Jamaica Bay Institute

Research Opportunities

in the Natural and Social Sciences
at the
Jamaica Bay Unit of
Gateway National Recreation Area

Prepared for:

National Park Service

Jamaica Bay Institute

1 Floyd Bennett Field

Headquarters Building 69

Brooklyn, NY 11234

Prepared by:

John Waldman

Biology Department, Queens College

65-30 Kissena Boulevard

Flushing, NY 11367

April 2008

Table of Contents

Coastal Geomorphology

Atmospheric Deposition Monitoring

Aquatic Ecology

Habitat Restoration

Invasive Aquatic Species

Chemical Contamination

Nutrient Enrichment and Eutrophication

Marine Debris

Plant Ecology

Wildlife Ecology

Warming and Sea Level Rise

Social Sciences

Appendices

About the Jamaica Bay Unit of Gateway National Recreation Area

The Gateway National Recreation Area (Gateway NRA), designated in 1972, is one of the first urban national parks. Gateway NRA includes Sandy Hook, New Jersey, tracts along the south side of Staten Island, Jamaica Bay, Floyd Bennett Field, and Breezy Point in New York. One of its primary components is the Jamaica Bay Unit. Jamaica Bay is a large water body that drains portions of Brooklyn, Queens, and Nassau counties of New York and discharges to the Atlantic Ocean through Rockaway Inlet. The Jamaica Bay Unit is approximately 6,500 hectares (16,000 acres) in area, about 75% water and wetlands and 25% uplands.

All three districts of Gateway National Recreation Area

The Jamaica Bay Unit of Gateway National Recreation Area

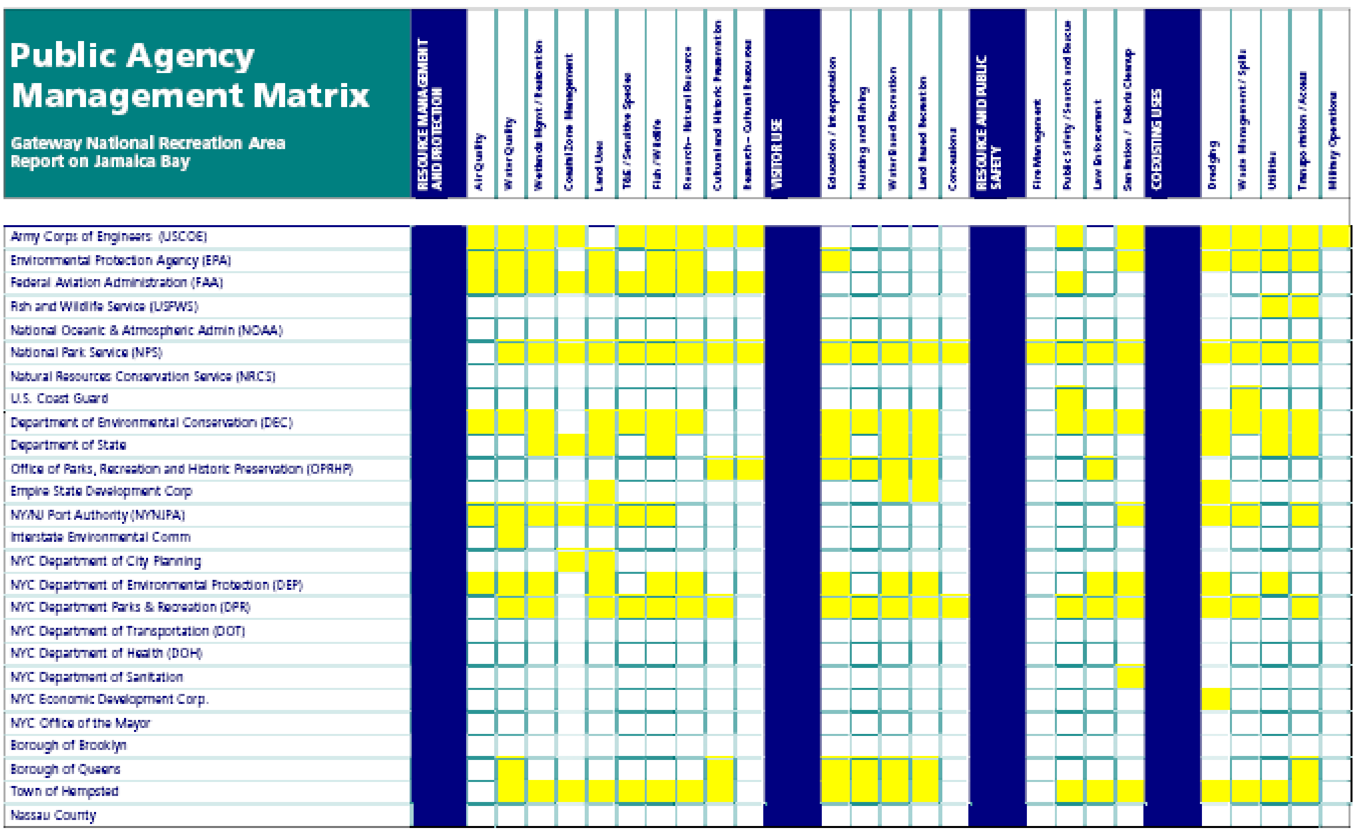
Although Jamaica Bay is natural, it is located within a heavily populated region and portions of it have received considerable modification by humans. Nonetheless, Jamaica Bay is one of the largest areas of open space within New York City; a significant natural area within one of the nation's most populous urban centers. Both within the Unit and in the heart of the bay itself, the Jamaica Bay Wildlife Refuge encompasses 3,700 hectares (9,155 acres) and is comprised of diverse habitats, including salt marsh, several fresh and brackish water ponds, upland fields and woods, and an open expanse of bay studded with islands.

Osprey lands on nest platform in the Jamaica Bay Wildlife Refuge

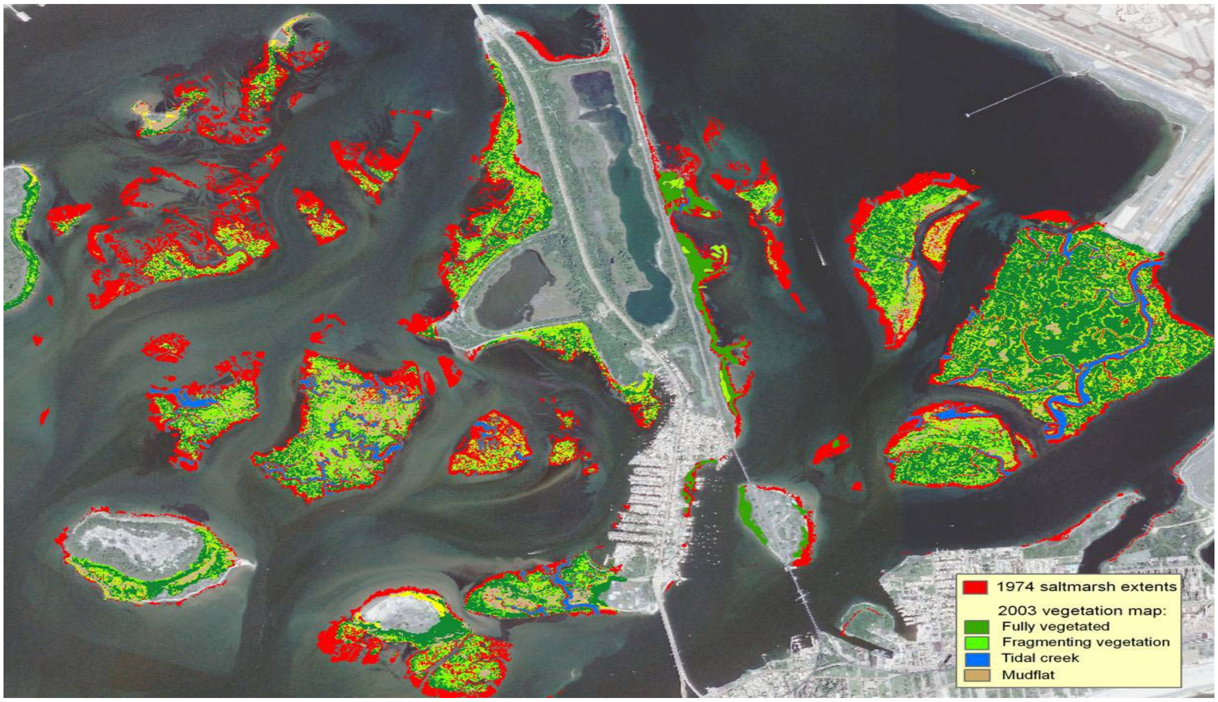
The Jamaica Bay Wildlife Refuge provides important habitat for both resident and migratory animals—most famously—for its birds, with more than 325 species having been seen there. Jamaica Bay is a critical stop-over area on the Eastern Flyway Migration Route. It is widely known as one of the best bird- watching locations in the western hemisphere; in fact, it was the first site to be designated by the National Audubon Society as an "Important Bird Area." Jamaica Bay also hosts large numbers of seasonally resident fishes, crustaceans, and horseshoe crabs

