7.2 Investigations into Recent Salt Marsh Losses in Jamaica Bay, New York

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7.2.1 INTRODUCTION AND OBJECTIVES

Coastal salt marshes of the northeastern United States, including those of New York City, Long Island and northern New Jersey, formed within the last 2000 to 6000 years, as the post-glacial rise in sea level slowed. Within the last 100-150 years, however, the marsh-building process has reversed in a number of locations, possibly linked in part to the recent acceleration of sea-level rise, relative to trends of the last few thousand years (Varekamp and Thomas, 1998; Kearney, 1996). This recent tidal wetland loss through erosion, submergence and related processes is well-documented in Louisiana, Chesapeake Bay, and elsewhere (e.g., Boesch et al., 1994; DeLaune et al. 1994, and Wray et al., 1995). However the phenomenon has not been reported from the New York metropolitan region. Field studies conducted as part of the JBERRT project during the summer of 2000 reinforces our initial findings in the Metro East Coast regional report prepared for the U.S. National Assessment of Climate Variability and Change (U.S. Global Change Research Program) that sections of Jamaica Bay salt marshes in New York City are currently in an erosive state (Hartig, 2001; Hartig, et al., 2001).

In this study, as part of the Goddard Institute for Space Studies/Columbia University contribution to the JBERRT project, selected salt marsh islands were examined on the ground in order to field check previous remote sensing observations, and to obtain additional data on *Spartina alterniflora* productivity. These data were collected in order to compare with regional marsh vegetation growth, to measure interannual variability, and to establish a preliminary baseline against which future changes can be assessed. Field work included measurements of *Spartina alterniflora* above-ground biomass, a survey of marsh vegetation distribution along transects, placement of feldspar horizon markers, and documentation of biogeomorphological indicators of salt marsh degradation.

7.2.2 STUDY AREA

7.2.2.1 Overview

This report concentrates on island salt water marshes of Jamaica Bay, one of the largest remaining coastal ecosystems in the New York City area. Jamaica Bay encompasses the Jamaica Bay Wildlife Refuge (JBWR), established in 1948 by New York City Department of Parks and Recreation and included by legislation since 1972 in the Jamaica Bay Unit of Gateway National Recreation Area (GNRA), National Park Service (Tanacredi and Badger, 1995). Located near John F. Kennedy International Airport, the geographical coordinates of Jamaica Bay are 41° N, 74°W (Figure 7.2-1).

The Jamaica Bay Unit of Gateway includes uplands, wetlands, and waters south of the Belt Parkway in Brooklyn and Queens. Although most of the island marshes lie within the Jamaica Bay Wildlife Refuge, inside GNRA, some fringing bay marshes are located outside the boundaries of the refuge and the GNRA. Jamaica Bay is a lagoon with diverse habitats including open water (littoral zone), coastal shoals, bars, mudflats, intertidal low to high marshes, and upland areas.

JBWR provides prime habitat for migratory birds. The intertidal mudflats are principal feeding grounds for migratory shorebirds such as Black Skimmers, plovers, and knots (Tanacredi and Badger, 1995). The Bay is also a major wintering ground for Brant, Mallards, American Black Duck, Canvasback Duck, and other waterfowl. Other wildlife, such as reptiles, amphibians, and small mammals can be found at JBWR (Tanacredi and Badger, 1995).

Much of the original tidal wetlands of Jamaica Bay have disappeared due to human activities for infrastructure development. Jamaica Bay in 1900 encompassed 24,000 acres (9717 hectares) of waters, marsh islands, as well as an extensive network of shoreline marshes extending beyond today's Belt Parkway (Englebright, 1975). Marshes covered an estimated 16,170 acres (6549 hectares). Bay waters covered 7,830 acres (3170 hectares) much of it shallow channels averaging 3 feet (1 meter) in depth. By 1970, total acreage with remaining shoreline marshes covered 13,000 acres (5263 hectares) of which 4000 acres (1619 hectares) were marshland. Waters covered approximately 9000 acres (3642 hectares), much of it dredged for filling (e.g. Grassy Bay) or for navigation maintained to depths greater than 30 feet (10 meters).

