information for the targeted ecosystems. In addition, the species for these projects were selected based on their ecological plant community associations and environmental setting (coastal) to provide much greater ecological value, sustainability and biodiversity than simply placing individual and "out of context" specimens. The plant species were also selected to help re-establish extirpated or less common indigenous coastal flora that have been absent from much of the NYC region since the early 20th Century. The use of appropriate soils that favor the growth of these coastal communities was a key element in the design that will provide long-term sustainability and significantly reduce the potential for the colonization of exotic plant species. This ecosystem approach provides the greatest habitat potential and function and ensures the long-term stability of the restorations by enabling substantial buffering capacity against invasive plants and changes as a result of natural environmental variations. Each of these restorations significantly contributes to improving the ecology of the Bay by restoring degraded lands into productive wildlife habitats, and increasing both plant biodiversity and the natural attenuation of stormwater through evapotranspiration and ground water infiltration. Because of their size and spatial distribution within the landscape, the positive cumulative feedback effect from each of these restorations is further enhanced.

The following provides a brief summary of each of these NYCDEP restorations.

Idlewild Park

The ecological restoration of Idlewild Park was part of a major sewer infrastructure improvement project to reduce street flooding in the southeast and northeast sections of the watershed. Idlewild is situated within the critically important headwaters of Jamaica Bay. Completed in 1997, this project restored 16-acres of indigenous coastal grasslands and woodlands, 5-acres of tidal wetlands and 2.5-acres of freshwater wetlands. As a result of this restoration, the park now has the highest density of *Amelanchier canadensis* (Canadian, shadbush, serviceberry) of any location within the city. NYCDEP maintains an active presence in restoring additional sections of the park through its association with the Eastern Queens Alliance (EQA) and NYCDPR's Natural Resources Group (NRG).

NYCDEP has participated in student planting projects organized by the EQA and is assisting with the groups Master Plan efforts for the continued environmental restoration of the 110-acre park and for expanded community use of this valuable local natural resource. The NYCDEP continues to issue vegetation management contracts to control invasive plants and to restore additional areas. When feasible, restoration requirements from other projects that are not possible at the site of disturbance are directed to Idlewild Park to help expedite the restoration process.

Paerdegat Basin

The ecological restoration of Paerdegat Basin is associated with the NYCDEP's current efforts to treat and capture CSOs to improve water quality within the basin. The construction of a 20-million gallon CSO storage tank with an additional capacity of 10-million gallons of in-line (pipe) storage will capture sanitary wastewater and stormwater during rain events for subsequent processing and treatment at the Coney Island WPCP after the rain event. The ecological restoration component of this project is currently in the design stage and has an expected construction start date of mid to late 2009. Highlights of this project include the restoration of 15 to 20-acres of tidal wetland, 40 to 50-acres of an indigenous coastal grassland/shrubland and a 6-acre Ecology Park. Additional restoration and enhancement of these acreages is expected should USACE's Jamaica Bay Ecosystem Restoration Project (JBERP) receive funding from Congress. The Ecology Park will be designed to showcase many of the ecosystems present within New York City and will enable a close-up view of these communities. The NYCDEP expects the Ecology Park to be an important environmental tool in helping area residents to gain an understanding of

the many ecosystem types found within New York City and the important role they have in maintaining a delicate ecosystem.

Springfield Gardens

As with the Idlewild project, this restoration is associated with NYCDEP's current efforts to alleviate flooding in southeast Queens. Some of the restoration areas overlap with the Idlewild restoration and provide a more contiguous restoration. The project has already restored 2-acres of tidal wetland and 2-acres of indigenous coastal woodlands. We expect that an additional two acres of tidal wetland and coastal grasslands will be restored by the end of 2007.

Innovative "Bluebelt" designs are currently being developed to improve Springfield Lake and the downstream tidal channel that is connected to Thurston Basin. The re-grading of the lake shoreline, invasive plant removal and the planting of freshwater wetland plants will help to restore much of the lost ecological function of this important community resource. The restoration of the tidal channel will allow greater tidal flushing for improved water quality to the backwaters of Jamaica Bay. The design of this project is consistent with the goals of the Master Plan for Idlewild Park currently being developed by the EQA.

Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Hendrix Creek Bond Act Restoration

With partial funding from the New York State Clean Water/Clean Air Bond Act, this project will include 0.25-acres of tidal wetland restoration and 0.8-acres of a coastal woodland buffer. This restoration complements the much larger upland restoration of the Pennsylvania Avenue Landfill and will provide a much greater ecological benefit with the vastly improved upland habitats and wildlife corridors of the landfill. Work on this project is expected to begin in fall 2007. The NYCDEP continues to pursue additional funding from a variety of other sources and grant programs for the restoration of additional locations around Jamaica Bay.

Thursby Avenue Wetland Restoration

This project will include 0.4-acres of tidal wetland restoration and 0.4-acres of a coastal woodland buffer along the shoreline of Sommerville Basin. Using the fishing piers constructed at the Edgemere Landfill by the Department of Sanitation New York (DSNY), partial public access to this restoration site is permitted. Work on this project is expected to begin late spring 2007.

Pennsylvania and Fountain Landfills

NYCDEP is responsible for the remediation and closure of two inactive hazardous waste sites, the Pennsylvania Avenue and Fountain Avenue landfills on Jamaica Bay. Although not required as part of the remediation, due to the location of these landfills within a sensitive environmental area, the NYCDEP took a proactive lead stewardship role in developing an innovative and comprehensive ecological restoration plan for these properties that would be consistent with and enhance the existing natural features of Jamaica Bay. In addition, the ecologically sound end-use design plan, with input from local community groups also considered future passive public uses in the post landfill remediation phase.

The landfills represent the largest restoration of this type undertaken in New York City in over 100 years and will provide significant habitat improvements for Jamaica Bay. The planting plan includes over 40 native tree and shrub species and over 30 forb (wildflowers) and graminoid

(grasses) species. To ensure that a sufficient number of plants would be available for the planting phase of the project, NYCDEP initiated a contract growing program at several area nurseries three years ago for the approximately 35,000 trees and shrubs that will be needed for the restoration. The contract growing of these plants enabled NYCDEP to use local provenance plant material that is better acclimated to our soil and climate conditions and ensures the dissemination of local genotypes. This plan also enabled the use of plants that are not readily available in the nursery trade. The use of seed grown plants has been maximized to the greatest extent possible to increase the genetic diversity of the planting.

The first planting began at the Pennsylvania Avenue Landfill in spring 2006 and the first plant will arrive at Fountain Avenue Landfill in spring 2007. Because of the large size of the total restoration area and the number of plants, in time the landfills will become a regional seed source to disseminate the new species to other parts of the New York City metropolitan area. The actual restoration limits can extend far beyond the physical restoration.

The following components used for the landfill restorations should be considered when developing future coastal upland restoration projects around the Bay:

A land ethic...reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land. Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity.

- Aldo Leopold

- Initiate contract growing of most plant materials
  - Maximize the use of seed grown plants
  - Limit the use of cuttings when seed germination is difficult or slow
- Develop soil sample collection program for analysis from existing plant communities targeted for restoration to closely "mimic" natural soil conditions of proposed plant communities:
  - higher sand content soils
  - low organic matter
  - low nutrients
  - low pH
- Use smaller plant material that will acclimate faster to the site and grow healthier
- Use varying sizes of same species to "mimic" a natural and uneven aged stand
- Use high wildlife value and low maintenance warm-season grasses over conventional low wildlife value and high maintenance cool-season lawn grasses
- Select appropriate plant material for site and existing environmental conditions (aesthetics should be considered least)
- Specify tight seasonal windows for various planting types
- Limit provenance of plant material to within a 150-mile radius of the planting site
- Species specific mycorrhizal fungus soil inoculation to help restore soil biological diversity and activity (this should not used in intact natural systems)
- Landscape subcontractor minimum qualifications

Restoration projects recently completed by NYCDPR include the restoration of Four Sparrow Marsh. Four Sparrow Marsh restored nearly 3-acres of tidal wetlands, a 0.7-acre woodland buffer, and removed invasive vegetation, anthropogenic soils and shoreline debris. The restoration of Gerritsen Creek is included under JBERP, but has been selected out as a separate project with an individual timeline because this

project also has funding from the New York State Clean Water/Clean Air Bond Act. A description of this restoration is outlined below.