This abutment of wild habitat and natural resources with urbanity makes management of Jamaica Bay complicated. More than 25 federal, state, and local agencies have some jurisdictional responsibilities in the bay, and numerous private and public entities have strong ties to it. However, the National Park Service has a uniquely broad purview of the Unit portion of Jamaica Bay. Its mission statement includes that "The Secretary shall administer and protect the islands and waters within the Jamaica Bay Unit with the primary aim of conserving the natural resources, fish, and wildlife located therein and shall permit no development or use of this area which is incompatible with this purpose." This is part of a larger mission for Gateway NRA that maintains, improves, and makes its resources available to the public for inspiration, education, and recreation. These include sites of critical natural and cultural importance to the maintenance and sustainability of local ecosystems, to the life of migratory and native species, and to the military, navigational, and aviation history of the region and the nation, especially in the context of the coastal defense of New York Harbor.

Table 1. Federal, state, and local agencies having a legal or jurisdictional responsibility for activities in the bay



This chart is a representative list rather than an exhaustive one. It is based on input received at public and agency workshops, not all agencies involved in the bay have indicated which activities they are responsible for.



Map demonstrating marsh loss in Jamaica Bay from 1974 to 2003

Strengthened environmental regulations and concerned citizens have greatly improved conditions in Jamaica Bay and, today, the bay can serve as a model for how the degraded resources of an urban water body can be rehabilitated. However, the bay is dynamic and not all of its changes are positive, most alarmingly, the trend towards disappearance of its salt marsh islands (Hartig et al. 2002). Nor are all aspects of its environment as well understood as they should be to best manage the bay. To help steer further scientific inquiry into this complex, stressed, but resilient ecosystem, creation of a research opportunities catalog was proposed, as have been developed for other National Parks. This research catalog for the Jamaica Bay Unit of Gateway National Recreation Area has two main objectives:

- *A Research Opportunities catalog will identify research needs that will directly assist park management in their efforts to better understand the park's natural resources and support resource protection actions.*

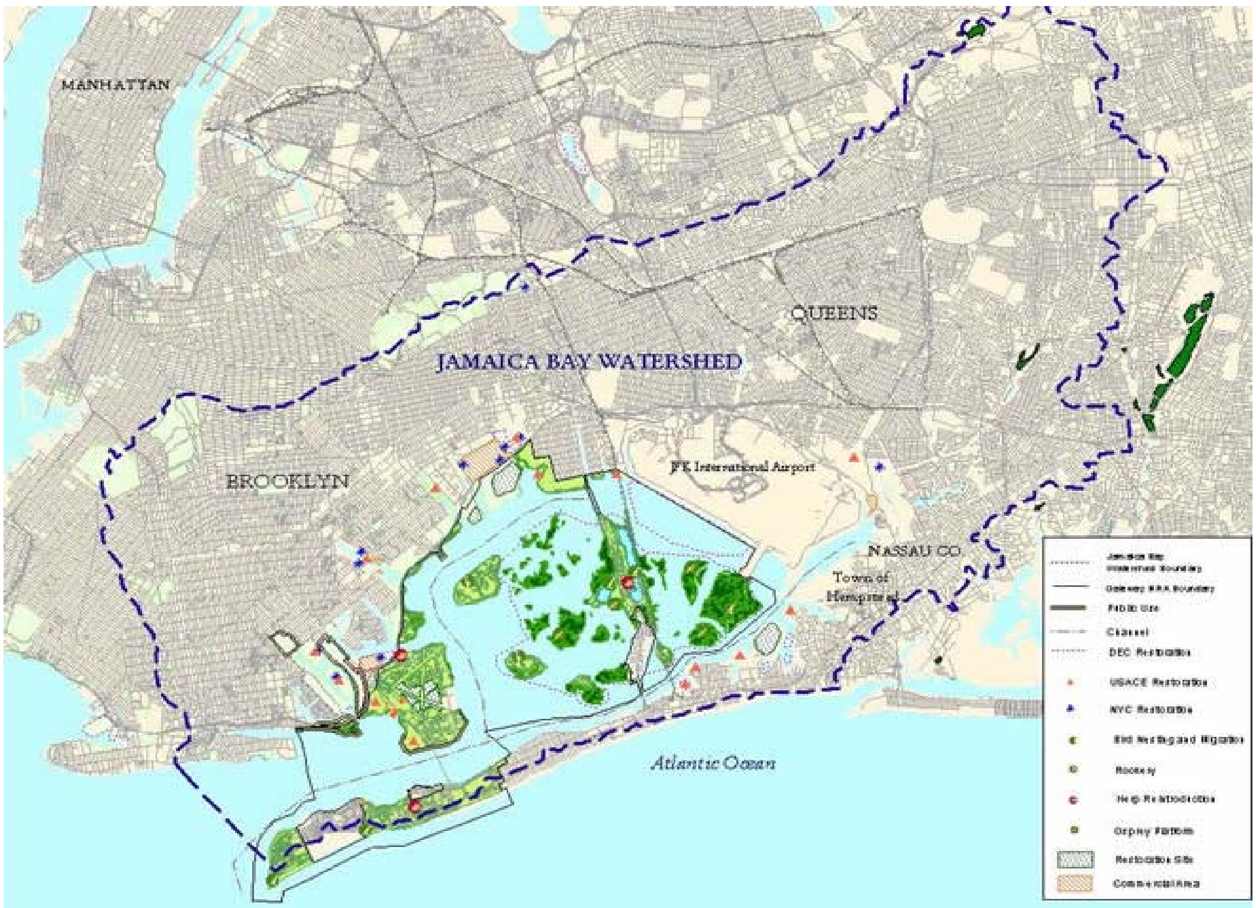
- *A Research Opportunities document will identify opportunities to study species, habitats, processes, and ecological principles within an urban setting: and the connections the metropolitan community has to these resources.*

Thus, we hope that this catalog of research opportunities for the Jamaica Bay Unit of Gateway NRA will highlight the availability of this site as a potentially world- class laboratory for research on the wildlife and environment of an urban park and, that it will focus scientific study on questions that will help maintain and perpetuate the bay's environmental recovery so that it can continue in its role as a superb urban wildlife amenity. It is intended that this catalog be updated on a periodic basis.

Location and Basic Characteristics

Maps in this section can be found at [http://nbii- nin.ciesin.columbia.edu/jamaicabay/maps.html](http://nbii-nin.ciesin.columbia.edu/jamaicabay/maps.html)

The word "Jamaica" comes from the Jameco or Yamecah Indians, part of the Canarsie tribe, who inhabited the northern shores of what is known today as Jamaica Bay. Jamaica Bay is situated at the southwestern end of Long Island, as the westernmost of the island's large south shore bays. It is located primarily within the New York City boroughs of Brooklyn and Queens, with a small eastern portion extending into the Town of Hempstead in Nassau County, New York. The bay is protected by a barrier beach and it connects with the sea through Rockaway Inlet at its western end. The Jamaica Bay watershed, including NPS and all other holdings is approximately 36,900 hectares (91,000 acres) in size; open water and wetlands extend for about 5,300 hectares (13,000 acres).