7.2.2.2 Salt Marsh Ecology

Salt marsh vegetation forms distinct zones in response to a combination of biophysical factors. At lower elevations, species composition is largely governed by physical and chemical forces. At higher elevations, interspecific competition determines the plant community (Bertness 1991a). Along the Atlantic Coast, Spartina alterniflora (salt marsh cordgrass), the dominant plant species of the low marsh intertidal zone, provides food and shelter for wildlife and physical structure (for peat accretion) to the marsh. It is replaced by the high marsh species *Spartina patens* (salt hay) at mean high water (MHW, Bertness 1991b). Flooding is less frequent in the high marsh portion of the intertidal zone. *S. patens* is rarely found in the low marsh, where oxygen flow to its rhizomes becomes limited by frequent inundation. On the other hand, *S. alterniflora* is restricted from the high marsh by *S. patens* competition. *Salicornia virginica* (glasswort) can also be present in the low marsh (Bertness and Ellison, 1987). Floristically, the high marsh is much more diverse than the low marsh, although all are halophytes–plants adapted to saline environments. The drier high marsh zone contains species such as *Juncus gerardii* and *Distichlis spicata*. *Iva frutescens* (high tide bush) and *Phragmites australis* (common reed) are found in the highest regions of the marsh.

Frequency of tidal flooding is the dominant factor in determining species location (Bertness 1991b). The high correlation between inundation time and zonation permits changes in salt-marsh plant community zonation to be used as sensitive indicators of sea-level rise. Wetland plant communities respond to sea-level rise by shifting from high to low marsh, to coastal shoals, and finally to mudflats, and also by migrating inland. On an unobstructed coastal plain, upland habitat will be ultimately converted to salt marsh. In the New York metropolitan area, extensive development limits opportunities for salt marsh migration onto adjacent upland or freshwater zones (e.g., Blanchard and Burg, 1992).

7.2.2.3 Sea-Level Rise and Accretion Rates

Rates of local sea-level rise (SLR) in the region range from 2.2 mm/yr in Port Jefferson, Long Island to 3.94 mm/yr at Sandy Hook, New Jersey. The rate of SLR at Jamaica Bay is around 2.76 mm/yr, based on tide gauge data (1856-1999) from Battery Park in Manhattan (Figure 7.2-2). Regional SLR trends exceed the mean 20th century global SLR of ~1.5 mm/yr, due in part to the recent global warming, and, in part, to local subsidence resulting from crustal readjustments to the removal of ice following the last glaciation (Gornitz, 2001; Gornitz et al., 2001).

Coastal salt marsh accretion in this area is generally fast enough to keep up with present rates of sea level rise. As can be seen from Table 7.2-1, which lists published data for the intertidal zone in Connecticut and New York, accretion rates generally equal or exceed local sea level rise trends. The only measurement of marsh accretion at Jamaica Bay was 8 mm/yr for the low marsh; that for high marsh was 5 mm/yr (Zeppie, 1977). These values lie near the upper range of the regional values (Table 7.2-1). However, the sampling covered a period when accretion may have been anomalously high due to dredging and filling activity associated with construction of John F. Kennedy International Airport, landfills (e.g., Penn and Fountain Avenue, and Edgemere landfills), residential development, and uncontrolled outfall from sewage treatment plants and combined sewage overflow (CSO). New, stricter environmental controls (in addition to landfill closure and completion of major construction activities around the Bay) have likely reduced the inorganic (sediment) accretion rate. The actual accretion rate at Jamaica Bay has not been measured since Zeppie's 1977 study, and new determinations are urgently needed.

7.2.3 PREVIOUS WORK

To determine changes in land extent of Jamaica Bay marshes, three sets of historic aerial photographs covering a central section of Jamaica Bay from 1959 to 1998, were analyzed, using stereopairs with greater than 60% overlap. Measurements of marsh area on aerial photographs for three island salt marshes (Yellow Bar Hassock, Black Wall Marsh, and Big Egg Marsh), revealed discernable land losses on island peripheries and expansion of tidal creeks. Table 7.2-2 summarizes acreage and percent land remaining since 1959 (Hartig et al., 2001). These three island marshes showed an average 12% reduction in landmass between 1959 and (Table 7.2-2; Figure 7.2-3). Inasmuch as the 1959 data were collected during high tide, when most of the marsh was inundated, the percent reductions calculated from later photographs, taken at mid to low tide, are considered to be conservative estimates.

In related work, the New York State Department of Environmental Conservation (NYSDEC) used Geographic Information System (GIS) analysis of digitized navigation charts and topographic maps dating from 1900, as part of their tidal wetlands mapping inventory for regulatory purposes. Based on more extensive aerial photo-coverage, they find even more significant marsh losses and accelerating erosion trends (Fred Mushacke, Dave Fallon, NYSDEC, priv. comm; see also:www.dec.state.ny.us/website/dfwmr/marine/twloss.html.).