Under the JBERP, for which NYCDEP is the local matching grant sponsor, a team of federal, state and local agency ecologists, biologists and other environmental professionals reviewed approximately 50-sites around the Bay for their restoration potential. After a careful review by this professional team, a number of larger restorations sites were identified that afforded the opportunity of restoring and enhancing multiple ecosystem types to maximize ecological biodiversity.

Although not currently authorized for funding by Congress, a brief summary of the proposed restoration efforts from JBERP Conceptual Plan are as follows.

Dead Horse Bay – The restoration of this site will include removal of anthropogenic fill-derived soils and invasive plant control, placement of ecosystem appropriate soils for the restoration of coastal dune and maritime forest habitats and to discourage the re-introduction of invasive plants, the re-grading of the shoreline to establish correct tidal wetland low marsh elevations for the planting of *Spartina alterniflora* and high marsh planting of *Spartina patens* and other high marsh plants.

Gerristen Creek; Photograph by Ralph McClurg, O'Brien & Gere

Gerristen Creek – Removal of anthropogenic fill-derived soils and invasive plant control, placement of ecosystem appropriate soils for the restoration of approximately 8-acres of coastal grassland and shrubland habitats and to discourage the re-introduction of invasive plants, the regrading of the shoreline to establish correct tidal wetland low marsh elevations for the approximate 8-acre planting of *Spartina alterniflora* and appropriate high marsh elevations for the approximate 0.5-acre planting of *Spartina patens* and other high marsh plants.

Fresh Creek; Photograph by Ralph McClurg, O'Brien & Gere

Paerdegat Basin – The restoration of this site under JBERP will supplement the restoration currently being designed as part of the Paerdegat Basin CSO project and includes the removal of anthropogenic fill-derived soils and invasive plant control, placement of ecosystem appropriate soils for the restoration of approximately 2.5-acres of coastal meadow and approximately 46-acres of coastal scrub/shrub habitats and to discourage the re-introduction of invasive plants, the regrading of the shoreline to establish correct tidal wetland low marsh elevations for the approximate 26-acre planting of *Spartina alterniflora* and appropriate high marsh elevations for the approximate 6-acre planting of *Spartina paten* and other high marsh plants.

Fresh Creek - Removal of anthropogenic fill-derived soils and invasive plant control, re-contouring of tributary bottom for increased tidal flushing, placement of ecosystem appropriate soils for the restoration of approximately 42-acres of coastal scrub/shrub and restoration of approximately 108-acres of maritime forest habitats and to discourage the re-introduction of invasive plants, the regrading of the shoreline to establish correct tidal wetland low marsh elevations for the approximate 36-acre planting of *Spartina alterniflora* and appropriate high marsh

elevations for the approximate 12-acre planting of *Spartina patens* and other high marsh plants.

Spring Creek - Removal of anthropogenic fill-derived soils and invasive plant control, placement of ecosystem appropriate soils for the restoration of approximately 42-acres of coastal dune and restoration of approximately 120-acres of maritime forest habitats and to discourage the re-introduction of invasive plants, the regrading of the shoreline to establish correct tidal wetland low marsh elevations for the approximate 25-acre planting of *Spartina alterniflora* and appropriate high marsh elevations for the approximate 9-acre planting of *Spartina patens* and other high marsh plants.

Elder's Point Marsh; Photograph by Don Riepe, Jamaica Bay Wildlife Refuge

Hawtree Point - Removal of anthropogenic fill-derived soils and invasive plant control, the placement of ecosystem appropriate soils for the restoration of approximately 2-acres of coastal scrub/shrub habitat and to discourage the re-introduction of invasive plants, the regrading of the shoreline to establish correct tidal wetland high marsh elevations for the approximate 0.06-acre planting of *Spartina patens* and other high marsh plants.