Jamaica Bay is embedded within a heavily urbanized region with extremely high population densities. According to 2005 U.S. Census Bureau estimates, there were 2,486,235 people residing in Brooklyn and 2,241,600 in Queens alone, part of the more than 8 million population of New York City and the nearly 22 million of the New York City metropolitan region.
Jamaica Bay has been characterized as a temperate, eutrophic estuary, with open water salinities ranging from about 20 to 26 parts per thousand (ppt), temperatures from 1°C to 26°C, and pH

from 6.8 to 9 (USFWS 1997). Muddy fine sand is the primary sediment of the eastern and northern portions of the bay, while fine to medium sands predominate in the higher energy southern and western sections nearer to Rockaway Inlet (USFWS 1997). Jamaica Bay's original average low tide depth of about 3 feet has been increased to 16 feet through landfilling of shallows, channel dredging, and the removal of sediments from "borrow" pits, some of which exceed 50 feet in depth. Because of these changes, the average residence time of a water molecule in the northern portion of the bay has risen from 11 days to 33 (NYCDEP 1994), with dredging accounting for a 70% increase in the volume of the bay (Rhoads et al. 2001). The bay's original network of freshwater and brackish creeks have been shortened, straightened, bulkheaded, and channelized, with two- thirds of the freshwater runoff diverted through four sewage treatment facilities. Thus, salinity gradients are now minimized within the system. Freshwater inputs total approximately one- half of one percent of the bay's volume per day (Rhoads et al. 2001).

Drain pipes empty into Jamaica Bay affecting the water quality of the bay and the salinity of surrounding areas.

These alterations to the original pattern of freshwater discharge have been so radical that the watershed of Jamaica Bay is sometimes referred to as a "sewershed"—a distinctly urban concept. Sewage treatment facilities contribute about 287 million gallons of treated effluent per day (West- Valle et al. 1991). Each semidiurnal tidal cycle (approximately 5- foot range) exchanges approximately one- third of the volume of the bay through Rockaway Inlet. This flushing plus the benefits of improved sewage treatment (Brosnan et al. 2006) have caused the water quality of Jamaica Bay to greatly improve since the Clean Water Act.

Selected Bibliography for Location and Basic Characteristics.

Brosnan, T.M., A. Stoddard, and L.J. Hetling. 2006. Hudson River sewage inputs and impacts: Past and Present. Pages 335- 348 *in* J.S. Levinton and J.R. Waldman, editors. The Hudson River Estuary. Cambridge University Press, New York, NY.

NPS (National Park Service). Undated. The evolving legacy of Jamaica Bay. Gateway National Recreation Area, National Park Service.

NYCDEP (New York City Department of Environmental Protection). 1994. Jamaica Bay comprehensive watershed management plan. New York, NY.

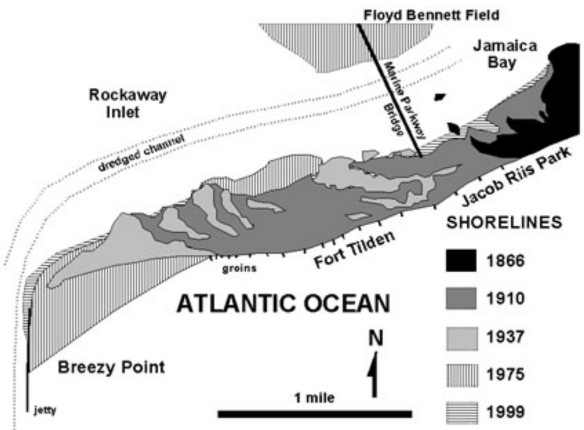
Rhoads, J.M., D.J. Yozzo, M.M. Cianciola, and R.J. Will. 2001. Norton Basin/Little Bay Restoration Project: historical and environmental background report. Report to U.S. Army Corps of Engineers.

USFWS (U.S. Fish & Wildlife Service). 1997. Significant habitats and habitat complexes of the New York Bight watershed. U.S. Fish & Wildlife service, Southern New England, New York Bight Coastal Ecosystems Program, Charlestown, RI.

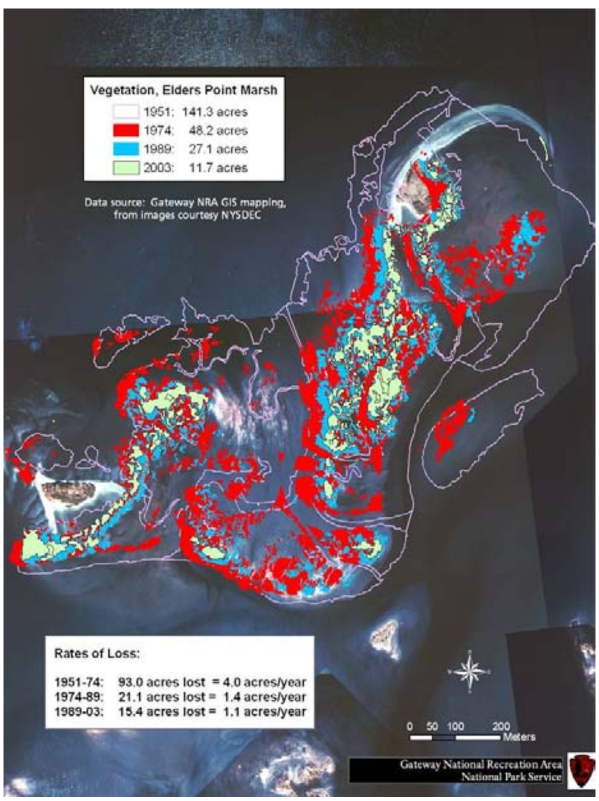
West- Valle, A.S., C.J. Decker, and R.L. Swanson. 1991. Use impairments of Jamaica Bay. Waste Management Institute, Marine Sciences Research Center, State University of New York, Stony Brook, NY.

Coastal Geomorphology

Background.



Map demonstrating the accretion of sand at the Breezy Point tip.



Map demonstrating marsh loss from 1951 to 2003.

Jamaica Bay is a geomorphologically recent and dynamic system (JABERRT 2002). It is post-Pleistocene in origin—nestled within the outwash plain of Long Island's Harbor Hill Moraine—and is protected from ocean waves by a portion of the long barrier beach that lines Long Island's south shore. Within historical times, once- populated Barren Island (near Rockaway Inlet) eroded, was abandoned, and then was landfilled to connect with the mainland as part of Floyd Bennett Field. Breezy Point—at the western tip of the barrier beach—has steadily extended westward. The bay's interior margin also is radically altered through development. Furthermore, Jamaica Bay's island marshes have been eroding at a very high rate and there was concern that they may eclipse within decades (Hartig et al. 2002). This threat has since been updated to disappearance within less than a decade (GNRA 2007). Human- made physical changes also affect the hydrology and sediment budget of the bay; channels are dredged for navigation and deep holes (borrow pits) persist from which sediments were obtained decades ago for landfilling.

(Above) Bulkheading at Floyd Bennett Field; (Below) The jetty at Breezy Point.

However, as an urban water body with an enormous population ringing it, Jamaica Bay has been largely "locked in place" physically to accommodate human needs. This includes construction of a broad suite of structures that "harden" it, including jetties, seawalls, bulkheads, and bridge abutments. Much of this hardening included geomorphological changes such as the straightening of creeks while bulkheading, and landfilling wetlands for development. But while humans have reduced the natural physical dynamism of Jamaica Bay to meet society's needs they also have induced new and potentially powerful stresses such as sea level rise and perhaps hurricanes and nor'easters of increased frequency and severity (Najjar et al. 2000; Gornitz et al. 2001). Thus, further geomorphological change to Jamaica Bay appears likely; how disruptive to its current uses it will be depends partly on a better understanding of its natural physical processes.

Research Needs.

Evidence of storm erosion at Floyd Bennett Field. Pre-hurricane (left) and post-hurricane (right) Ernesto photos. Source: Rip Kirby, 2006

The major focus of future work on the geomorphology of Jamaica Bay should be on its resiliency and adaptability to the effects of climate change. What will Jamaica Bay look like in 25, 50, and 100 years? But to place forecasts of sea level change and the impacts of major storms in perspective, a better understanding of ongoing physical processes such as shoreline accretion and loss and sediment availability are needed. Thus, both retrospective and prospective research needs to be synthesized. Specifically, what is the history of major storms and their effects on the bay system? Are major geomorphological changes mostly incremental or storm- event related? These kinds of studies can include assessment of historical records, analysis of sediment cores, and other methods.