7.2.4 METHODOLOGIES

7.2.4.1 Selection of Study Sites

Of more than 15 named island salt marshes in Jamaica Bay, three relatively undisturbed marshes were selected for detailed field observations and vegetation sampling. The three study sites include: 1) Big Egg Marsh, 2) Rulers Bar Hassock, bordering on upland zones associated with the Broad Channel Island community the Jamaica Bay Wildlife Refuge, and 3) Yellow Bar Hassock. Adjacent to Rulers Bar Hassock Marsh are the uplands dominated by shrubs and thickets including extensive stands of Northern Bayberry (*Myrica pennsylvanica*) within the Jamaica Bay Wildlife Refuge. Yellow Bar Hassock and Big Egg are peat-rich marshes with extensive meandering tidal channels, whereas Rulers Bar Hassock is a sandy shore tidal marsh with limited channel inlets. All three marshes are dominated by *Spartina alterniflora*. The mean tidal range (difference between mean high and mean low water) for Jamaica Bay is typically 1.6 meters (5 feet).

7.2.4.2 Geomorphological Investigations.

Noting that significant changes in marsh size had occurred between 1959 and 1998 from a survey of aerial photographs, field work during the summer of 2000 focused on documenting additional ground evidence of salt marsh transformations. This latest effort expanded upon the work of the previous summer, which had begun a photographic survey and classification of erosive landforms.

Feldspar markers. In addition, an attempt was made to measure marsh accretion, using the well-established methodology of feldspar horizon marker plots (Richard, 1978). A layer of white feldspar grains (particle size in fine sand range, 0.625 to 1mm), several millimeters thick was spread over each test plot, and the locations marked with flags.

7.2.4.3 Vegetation Sampling

Biomass data collection. Measurements of *Spartina alterniflora* standing crop biomass were taken from the middle to close to the end of the growing season, July through October, 2000. Such baseline data collection was conducted in order to: 1) determine above-ground *Spartina alterniflora* biomass in Jamaica Bay and to compare with data from the previous year, 2) compare with regional values, and 3) evaluate the effects (if any) of recent erosion and inundation on salt marsh grass growth. Below-ground production also contributes to vertical accretion and soil organic matter (Reed, 1995); however, this study was limited to above-ground production--a frequently used measure of vegetation status (e.g., Bertness, 1991; Nixon and Oviatt, 1973).

At the three marsh sites in Jamaica Bay (Big Egg Marsh, Rulers Bar Hassock, and Yellow Bar Hassock), quadrats were placed 50 feet apart along linear transects for sampling (Figure 7.2-1, see insets A, B, and C). On Yellow Bar Hassock, transects were conducted with the aid of a compass from the point where the field team disembarked from the National Park Service boat, on the south side of the island, heading northwest, facing the World Trade Towers in Manhattan, up to a large tidal channel, which prevented further sampling (see Fig. 1, inset A). Shoreline transects at Rulers Bar Hassock were traversed, eastward starting at the most seaward vegetated zone accessible by foot, to the wetland-upland boundary (Figure 7.2-1). At Big Egg Marsh (Figure 7.2-1), the traverse went from upland boundary toward a tidal channel in a northwesterly direction. Within preselected swaths based on accessibility, transect starting locations were randomly selected. Transects were conducted at least twice within the growing season at each marsh. In the summer of 2000, the three sites were sampled over two periods, the first between July and August, and then again in October. For each transect, species composition was recorded in 1m^2 quadrats; *Spartina alterniflora* was clip-harvested from a 0.25 m^2 corner of each plot. Collected material was dried to constant weight at 105^{o} C (e.g., Nixon and Oviatt, 1973).

Species composition. Species composition at Big Egg Marsh, Rulers Bar Hassock and Yellow Bar Hassock was recorded from 1m^2 plots during transect sampling procedures. Additional species observed during a field survey at Jo Co Marsh were also recorded. Species were listed on field data sheets (summarized in Table 7.2-3). They are listed according to the frequency with a species occurs in a wetland versus upland setting.

7.2.5 RESULTS

7.2.5.1 Geomorphologic Changes

Geomorphological characteristics of marsh loss observed at Jamaica Bay include island perimeter erosion, tidal channel enlargement, and expansion of tidal pools. Erosion occurs by slumping and undercutting of peat along both island edges and interior tidal channel banks (Figure 7.2-4 , Figure 7.2-5 and Figure 7.2-6). The retreat of low marsh along a tidal channel at Yellow Bar Hassock, for example, has exposed underlying peat layers (Figure 7.2-7), showing an early stage in the conversion of marsh to mudflat.