Bayswater State Park - Removal of anthropogenic fill-derived soils and invasive plant control, placement of ecosystem appropriate soils for the restoration of approximately 1-acre of coastal dune habitat and to discourage the re-introduction of invasive plants, the regrading of the shoreline to establish correct tidal wetland low marsh elevations for the approximately 3-acre planting of *Spartina alterniflora* and appropriate high marsh elevations for the approximate 0.5-acre planting of *Spartina patens* and other high marsh plants.

Dubos Point - Removal of anthropogenic fill-derived soils and invasive plant control, placement of ecosystem appropriate soils for the restoration of approximately 2-acres of maritime forest habitat and to discourage the re-introduction of invasive plants, the regrading of the shoreline to establish correct tidal wetland low marsh elevations for the approximate 3.5-acre planting of *Spartina alterniflora* and appropriate high marsh elevations for the approximate 1.0-acre planting of *Spartina patens* and other high marsh plants.

Brant Point - Removal of anthropogenic fill-derived soils and invasive plant control, placement of ecosystem appropriate soils for the restoration of approximate three acres of maritime forest habitat, three acres of coastal meadow habitat and to discourage the re-introduction of invasive plants, the re-grading of the shoreline to establish correct tidal wetland low marsh elevations for the approximate 2-acre planting of *Spartina alterniflora* and appropriate high marsh elevations for the approximate 1.0-acre planting of *Spartina patens* and other high marsh plant.

Elders Point Salt Marsh Islands - The Marsh Islands ecosystem is an integral part of Jamaica Bay, which has been targeted for restoration by the USACE, the Port Authority, NPS, NYCDEP, NYSDEC, the Natural Resource Conservation Service (NRCS), and Harbor Estuary Program (HEP). The restoration effort is being led by the USACE and will be monitored by the agencies to ensure that this and future restoration efforts in

Jamaica Bay provide long-term environmental benefits to the estuary.

Elders Point is comprised of two separate islands, Elders Point East and Elders Point West, that total approximately 21 vegetated acres. Originally, one island comprised of approximately 132 acres, the loss of marsh in the center portion severed the two ends, resulting in two separate islands connected by mudflat. The restoration plan for Elders East and Elders West includes restoring the existing vegetated areas and the sheltered and exposed mudflats by placing fill material up to an elevation that is suitable for low marsh growth. This includes hand planting more than 700,000 plants on Elders East and replanting more than 200,000 plants on Elders West. On Elders East, *Spartina alterniflora (*saltmarsh cordgrass) will be planted throughout the low marsh zone of the site. A mixture of *Spartina alterniflora (*saltmarsh cordgrass), *Spartina patens (*salt hay), and *Distichis spicata* (spike grass) will be planted in the elevation zones between the low marsh and upland. Fill material will be placed between the existing vegetation in such a manner as to avoid damage to the existing vegetation. A no-planting area covering approximately five acres on the southeast side of Elders West will be established to evaluate project progress. Saltmarsh cordgrass will be planted throughout the remainder of the site.

In 2006, seed for the replanting was collected, processed and stored in facilities operated by the NRCS. The seed was germinated and grown and planting has begun at Elders Point East. To facilitate planting at Elders Point West, additional seed is currently being collected, processed and stored for planting next spring. The NRCS is overseeing the growing at their Plant Materials Centers in Cape May, NJ, Beltsville, MD, Lansing, MI and Alderson, WV. In March 2006, the Corps awarded a $13 million contract for the Elders Point (East) Island Restoration in Jamaica Bay, to Galvin Brothers of Great Neck, NY. To re-contour Elders Island, the Corps is pumping more than 300,000 cubic yards of sand that was dredged from various channels in the harbor. Once tidal flow to the areas has been reestablished, water and sediment quality will be improved, promoting the return of native fish and wildlife.

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