Salt marshes have long been recognized as serving a role in storm protection – temporarily storing storm waters and attenuating wave energy. With marsh loss, how will this storm protection function be affected? The functions of storm water retention and wave attenuation should be quantified within Jamaica Bay. At present, salt marsh habitat is being converted to intertidal mudflat. How does the wave attenuation function of vegetated wetlands compare to intertidal mudflats?

Sediment transport demonstrated in pre- (left) and post-(right) hurricane Ernesto photos of the beach near Floyd Bennett Field. The beach experienced a loss of approximately 5 meters in width and 15 meters in elevation depositing the sediment at the base of the adjacent Marine Parkway Bridge (below). Source: Rip Kirby, 2006.

It is important to understand the role of shoreline hardened shoreline structures on Bay sediment transport processes. Are there portions of the hardened Bay shoreline where structures can be removed, thereby restoring natural geomorphological processes (e.g., cross- shore linkages among the nearshore Bay subtidal environment, intertidal environment, and adjacent upland)? Experimental and pilot studies could be designed to evaluate the response of shoreline processes to removal of structures.

It is known that there is considerable transport of coarse sediments through the bay's channels and that Grassy Bay is a sediment sink (JABERRT 2002) but can a total sediment budget, including important sources and other sinks be constructed? And can useful predictions be made from it regarding relationships between sediment budgets and maintenance of salt marsh and other bay habitats? Is there a definite link between marsh erosion as a sediment source and borrow pits as a sediment sink? If so, would filling of borrow pits slow marsh loss?

How will sea level rise affect hydrological and salt flux linkage of Jamaica Bay to the broader Hudson River estuary and New York Bight, as currently understood (Oey et al. 1985)

Selected Bibliography for Coastal Geomorphology.

GNRA (Gateway National Recreation Area). 2007. An update on the disappearing salt marshes of Jamaica Bay, New York. National Park Service.

Gornitz, V., S. Crouch, and E.K. Hartig. 2001. Impacts of sea level rise in the New York City metropolitan area. Global and Planetary Change 32:61- 88.

Hartig, E.K., V. Gornitz, A. Kolker, F. Mushacke, and D. Fallon. 2002. Anthropogenic and climate- change impacts on salt marshes of Jamaica Bay, New York City. Wetlands 22:71–89.

JABERRT (Jamaica Bay Ecosystem Research and Restoration Team). 2002. Final Report. Division of Natural Resources, Gateway National Recreation Area, National Park Service and Aquatic Research and Environmental Assessment Center, Brooklyn College.

Najjar, R.G., H.A. Walker, P.J. Anderson, E.J. Barron, R.J. Bord, J.R. Gibson, V.S. Kennedy, C.G. Knight, J.P. Megonigal, R.E. O'Connor, C.D. Polsky, N.P. Psuty, B.A. Richards, L.G. Sorenson, E.M. Steele, and R.S. Swanson. 2000. The potential impacts of climate change on the mid- Atlantic coastal region. Climate Research 14:219- 233.

Oey, L.- Y., G.L. Mellor, and R.I. Hires. 1985. A three- dimensional simulation of the Hudson- Raritan Estuary. Part I: Description of the model and model simulations. Journal of Physical Oceanography 15:1676- 1692.

Atmospheric Deposition Monitoring

Background.

New York City contributes vast quantities of atmospheric contaminants to Jamaica Bay

Jamaica Bay is situated within an enormous metropolitan region, which renders it a potential sink for the deposition of atmospheric contaminants of local origin. However, it also lies on the east coast of North America and, hence, is in the path of distantly-sourced atmospheric contaminants that drift eastward carried by the prevailing pattern of air flow across the continent (Lovett 1994). A significant fraction of Zn, Cu, and Cd present in Jamaica Bay was found to enter the system through atmospheric fallout (Seidemann 1991). Of particular concern among atmospheric pollutants are nitrogen and phosphorus because of their potential contributions to aquatic eutrophication. However, estimates from data collected in 2002- 2003 indicate that fallout from neither is a major vector to Jamaica Bay (NYCDEP 2007). Other compounds are of greater concern. Recent monitoring of locations in the metropolitan region has shown atmospheric deposition of polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) reach the Hudson estuary by three processes: gas absorption, dry particle deposition, and wet deposition (Totten et al. 2006). Although there are geographic differences in fluxes of these compounds among regional locations, as a whole, levels seen are considerably higher than in non- urban areas elsewhere in the U.S. A number of other compounds are monitored by the New York State Department of Environmental Conservation as near to Jamaica Bay as Queens College (~13 km); these include ozone, sulfur dioxide, oxides of nitrogen, carbonyl, and methane (http://www.dec.ny.gov/docs/07networkplan12.pdf).

Research Needs.

Atmospheric deposition of PCBs and PAHs were monitored at Hudson estuary locations such as Sandy Hook and Jersey City; however, no regular monitoring has occurred at Jamaica Bay. There are a number of possible research questions on this topic. How important is atmospheric deposition of these compounds to their loads in the bay? Does Jamaica Bay's geographic position render it differentially more or less of a sink for these pollutants than elsewhere within the New York metropolitan region? Which other contaminants enter Jamaica Bay in significant quantities through atmospheric deposition?

Selected Bibliography for Atmospheric Monitoring.

Lovett, G.M. 1994. Atmospheric deposition of nutrients and pollutants in North America: an ecological perspective. Ecological Applications 4:629- 650.

NYCDEP (New York City Department of Environmental Protection). 2007. Draft Jamaica Bay Watershed Protection Plan.

Seidemann, D.E. 1991. Metal pollution in sediments of Jamaica Bay, New York, USA—An urban estuary. Environmental Management 15:73- 81.

Totten, L.A., S. J. Eisenreich, C.L. Gigliotti, J. Dachs, D.A. VanRy, S. Yan, and M. Aucott. 2006. Atmospheric deposition of PCBs and PAHs to the New York/New Jersey Harbor Estuary. Pages 398- 412 *in* J.S. Levinton and J.R. Waldman (editors). The Hudson River Estuary. Cambridge University Press, NY.

Aquatic Ecology

Habitat Restoration

Background.

Sediment spray is applied to the pilot marsh restoration site, Big Egg Marsh in Jamaica Bay, to increase the elevation

Subsequent to the New York City region's water quality having improved following passage of the Clean Water Act of 1972, the emphasis of environmental action has shifted to habitat restoration and protection (Waldman 1999), paralleling a nationwide trend sometimes expressed with the powerful, if inelegant mantra: "It's the habitat, stupid." Jamaica Bay is rife with stretches of water and uplands that have been altered, often drastically, by human actions. Many of these changes are too radical to be reversed. But others are amenable to at least some change either back toward their original states, or to some other form that provides an improved level of ecological function. For example, seven large areas in Jamaica Bay with potential for significant habitat restoration are discussed in USACE (2003).

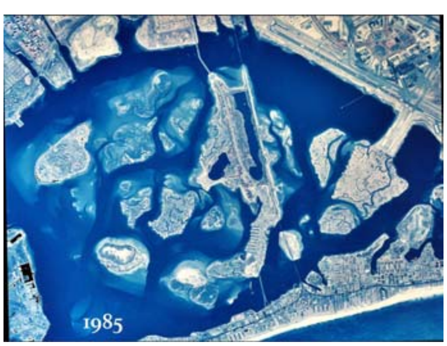
A recent comprehensive review of habitat restoration opportunities in the Hudson – Raritan Estuary includes many references to Jamaica Bay (Bain et al. 2007). Four principles—all applicable to Jamaica Bay—were adopted by this study: the ecosystem is human dominated, it has been irreversibly changed, it is dynamic and will change further, and environmental enhancements can be made by the application of science and technology. Potential actions could be based on some combination of the primary philosophical rationales for restoration: returning to the original conditions, the restoration of ecological integrity, health, or stability, "rewilding" (reestablishment of the original evolutionary setting so that natural evolution guides the future state of the system, and "renaturing" (designing ecosystems for nature and people). Eleven sets of target ecosystem characteristics were outlined by Bain et al. (2007) that considered such topics as oyster reefs, eelgrass beds, wetlands, and fish habitat, among others. This carefully considered report should serve as something of a blueprint, or at least an important source of recommendations, for habitat restoration in the bay.