Enlargement and coalescence of both interior tidal pools and pools near the edges of channels, as well as development of mudflats at the expense of low marsh, may be early signs of marsh inundation (Figure 7.2-8, Figure 7.2-9). Closely associated with the expansion of these pools is the decline in low marsh vegetation (e.g., compare Figure 7.2-10 showing a stand of healthy *Spartina alterniflora* on Rulers Bar Hassock with Figure 7.2-8 and Figure 7.2-9, from Big Egg Marsh). At Big Egg Marsh, the *Spartina alterniflora* vegetation cover has decreased, *Ulva* is taking over, and the peaty substrate is decomposing to a more soupy consistency. Unusually dense concentrations of ribbed mussels (*Geukensia demissus*) are frequently found attached to the bases of *Spartina alterniflora* stems (Figure 7.2-11). These may accumulate into mounds, where *S. alterniflora* has died off. These observed biogeomorphological features, taken together, indicate an increased level of waterlogging leading to the disintegration of the underlying peat root network and the undermining of marsh stability. They represent elements of the process of low marsh transformation to mudflats. The geomorphological changes can be summarized as follows:

A. Erosion.
    1. Slumping, undercutting, and inward retreat of peat from bank ledges along island peripheries and tidal creeks (Figure 7.2-4, Figure 7.2-5, Figure 7.2-6 and Figure 7.2-7).
    2. Widening of tidal channels (Figure 7.2-4).

B. Inundation.
    1. Progressive enlargement of internal tidal pools (Figure 7.2-9).
    2. Residual mounds from die-off of mussel beds (*Geukensia demissus)*, some still attached to vegetated remnants of *Spartina alterniflora* (Figure 7.2-11)
    3. Widespread deterioration of marsh vegetation, leading to generalized scour and surface lowering (Figure 7.2-8 and Figure 7.2-9).
    4. Excessive peat porosity, with “soupy” consistency.
    5. Conversion of low salt marsh to more aquatic wetland types (e.g., mudflats, bars, and coastal shoals) (Figure 7.2-8).

Feldspar markers. Attempts to measure local accretion rates by the feldspar horizon marker method proved unsuccessful. While the feldspar horizon marker plot locations had been clearly identified during the 2000 field season, no marker plots were recovered. At four separate plots on Big Egg Island, the marker flags still remained, but the feldspar had been washed away, although there had been no major storms that summer. Possible reasons for the disappearance of the feldspar layer include: 1) bioturbation, 2) mixing with darker organic sediments, and 3) resuspension by tides. While bioturbation cannot be ruled out, no significant burrowing activity was noted on the test plots. If feldspar had become admixed with organic, peaty sediments (i.e., through accretion), then traces of the feldspar should still remain. Its white color and granular texture would stand in sharp contrast to the dark, nearly black color of the peat. The feldspar was probably resuspended by tidal currents or waves. The loss of feldspar is consistent with the other evidence for active erosional processes in this area.

7.2.6 VEGETATION STUDIES

The dominant species in low marsh areas, including all of Yellow Bar Hassock, was *Spartina alterniflora.* High marsh vegetation assemblages occupied restricted areas or were missing altogether from the communities sampled, particularly on Yellow Bar Hassock. Isolated patches of *Spartina patens* and *Salicornia virginica* were growing at a few higher elevation sites, while *Ulva lactuca* was found in the mudflats and in scattered, bare areas in between *S. alterniflora* (Table 7.2-3, Figure 7.2-8 and Figure 7.2-9). Any former extensive stands of high marsh on Yellow Bar Hassock, originally present, as inferred from textural analysis of some marsh vegetation on the 1959 photographs, were no longer present during the 1999-2000 field seasons. All rooted low marsh species were either obligate or facultative wetland species (Table 7.2-3). Additional facultative species were found in the high marsh zones of Big Egg Marsh and Rulers Bar Hassock, including *Iva frutescens, Myrica pensylvanica,* and *Phragmites australis*. However, due to logistical constraints, field work in Big Egg Marsh was limited to the drier, more interior marshes, since the large channels were not passable by foot during low tide.

Mean biomass in the three selected marshes in 2000 ranged from 833 gm/m^2 to 1394 gm/m^2 with an overall mean of 1106+/-200 gm/m^2 by dry weight (Table 7.2-4, Table 7.2-5 and Table 7.2-6). These values are similar to those measured in the 1999 field season (695-1442 gm/m^2, with a mean of 992+/-234 gm/m^2 by dry weight (compare Table 7.2-4 and Table 7.2-5). These productivity levels are typical of healthy marshes in this region (Table 7.2-6), in spite of evidence of erosion and inundation, mentioned above. The quadrats included the nearest vegetated edge to barren microgeomorphological features such as pools and creeks that crossed the transect. Needless to say, the presence of such barren features diminished the total standing crop density. Averaging low biomass patches near pools along with stands of healthy, dense-vegetation within a quadrat may have reduced the biomass average somewhat, but gave a more overall representative value for growing marsh vegetation. Our transects intersected marsh areas that are still relatively intact, and may therefore underestimate the status of marsh areas that are in a more advanced stage of transformation to mudflats. The relatively high variability in mean biomass measured from marsh to marsh in a given year is likely caused by the unevenness in vegetation density (Table 7.2-4, Table 7.2-5 and Table 7.2-6). On the other hand, the differences in mean biomass at any given marsh over the two-year sampling period are generally lower than the spatial variability among the marshes.

7.2.7 DISCUSSION

Above-ground plant biomass of *Spartina alterniflora* at Jamaica Bay is comparable to regional values (compare Table 7.2-4 and Table 7.2-7), in spite of the biogeomorphological features indicative of erosion and inundation, described above. Paradoxically, increased above-ground productivity may accompany increased marsh flooding or immersion (Reed, 1995). Some studies suggest that growth may be stimulated even as tidal heights increase. The observed declines in salt marsh grass density, associated with enlargement of tidal pools and mudflat encroachment onto low marsh in some areas, point to increased soil waterlogging (e.g., Figure 7.2-8 and Figure 7.2-9). These features may represent the first effects of rising sea level.

The survival and growth of a salt marsh is a delicate equilibrium between changes in sea level, compaction and subsidence, upward accumulation of peat, inorganic sediment deposition, and erosion by waves. In most places, marshes are keeping pace with current rates of relative sea level rise. However, where rates of relative sea level rise exceed rates of mineral sedimentation and vertical peat accretion, as is already happening in Louisiana and in the Chesapeake Bay (Kearney, 1996; Boesch et al., 1994; DeLaune et al. 1994, and Wray et al., 1995), the marsh may begin to drown in place. In Connecticut, Warring and Niering (1993) found high marsh converting to low marsh, not inconsistent with the recent period of sea level rise (see also Varekamp and Thomas, 1998). Similarly, Fallon and Mushacke (1996) have recorded examples of high to low marsh conversion and the disappearance of several tidal wetland islands at various sites on the South Shore of Long Island.

Although *S. alterniflora* is well-adapted to the intertidal zone, longer periods of flooding during the tidal cycle leads to gradual build-up of hydrogen sulfide (H_2S) in marine sediments, which is generally toxic. While *S. alterniflora* normally oxygenates its roots to prevent excessive H_2S build-up, as sea level rises, intertidal pools on the seaward side of the marsh become progressively submerged over a greater portion of the tidal cycle. As these pools become anoxic, due to H_2S accumulation, *S. alterniflora* ultimately dies. Plant death may lead to collapse of the peat layers, due to deterioration of the dense root network which holds the peat together. The patchy decreases in *S. alterniflora* density, excessive peat porosity (sediment has "soupy" consistency), apparent expansion of tidal pools and surface lowering in places, and invasion of *Ulva* show marshes in the process of changing to mudflats.

In Jamaica Bay, the historic rise in sea level may be an important causative factor leading to the observed signs of marsh erosion and inundation. However, it does not completely explain the recent <u>acceleration</u> of marsh loss (Fallon and Mushacke, 2001, priv. comm.), inasmuch as the rate of SLR in this area has remained relatively constant throughout the 20th century (Figure 7.2-2; Gornitz et al., 2001). Storm activity along the Atlantic Coast, although displaying considerable interdecadal variability, has not shown an upward trend during this period (Zhang et al., 2000; Dolan and Davis, 1994.). Some erosion due to storm waves may be increasing with rising sea levels, as the return period of high wave events decreases (for an analogous example regarding coastal flooding, see Gornitz, 2001).

Nevertheless, other processes must contribute to current marsh losses, although their exact causes still remain uncertain. Among these are reduced sediment loads available for vertical marsh accretion, cessation of landfill activities, pollutants, waterfowl herbivory, and boat traffic.