Research Needs.

Salt Marshes.

The salt marshes of Jamaica Bay provide important ecological services, including wildlife habitat, support for the food web, shoreline erosion control, and water column filtration (GNRA 2007). Unfortunately, there have been profound losses of salt marsh in Jamaica Bay, in both perimeter and island locations, but especially the latter. Prior to European colonization, Jamaica Bay contained about 16,000 acres of salt marsh (USFWS 1997). This vast wetlands wilderness was whittled away over the subsequent centuries by draining and landfilling, primarily along the perimeter, until by 1971, only 4,000 acres of salt marsh remained. But since the mid- 1970s most salt marsh losses have occurred on the islands. Analysis of aerial photographs shows that between 1924 and 1974, salt marsh disappeared at a rate of 0.4% annually, but that since 1974 the rate has increased to 1.4% per year (Hartig et al. 2002). Most dramatically, Duck Point marshes decreased between 1974 and 1999 from 103 acres to 38 acres. Overall island low marsh vegetation losses since 1974 averaged 38%, with smaller islands losing up to 78% of their vegetation cover (Hartig et al. 2002). The newest assessment is that five representative island marshes are eroding at an accelerated rate and may disappear by 2012 (GNRA 2007).

Although salt marshes in other east coast systems are deteriorating because of grazing by salt marsh periwinkle, *Littoraria irrorata* (Silliman and Bertness 2002), the recent losses in Jamaica Bay appear to be caused by a variety of factors, potentially interacting synergistically. These factors include reduced sediment input, shoreline hardening which eliminate areas for potential accretion inland to balance deeper water marsh losses, dredging for navigation channels, boat traffic, sea- level rise, nitrogen pollution, and perhaps grazing (Hartig et al. 2002, NYCDEC 2007).



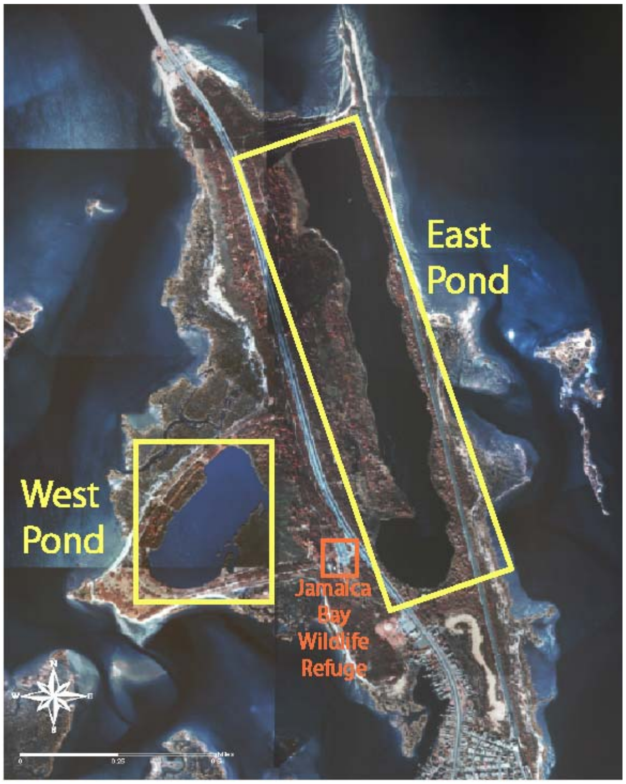
Maps demonstrating predicted marsh loss occurring in Jamaica Bay; marsh islands in 1985 (left) and the loss predicted for 2024 (right).

Further understanding of the agents of salt marsh loss and their relative contributions is needed. This includes a better comprehension of the underlying geology and sediment textural and chemical properties, and of the ecological role of the ubiquitous ribbed mussels, *Geukensia demissa* (Franz 2001). Strategies are needed first, to stop additional deterioration, if this is possible and, second, to rebuild salt marshes. Some pilot remediation efforts have already been launched, such as on the two islands at Elders Point and the Big Egg Marsh experimental restoration. Their levels of success and other marsh restoration efforts require stringent evaluation. The particular metrics used to evaluate success also need to be carefully considered (Windham et al. 2004).

At the Elders Point Marsh restoration site: (above) planting Spartina alternaflora by hand (below) fencing acts as both pathway guide and grazing bird deterrent.

Finally, given that considerable salt marsh loss has occurred and more is likely, assessment of the ecological value of the resultant mudflat habitat is needed. Which species predominate? Which are lost? And at what life stages, e.g., what is the net change in nursery functions? How is overall primary and secondary productivity on a real basis affected? Are there other ecological ramifications?

Freshwater Wetlands and Basins.



(Above) Map of the Jamaica Bay Wildlife Refuge with fresh water ponds noted; (Below) A wide variety of birds utilize the fresh water wetlands as both residence and stopping points along migration routes. In this photo: East Pond.

Freshwater habitat for wildlife is very limited in the Jamaica Bay system. Because of landfilling and sewer diversions, the freshwater wetlands of Jamaica Bay now comprise less than 1% of their historic coverage (NYCDEP 2007). However, the 120- acre East and 45- acre West Ponds, constructed in the 1950s represent historical additions of low salinity waters where they had not occurred. Assessment of the effects of the limited availability of freshwaters as an ecological resource for spawning, nurseries, or other habitat values is needed. If warranted, strategies to increase ponded freshwaters and freshwater tidal wetlands should be considered. Can existing flows be augmented? Also, is the invasive plant, purple loosestrife, *Lythrum salicaria*, a threat to the remaining freshwater wetlands? As part of this restoration effort, it would be instructive to conduct an historical survey to determine the extent and location of freshwater tidal wetlands prior to the intensive urban development period, thereby supporting design of habitat restoration initiatives.

Oyster reefs.

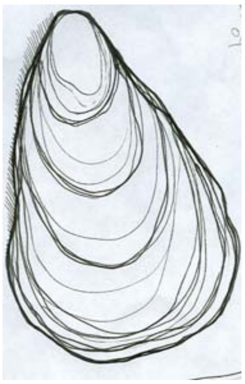


Illustration of American oyster by Anne Yen

Oysters, *Crassostrea virginica*, once were plentiful in Jamaica Bay, with large middens generated by Native Americans having been left in the Inwood, Hog Island, and Bayswater sections of the system (Bellot 1917). At its peak, Jamaica Bay produced 700,000 bushels of oysters per year (Franz 1982). The oyster beds survived well into the twentieth century but all shellfishing in the bay was prohibited in 1921 because of diseases transmitted from sewage. Not long after the bay's oyster beds were temporarily lost from the severe hurricane of 1938 (Grambo and Vega 1984). Recovery was only partial, and a further decline ensued, with oysters now either absent or extremely limited in abundance and distribution. Because oyster beds provide considerable ecosystem services in the form of water column filtration and nursery habitat for many marine animals (Kirby 2004), there is strong interest in restoring them throughout New York Harbor and western Long Island, including Jamaica Bay.

The overriding research question concerning oyster reef restoration in Jamaica Bay is what is limiting their natural recovery at this time? Experiments conducted by staff at Brooklyn College suggest that oysters can survive and grow in Jamaica Bay (Potts 2004). However, there is neither evidence of natural recovery nor even recent definitive sightings of oysters in the wilds of the bay. Oysters disperse through larval drift—is the bay too far from present- day seed oyster sources for natural colonization to occur? Given that oysters will survive when placed in the bay but apparently don't reproduce, it may be that salinity is the limiting factor. That is, oysters were prevalent when the creeks leading to the bay had salinity gradients with the brackish conditions that oysters prefer between the fresh headwaters and the open bay. But routing of street runoff to sewers has changed most tributaries greatly so that they are now highly saline dead- ended creeks with little freshwater discharge, unsuitable for oyster reproduction. However, this hypothesis requires testing.

Eelgrass.

Eel grass (Zostera marina)

Eelgrass, *Zostera marina*, is not presently known in Jamaica Bay. In fact, it is not definitively known to have occurred there. But, given its historical and present- day distribution in similar Long Island region systems, it would appear highly likely that it was native to the bay. Eelgrass all along the east coast suffered tremendous declines between 1930 and 1933 because of "wasting disease," with only partial recoveries at many locations (Short et al. 1988). Eelgrass restoration is of high interest as a goal in other places coastwide because of its demonstrated value as habitat for a myriad of forms of marine life (Hughes et al. 2002); restoration programs presently are occurring in other bays on Long Island.