Most of the tidal wetlands losses between 1900 and 1974 were probably linked directly and indirectly to anthropogenic activities (e.g., filling and dredging, development in Brooklyn and

Queens in and around the Bay, including Broad Channel Island and JFK International Airport, and rail and highway construction) (Englebright, 1975). Earlier dredging of navigation channels may have initiated an erosive cycle, which may have reached a critical threshold in recent years. Furthermore, the historic westward growth of the Rockaway spit and its subsequent stabilization may have prevented offshore sediments from entering the Bay and the widespread twentieth century urbanization of Long Island may have eliminated upland sediment sources, as well as overwash deposits from storms. This sediment deficit may have increased in recent decades, as dredge and fill operations were curtailed, after establishment of Gateway. A critical level of mineral sediment input is necessary for salt marsh survival; if soil bulk density is too low, plant growth cannot be maintained (DeLaune, et al., 1994). Waves triggered by barge and boat traffic along navigation channels could also be responsible for some marsh erosion.

The salt marshes of Jamaica Bay may be more vulnerable to the impacts of future sea level rise than neighboring marshes on Long Island. Jamaica Bay marshes are either on islands or constrained on their landward sides by existing urban development, which limits their potential to migrate inland with rising sea levels.

The areal expanse of low marsh *Spartina alterniflora* is already in decline. Interior tidal pools appear to be enlarging. As these pools expand and coalesce over time, total biomass production by the marsh will be eventually reduced. If significant portions of *Spartina alterniflora* salt marshes were to disappear, this would adversely impact the entire Jamaica Bay ecosystem as it relates to wildlife habitat, marsh productivity, biodiversity, and flood control.

Further research is urgently needed to determine the extent to which past channelization and changes in sedimentation rates have affected Jamaica Bay marsh growth. A key variable is the accretion rate, which determines the ability of the salt marsh to keep pace with accelerated sea level rise. The accretion rate depends on the sediment load, the biological input, and the hydraulic movement of particles. Other than a single study by Zeppie (1977), these factors are largely unknown in Jamaica Bay. A priority research objective will be to measure the accretion rate at a number of sites within Jamaica Bay. Possible techniques include feldspar marker horizons, radioisotope geochronology, and Sediment Erosion Tables (SETs). Installation of the latter devices has been proposed within Jamaica Bay, in collaboration with the USGS. These platforms have been used internationally and are effective at separating the components of surface accretion and shallow subsidence in marshes. Other methods of measuring accretion rates involve isotope geochronology (i.e., ^{210}Pb, ^{137}Cs, and ^{7}Be) of sediment cores. Additional monitoring of marsh loss by remote sensing as well as field mapping of erosional processes should be undertaken. Data collection should continue at various locations over a multi-year period, to assess changes in salt marsh biomass productivity and to determine the range of spatial and interannual variability.

7.2.8 CONCLUSIONS

Field work undertaken during the JBERRT program provides further evidence that a number of the island salt marshes of Jamaica Bay may be eroding and drowning. The ground truth data substantiate remote sensing observations of significant marsh losses, particularly during recent decades (Hartig, 2001; Hartig et al., 2001; NYSDEC, 2001). Processes of erosion include slumping and inward retreat of peat along banks of creeks and island edges, and widening and extension of tidal channels. Lack of accretion is indicated by the disappearance of feldspar markers over the field work season. Inundation is manifested though expansion and coalescence of interior tidal pools, patchy decreases in salt marsh grass density, collapse of the peat root network, leading to excess peat porosity, general surface lowering and conversion of low marsh, in the affected areas, into mudflats. The processes of marsh loss through erosion and inundation seen at Jamaica Bay are very similar to those reported for Louisiana and Chesapeake Bay (DeLaune et al., 1994, Kearney, 1996; Boesch et al., 1994; Wray et al., 1995), although the causative mechanisms may differ somewhat from one locality to the other. While regional sea level rise may be an important underlying cause, other local processes may be even more significant. Several possible factors, potentially interacting synergistically, have been proposed, among which the general sediment deficit may be the most critical. Other potential factors include the erosive effects of previous dredging for navigation channels and wave action due to boat traffic, as well as excessive waterfowl grazing. Vegetation productivity of low marsh (standing crop biomass) ranged from 800 to 1400 g/m^2 in 2000 and 700-1440 g/m^2(dry weight) in 1999. These values compare favorably with other healthy marshes in the region, in spite of the biogeomorphological deterioration, detailed above.

Regardless of the ultimate causes of marsh losses, their diminution is occurring rapidly and may even be accelerating (NYSDEC, 2001). At current rates of reduction, most of the island *Spartina alterniflora* wetlands could be lost within the next few decades, even without any further increases in mean sea level. Further studies, including measurement of accretion rates, are needed immediately to establish the processes responsible for the decline of Jamaica Bay wetlands, before appropriate remedial action can be undertaken.

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7.2.10 TABLES

Table 7.2-1 Surface accretion rates measured in the metropolitan New York region as compared with the mean rate of sea level rise.

State	Salt Marsh Zone	Accretion Rate (mm/yr)	Time (years)	Method	SLR (mm/yr)
CT	low	8.0-10.0	10	Particle layer	2.1
CT	high	2.0-6.6	10	Particle layer	2.1-2.9
CT	high	1.8-2.0	58	^{210} Pb	2.1
	low	3.3	58	^{210} Pb	2.1
NY	low	4.7-6.3	103	^{210} Pb	2.2
NY	low	4.0	88	^{210} Pb	2.2
NY	high	5.0	100	^{210} Pb	2.8
	low	8.0	100	^{210} Pb	2.8
NY	low	2.5	171	Historic record	2.2
NY	low	2.0-4.2	1	Particle layer	2.2

Sources: see Hartig et al. 2001 for complete citations.

Table 7.2-2Changes in area at three selected island salt marshes, Jamaica Bay Wildlife Refuge, Gateway National Recreation Area, New York.

	1959	1976		1998		
Marsh Name/ (Salt Marsh Zone)	**Acres (Ha)**	**Acres (Ha)**	**% Loss Since 1959**	**Acres (Ha)**	**% Loss Since 1976**	**% Loss Since 1959**
Yellow Bar Hassock (Low)	189 (76.5)	173 (70)	8	165 (66.8)	5	13
Black Wall Marsh (Low)	44 (17.8)	43 (17.4)	2	41 (16.6)	5	7
Big Egg Marsh (Low)	75 (30.4)	76 (30.8)	-1	64 (25.9)	16	15
Total area	**308 (125)**	**292 (118)**	**5%**	**270 (109)**	**8%**	**12%**

Note: Acres are listed first, then hectares (ha) in parentheses.

Table 7.2-3 Plant species observed in 1.0m^2 plots along transects from three island salt marshes, Jamaica Bay.

Scientific name	Common name	Regional Ind. Status	Marsh
Spartina alterniflora	Smooth cordgrass	OBL	Big Egg, Rulers Bar Hassock, Yellow Bar Hassock
Spartina patens	Salt hay grass	FACW+	Big Egg, Yellow Bar Hassock
Spartina cynosuroides	Big cordgrass	OBL	Big Egg
Phragmites australis	Common reed	FACW	Big Egg, Rulers Bar Hassock
Salicornia virginica	Glasswort, samphire	OBL	Big Egg, Yellow Bar Hassock
Iva frutescens	Marsh elder, Big-leaf sumpweed	FACW+	Big Egg, Rulers Bar Hassock
Myrica pensylvanica	Northern bayberry	FAC	Big Egg
Toxicodendron radicans	Poison ivy		Big Egg
Fucus sp.	Brown seaweed, Rockweed	NL	Yellow Bar Hassock
Ulva sp.	Sea lettuce	NL	Yellow Bar Hassock, Rulers Bar Hassock

Notes:

1. OBL = Obligate wetland species–occurrence more than 99% of the time is in wetland habitats.
2. FAC, FAC+ = Facultative wetland species–occurrence more than 66-99% of the time is in wetland habitats.
3. NL = Not Listed–aquatic algae are not included in the National List for wetland species.

Table 7.2-4 Mean biomass of *Spartina alterniflora*, 1999 field season.

Location	Sampling Period	Mean Biomass gms x 1.0m^{-2}	Mean Biomass gms x 1.0m^{-2}
Big Egg Marsh	July	1065	
	August/Sept	768	
	October	1053	962
Rulers Bar Hassock	July	1442	
	August/Sept	1156	
	October	1012	1203
Yellow Bar Hassock	July	695	
	August/Sept	998	
	October	744	812
Total		**992.5 ± 234**	**992**

Table 7.2-5 Mean biomass of *Spartina alterniflora*, 2000 field season.

Location	Sampling Period	Mean Biomass gms x 1.0m^{-2}	Mean Biomass gms x 1.0m^{-2}
Big Egg Marsh	July	833	
	October	1001	917
Rulers Bar Hassock	August	1262	
	October	1394	1328
Yellow Bar Hassock	August	1020	1073
	October	1125	
Total		**1106 ± 200**	1106

Table 7.2-6 Summary of 1999 and 2000 measurements of mean biomass of *Spartina alterniflora,* Jamaica Bay.

Location	Year	Mean Biomass (gm x m^2)	N
Big Egg Marsh	1999	962	18
	2000	917	12
Rulers Bar Hassock	1999	1203	8
	2000	1328	8
Yellow Bar Hassock	1999	812	13
	2000	1073	11
Mean Biomass		**1049 ± 191**	**70**

Table 7.2-7 Mean biomass of *Spartina alterniflora* at regional salt marsh ecosystems.