Analysis of historical information—literature or museum holdings—might demonstrate the historical presence of eelgrass in Jamaica Bay. But the overriding question for generating eelgrass beds in Jamaica Bay is—what is the limiting factor that prevents natural colonization or recolonization? Is their non- reestablishment due to a lack of propagules? Or is there an unrecognized factor, such as turbidity levels that prevent seedlings from surviving? How would epiphytes interact with eelgrass in the bay? Alternatively, nutrient overenrichment and its encouragement of marine algae such as *Ulva* may be preventing eelgrass recolonization. For the Chesapeake Bay system there are an established suite of factors that necessary for the establishment and maintenance of seagrass habitats (Dennison et al. 1993); this work and other similar studies should be reviewed and adapted to Jamaica Bay.

Other Aquatic and Wetland Plant Communities


Crew working on the Elders Point Marsh restoration project inventory and monitor the variety of plants on Joco Marsh, the control site for the project. Source: Patti Rafferty

Jamaica Bay is home to a variety of aquatic and wetland plant communities whose makeup depends on such factors as salinity and duration of tidal inundation, elevation, soil type, and the presence or absence of nonindigenous competitors and grazers. Marine algae is found throughout subtidal and intertidal waters of the bay, with the sea lettuce, *Ulva latuca*, predominating. Wetland herbaceous communities include low salt marsh, high salt marsh, and freshwater emergent marsh (NYCDEP 2007). The low salt marsh is dominated by saltmarsh cordgrass, *Spartina alterniflora*, whereas salt meadow cordgrass, *Spartina patens*, predominates in the high salt marsh. However, the high salt marsh has a greater variety of species, common examples including salt grass, *Distichlis spicata*, black grass, *Juncus gerardii*, glasswort, *Salicornia spp*., and sea lavender, *Limonium carolinianum*. Emergent freshwater marshes are composed of examples such as pickerelweed, *Pontedaria cordata*, cattail, *Typha* spp., and bullrush, *Scirpus validus*, harbor sedges, *Carex* spp., rushes, *Juncus* spp., and water plantain, *Alisma* spp.(Mack and Feller 1990).

The identity and distribution of marine algae in Jamaica Bay requires attention. Further inventorying and mapping of freshwater marsh and salt marsh vegetation is needed, especially for the latter in light of the dynamic conditions being observed in the bay of ongoing salt marsh loss and sea level rise. Identification and mapping of state and federally- listed rare and threatened species should also be encouraged, with the resultant information distributed only within governmental guidelines. The threat to these communities posed by established invasive species should be assessed.

Borrow Pits.

Borrow pits, locations where sediments were dredged for landfilling, have been created in Jamaica Bay since the late 1800s. Materials for Floyd Bennett Field airfield and much of the land under JFK Airport were obtained from the bay bottom, resulting in borrow pits (NYCDEP 2007). Both Norton Basin and Little Bay contain borrow pits created during the development of the Edgemere Landfill in 1938 (Rhoads et al. 2001). Although landfilling reduced the area of open water and wetlands in Jamaica Bay from about 25,000 to 13,000 acres, the creation of borrow pits and channel dredging have increased the volume of the bay by 350% (NYCDEP 1994). Borrow pits are problematic because their deeper waters do not circulate well and may stratify in summer. As plankton and detritus settle into the stratified lower layer, they decompose and draw down available oxygen without replacement by mixing, thereby creating hypoxic conditions dissuasive to life. Borrow pits also serve as sediment sinks—areas into which sediments that might replenish shallow eroded areas (including salt marshes) are lost to the system.

Potential remediation of borrow pits is centered on the obvious solution of filling them back up again, either partly or wholly. The primary issue, however, is where to obtain sufficient sediments that meet federal and state guidelines for contamination? Borrow pits are looked upon as attractive sinks for unwanted sediments from other areas of New York Harbor. Must clean sediments only be used or can contaminated sediments be sequestered in borrow pits without causing ecological harm by capping them with clean sediments? How long would it require for natural sedimentation to make a significant difference in their depths? However, before restoration projects are considered, is it clear that borrow pits, despite their unnaturalness, have ecological value and these must be quantified and compared to the expected values of the restored habitat.

Dead- ended Creeks.

Eight of the original tributaries to Jamaica Bay have been radically transformed to dead- ended creeks. These once lotic systems now have little freshwater runoff at their heads and their nearly mono- saline waters essentially rise and fall with the tide, with only modest flushing occurring. The consequent high retention times lead to some of the poorest water quality in the Jamaica Bay system (Grassy Bay has a retention time of about 100 days, Norton Basin and Little Bay may have similar values; Rhoads et al. 2001). These new morphologies are far less productive than their original incarnations, but they do have some habitat value (Rhoads et al. 2001). A study conducted in 1971 showed low diversity of finfish and shellfish in several dead- ended creeks and a very low standing crop of finfish compared with other estuaries (Rhoads et al. 2001).

Despite these biologically deficient conditions, it is possible that these dead- ended creeks can be somewhat remediated and enhanced. Would dredging of accumulated sediments that are likely across their mouths increase flow and should their bottoms be recontoured? Is it possible to direct more freshwater discharge to the heads of these creeks to reduce retention time and restore the natural salinity gradient? Should shoreline softening be stressed, i.e., replacing hard structures and bulkheads with vegetated slopes, thereby enhancing habitat value? Are other forms of *in situ* habitat restoration in the form of small marshes, beaches, mudflats, or other types worthwhile? Would these systems receive appreciable benefits from inclusion of artificial habitats such as rip- rap along shorelines or placement of manmade structures such as reef balls on their bottoms?

Bay to Upland Transition Habitat

A significant portion of the Jamaica Bay shoreline is hardened with bulkheads, rip- rap, docks/piers, and other hard structures. Estuarine beaches are often absent or highly impacted by these structures. The natural transition zone from Bay habitat, marshes and estuarine beaches to upland communities is rarely encountered within Jamaica Bay. These estuarine beach and transitional habitats are essential for horseshoe crab spawning, diamondback terrapin nesting, storm wave energy attenuation, capture of nutrients and sediment transport from upland sources, and other ecological and geomorphological values (Nordstrom 1990, Roman and Nordstrom 1996). An inventory of the Jamaica Bay shoreline is needed to identify areas where shoreline restoration would be feasible, then studies are required to evaluate appropriate restoration techniques/designs and evaluation of ecosystem responses to restoration actions.

Hardened shore lines along the shorelines of Jamaica Bay (Left) Hardened shoreline along Floyd Bennett Field; (Right) Docks of personal property prevent important activities such as spawning and nesting by a variety of species.

(Left) Diamondback Terrapin burrows in the rack line at the Jamaica Bay Wildlife Refuge; (Right) Horseshoe crabs mate while hungry shorebirds consume freshly lain eggs around them.

Selected Bibliography for Habitat Restoration.

Bain, M., J. Lodge, D.J. Suszkowski, D. Botkin, A. Brash, C. Craft, R. Diaz, K. Farley, Y. Gelb, J.S. Levinton, W. Matuszeski, F. Steimle, and P. Wilber. 2007. Target ecosystem characteristics for the Hudson Raritan Estuary: technical guidance for developing a comprehensive ecosystem restoration plan. A report to the Port Authority of NY/NJ. Hudson River Foundation, New York, NY.

Bellot, A.H. 1917. History of the Rockaways from the year 1685 to 1917. Bellot's Histories, Inc., Far Rockaway, NY.

Dennison, W.C., R.J. Orth, K.A. Moore, J.C. Stevenson, V. Carter, S. Kollar, P.W. Bergstrom, and R.A. Batiuk. 1993. Assessing water quality with submersed aquatic vegetation. BioScience 43 86- 94

Franz, D. R. 1982. A historical perspective on mollusks in lower New York Harbor, with emphasis on oysters. Pages 181- 197 *in* G.F. Mayer, editor. Ecological Stress and the New York Bight: Science and Management. Estuarine Research Federation, Columbia, SC.

Franz, D.R. 2001. Recruitment, survivorship, and age structure of a New York ribbed mussel population (*Geukensia demissa*) in relation to shore level – a nine year study. Estuaries 24:319- 327.

Grambo, G., and C. Vega. 1984. Jamaica Bay: a site study. U.S. Geologic Survey: Long Island Division.

Hartig, E.K., V. Gornitz, A. Kolker, F. Mushacke, and D. Fallon. 2002. Anthropogenic and climate- change impacts on salt marshes of Jamaica Bay, New York City. Wetlands 22:71–89.

Hughes, J.E., L.A. Deegan, J.C. Wyda, M.J. Weaver, and A. Wright. 2002. The effects of eelgrass habitat loss on estuarine fish communities of southern New England. Estuaries 25:235- 249.

Kirby, M.X. 2004. Fishing down the coast: historical expansion and collapse of oyster fisheries along continental margins. Proceedings of the National Academy of Sciences of the United States of America 101(35):13096- 13099.

Mack, L., and J.M. Feller. 1990. Salt marshes of New York City. City of New York, Parks and Recreation & Natural Resource Group, New York, NY.

Nordstrom, K.F. 1992. Estuarine Beaches. London: Elsevier Science Publishers.

NYCDEP (New York City Department of Environmental Protection). 1994. Jamaica Bay Comprehensive Watershed Management Plan.

NYCDEP (New York City Department of Environmental Protection). 2007. Draft Jamaica Bay Watershed Protection Plan.

Potts, M. 2004. Fate of Jamaica Bay oyster to be decided. New York Daily News, May 12, 2004.

Rhoads, J.M., D.J. Yozzo, M.M. Cianciola, and R.J. Will. 2001. Norton Basin/Little Bay Restoration Project: historical and environmental background report. Report to U.S. Army Corps of Engineers.

Roman, C.T., and K.F.Nordstrom. 1996. Environments, processes, and interactions of estuarine shores. Pages 1- 12 in *Estuarine Shores* (K.F. Nordstrom and C.T. Roman, eds.). J. Wiley and Sons, England.

Short, F.T., B. W. Ibelings, and C. denHartog. 1988. Comparison of the current eelgrass disease to the wasting disease of the 1930s. Aquatic Botany 30: 295- 304.

Silliman, B.R., and M.D. Bertness. 2002. A trophic cascade regulates salt marsh primary production. Proceedings of the National Academy of Sciences 99:10500- 10505.

USACE (U.S. Army Corps of Engineers). 2003. Jamaica Bay Ecosystem Restoration Project: land history disturbance maps interagency meeting. New York District, USACE.

USFWS (U.S. Fish & Wildlife Service). 1997. Significant habitats and habitat complexes of the New York Bight watershed. U.S. Fish & Wildlife service, Southern New England, New York Bight Coastal Ecosystems Program, Charlestown, RI.

Waldman, J. 1999. Heartbeats in the Muck: the History, Environment, and Sea Life of New York Harbor. Lyons Press, NY.

Windham, L., M.S. Laska, and J. Wollenberg. 2004. Evaluating urban wetland restorations: case studies for assessing connectivity and function. Urban Habitats 29(1):130- 146. http://www.urbanhabitats.org/v02n01/evaluating_full.html

Invasive Aquatic Species

Background.

Asian Shore Crab with egg mass found at Plumb Beach in Jamaica Bay.

Jamaica Bay is open to many invasive organisms in part due to it's orientation to the busy shipping ports of the city as well as seed colonization of aquatic plants.

Nonindigenous plants and animals have the potential to cause profound changes in the ecology of established aquatic communities (NYSDEC & NYSDAM 2005). Some of these colonizations may have some perceived positive benefits, whereas others are viewed as neutral or distinctly harmful. Worldwide, organisms have been invading marine aquatic habitats at an exponentially increasing rate over the past two centuries (Ruiz et al. 2000). Locations such as Jamaica Bay, not far from the major international port of New York and New Jersey, may be particularly vulnerable to the highly important vector of transoceanic shipping (i.e., ballast water releases, attaching organisms). Moreover, such processes may have been occurring in this highly urban and commercial region for some time, resulting in "cryptogenic" colonizations (Carlton 1996) that occurred so long ago that the established organisms are treated as part of the natural, and even, native, community (e.g., green crab, *Carcinus maenus* and periwinkles, *Littorina littorea*). Also, as a coastal water body with considerable tidal interchange and a variety of habitats, Jamaica Bay is physically open to the settling and survival of seeds and larvae of colonizers from elsewhere along the ocean coast.

Research Needs.

An inventory of nonindigenous plants, invertebrates, and vertebrates is needed for Jamaica Bay. Comprehensive and annotated regional inventories such as that developed for the proximal Hudson River (Mills et al. 1996) allow for analyses of large- scale patterns (e.g., Strayer 2006). The inventory should include, where possible, information on time and location of first sighting, the likely geographic and vector source, and current distribution and abundance in the Jamaica Bay system.

Japanese shore crab with eggs found under drift wood at Plumb Beach in Jamaica Bay.

Because the flora and fauna of Jamaica Bay is incompletely known and because new colonizations are likely going to continue to occur, field survey work is needed to identify new invaders and to map the distributions of those already recognized. Particular attention should be paid to widely dispersive and harmful potential invasives. Two examples are of burrowing animals that weaken marsh structure, a prime concern in Jamaica Bay. Both are established on the Pacific coast and one, the Chinese mitten crab, *Eriocheir sinensis*, was observed in the Hudson River in 2007. The other, *Sphaeroma quoianum*, is a highly destructive isopod (Talley et al. 2001). Another threat is the veined rapa whelk, *Rapana venosa, n*ative to the Sea of Japan, which consumes hard clams and which became established in lower Chesapeake Bay in 1998 (Harding and Mann 2005). Because it is within a large metropolitan region, Jamaica Bay also may be especially vulnerable to introductions of exotics from aquarium releases, such as the "killer algae," *Caulerpa taxifolia* (Williams and Grosholz 2002)

Established nonindigenous species have entered the biological communities of Jamaica Bay with little study of their local ecological roles. Research is needed on the autecology of such species, which could include long- established forms, such as various sea squirts (ascidiaceans) and recent invaders, such as the regionally highly dominant Japanese shore crab, *Hemigrapsus sanguineus* (Ledesma and O'Connor 2001), not seen in North America until found in New Jersey in 1988. This crab has been found to greatly depress intertidal abundances of native and other non- native crabs in nearby western Long Island Sound (Kraemer et al. 2007). Another regionally established species with possible human health consequences is the Indo- Pacific lionfish, *Pterois volitans*, first observed in New York in 2001 (Whitfield et al. 2002). Although not officially recorded from Jamaica Bay, juveniles of this warm water species are now annually observed in the coastal bays of Long island to the east, making it highly likely to also occur in Jamaica Bay. This species causes painful stings when handled.

It also is possible that regular monitoring or serendipity will reveal a new and incipient colonization to North America taking place in Jamaica Bay. In similar situations that have occurred worldwide, eradication success is closely allied with the speed of proactive responses. Development of a rapid- response plan prior to such a sighting would greatly enhance the possibility of successful eradication (Simberloff 2003). Thus, assessment of, and, possibly, improvement to current governmental response strategies in Jamaica Bay are warranted.

Selected Bibliography for Invasive Aquatic Species.

Carlton, J.T. 1996. Biological invasions and cryptogenic species. Ecology 77:1653- 1655.

Harding, J.M., and R. Mann. 2005. Veined rapa whelk (*Rapana venosa*) range extensions in the Virginia waters of Chesapeake Bay, USA. Journal of Shellfish Research 24:381- 385.

Kraemer, G.P., M. Sellberg, A. Gordon, and J. Main. 2007. Eight- year record of *Hemigrapsus sanguineus* (Asian Shore Crab) invasion in western Long Island Sound estuary. Northeasten Naturalist 14:207- 224.

Ledesma, M.E., N.J. O'Connor. 2001. Habitat and diet of the non- native crab *Hemigrapsus sanguineus* in southeastern New England. Northeastern Naturalist 8:63- 78.

Mills, E.L., D.L. Strayer, M.D. Scheuerell, and J.T. Carlton. 1996. Exotic species in the Hudson River basin: a history of invasions and introductions. Estuaries 19:814- 823.