Marsh Location	Biomass (gm x m^{-2})
Virginia	1290
Maryland	1100
Delaware	560
New Jersey	1600
Long Island	827
Rhode Island	840

(Source: Nixon & Oviatt, 1973)

7.2.11 FIGURES

Figure 7.2-1 Index map of the Jamaica Bay Unit, Gateway National Recreation Area. Insets show (A) Yellow Bar Hassock, (B) Rulers Bar Hassock, and (C) Big Egg Marsh. (Sources: Hagstrom Map of the Borough of Queens, City of New York, Hagstrom Map Company, Inc. and USGS Far Rockaway and Jamaica, N.Y. Quadrangles, 7.5 minute topographic series).

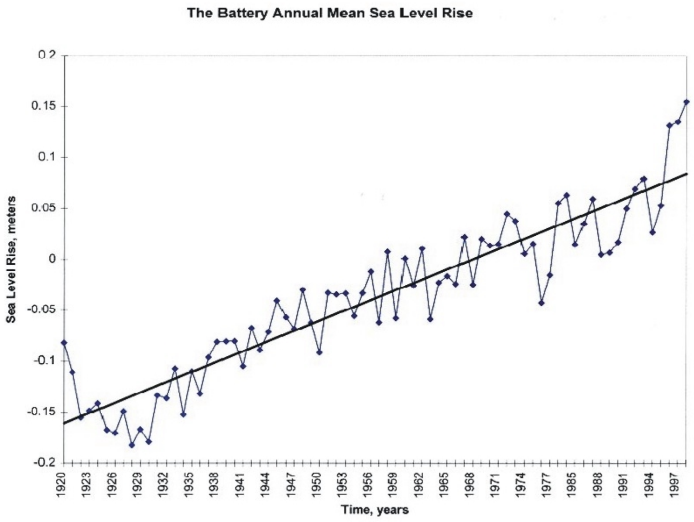

Figure 7.2-2 Historic sea level rise, the Battery, New York City.

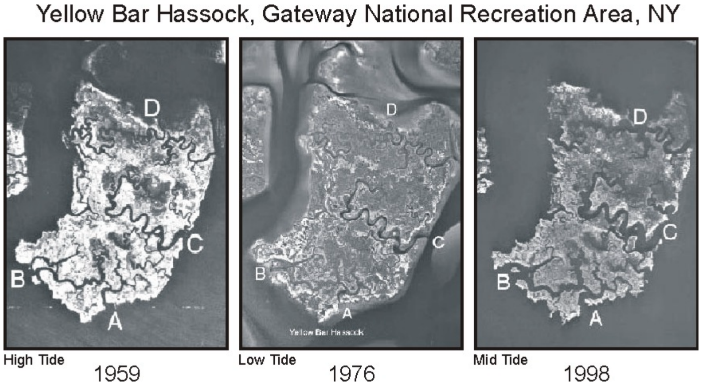

Figure 7.2-3 Aerial photographs of Yellow Bar Hassock showing marsh loss over a 39-year period. (A) April 7, 1959, high tide; (B) March 29, 1976, low tide; and (C) March 13, 1998, mid-tide.

Figure 7.2-4 Slumped peat block adjacent to intact marsh along tidal creek, Yellow Bar Hassock, at low tide.

Figure 7.2-5 The same as Figure 7.2-4, at mid-tide.

Figure 7.2-6 Incised edge of low marsh adjacent to slumped block, Yellow Bar Hassock, mid-tide view.

Figure 7.2-7 Erosion of low marsh along tidal channel, Yellow Bar Hassock, exposing underlying peat layers. This illustrates a transitional stage in the transformation of low marsh to mudflats.

Figure 7.2-8 View of Big Egg Marsh near low tide, looking southwest toward the Marine Parkway Bridge. Note extent of exposed mudflats and sparse growth of salt marsh grass.

Figure 7.2-9 View of Big Egg Marsh at low tide, looking southeast toward Rockaway Beach. Note mudflats covered with *Ulva* and sparsity of salt marsh grass

Figure 7.2-10 View of Rulers Bar Hassock, looking west, showing dense, healthy *Spartina alterniflora* growth. Note contrast in vegetation density between this and Figure 7.2-8 and Figure 7.2-9.

Figure 7.2-11. Dense accumulations of *Geukensia demissus on Spartina alterniflora* at low tide, Beach Channel Island, near North Channel Bridge.