NYSDEC & NYSDAM (New York State Department of Environmental Conservation & New York State Department of Agriculture and Markets). 2005. Final Report of the New York State Invasive Species Task Force.

Ruiz, G.M., P.W. Fofonoff, J.T. Carlton, M.J. Wonham, and A.H. Hines. 2000. Invasion of coastal marine communities in North America: apparent patterns, processes, and biases. Annual Review of Ecology and Systematics 31:481- 531.

Talley, T.S., J.A. Crooks, and L.A. Levin. 2001. Habitat utilization and alteration by the invasive burrowing isopod, *Sphaeroma quoianum*, in California salt marshes. Marine Biology 138:561- 573.

Simberloff, D. 2003. Eradication—preventing invasions at the outset. Weed Science 51: 247- 253.

Strayer, D.L. 2006. Alien species in the Hudson River. Pages 296- 310 *in* J.S. Levinton and J.R. Waldman (editors). The Hudson River Estuary. Cambridge University Press, NY.

Whitfield, P., T. Gardner, S.P. Vives, M.R. Gilligan, W.R. Courtenay, Jr., G.C. Ray, and J.A. Hare. 2002. Biological invasion of the Indo- Pacific lionfish (*Pterois volitans*) along the Atlantic coast of North America. Marine Ecology. Progress Series 235:289- 297.

Williams, S.L., and E.D. Grosholz. 2002. Preliminary reports from the *Caulerpa taxifolia* invasion in southern California. Marine Ecology. Progress Series 233:307- 310.

Chemical Contamination

Background.

The urban waters and underlying sediments of New York City, including Jamaica Bay, contain a legacy of contaminants from the directed and largely unregulated discharges of the industrial era to the nonpoint- source pollution that washes off parking lots and roads and falls from the sky, among other sources (Steinberg et al. 2004). These contaminants are assimilated by the biota and become biomagnified along the food chain. Contaminant loads of algae, invertebrates, and fishes vary by location within Jamaica Bay and with trophic position. A major dichotomy is between rooted or sedentary organisms such as plants and most bivalves whose body burdens strongly reflect local contaminant sources and fish, which are highly mobile and may or may not be resident within Jamaica Bay. Important differences exist within fish species, such as striped bass, where some individuals spend considerable portions of their lives in the Hudson River, where they can accumulate high PCB loads, and others that do not (Waldman et al. 1990; Farley et al. 2006). Given its location at the mouth of the Hudson, a large spectrum of body burden levels would be expected among striped bass caught from Jamaica Bay.

Some sediment chronologies (through coring) have been estimated for Jamaica Bay. Using this approach Bopp et al. (2006) found sewage effluent to be the primary source of Ni, Zn, Cu, and Cd to the system, but Seidemann (1991) estimated that atmospheric fallout also contributes a significant fraction. Monitoring programs in the 1990s showed significant sediment toxicity at sites within the bay (Steinberg et al. 2004). Additionally, fish and shellfish samples from Jamaica Bay showed some species above the New York State Department of Health tolerance limits for PCBs and chlordane (Skinner et al. 1997a,b). Relatively high levels of Cu, Hg, Pb, and dieldrin were found in blue mussels from Jamaica Bay in comparison with mollusks sampled from other locations around the U.S. (O'Connor 2002).

Research Needs.

Periodic assessment of contaminant levels in the sediments and biota of Jamaica Bay are needed to chart trends and to reveal the presence of new contaminant sources. Jamaica Bay also presents an opportunity for researchers to study how contaminants enter and distribute through a highly urban system, i.e., fate and transport, and to examine their sublethal effects and the development of resistance (Wirgin et al. 2006) on its broad suite of aquatic organisms. Indeed, it's been said that the Hudson River estuary as a whole ". . . represents a superb environment for the study of AH (aromatic hydrocarbon) pollutants in the natural world (Wirgin and Waldman 2006). In that context, Jamaica Bay might be viewed as a useful comparative site within the larger estuarine complex.

Although a small set of fishes of Jamaica Bay have been analyzed for contaminants, with some levels found problematic, it would useful to know if serious biomagnification is occurring at higher trophic levels of fish- eating organisms such as cormorants, osprey, and diamondback terrapins. The relative roles of local vs. distant contaminant sources, by contaminant type is not well understood and it may be that landfills leach pollutants at locally significant levels.

Selected Bibliography for Chemical Contamination.

Bopp, R.F., S.N. Chillrud, E.L. Shuster, and H.J. Simpson. 2006. Contaminant chronologies from Hudson River sedimentary records. Pages 383- 397 *in* J.S. Levinton and J.R. Waldman, editors. The Hudson River Estuary, Cambridge University Press.

Farley, K.J., J.R. Wands, D.R. Damiani, and T.F. Cooney, III. 2006. Transport, fate, and bioaccumulation of PCBs in the lower Hudson River. Pages 368- 382 *in* J.S. Levinton and J.R. Waldman, editors. The Hudson River Estuary, Cambridge University Press.

O'Connor, T. 2002. National distribution of chemical concentrations in mussels and oysters in the U.S. Marine Environmental Research 53:117- 143.

Seidemann, D.E. 1991. Metal pollution in sediments of Jamaica Bay, New York, USA—An urban estuary. Environmental Management 15:73- 81.

Skinner, L.C., A.J. Newell, J. Waldman, and J. Shastay, Jr. 1997a. Chemical residues in fish, bivalves, crustaceans and a cephalopod from the New York- New Jersey Harbor estuary: PAHs in winter flounder and softshell clam. New York State Department of Environmental Conservation.

Skinner, L.C., R. Prince, J. Waldman, A.J. Newell, and J. Shastay, Jr. 1997b. Chemical residues in fish, bivalves, crustaceans and a cephalopod from the New York- New Jersey Harbor estuary: dioxins and furans. New York State Department of Environmental Conservation.

Steinberg, N., D.J. Suszkowski, L. Clark, and J. Way. 2004. Health of the Harbor: the first comprehensive look at the state of the NY/NJ Harbor Estuary. Report to the NY/NJ Harbor Estuary Program. Hudson River Foundation, New York, NY.

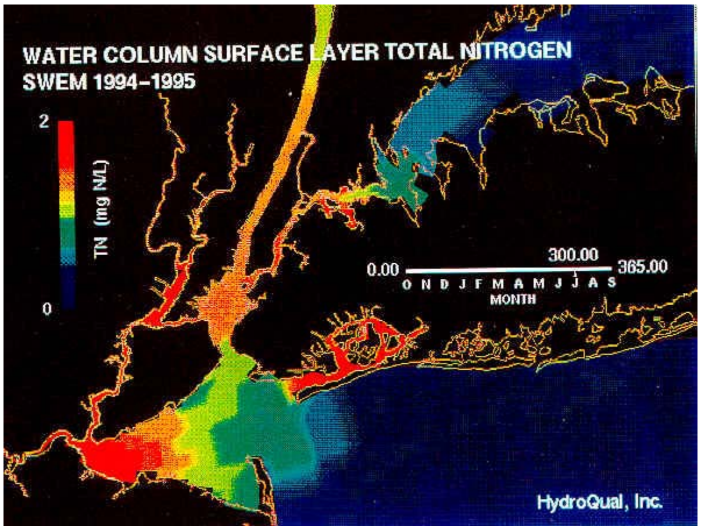
Waldman, J.R., D.J. Dunning, Q.E. Ross, and M.T. Mattson. 1990. Range dynamics of Hudson River striped bass along the Atlantic coast. Transactions of the American Fisheries Society 119:910- 919.

Wirgin, I., and J. Waldman. 2006. Bioaccumulation and toxicities of aromatic hydrocarbon contaminants at different trophic levels of the Hudson River Ecosystem. Pages 1552- 1568 in W.N. Rom, editor. Environmental and Occupational Medicine, 4th Edition, Lippincott- Raven Publishers.

Wirgin, I., J.S. Weis, and A.E. McElroy. 2006. Physiological and genetic aspects of toxicity in Hudson River species. Pages 441-464 *in* J.S. Levinton and J.R. Waldman (editors). The Hudson River Estuary. Cambridge University Press, NY.

Nutrient Enrichment and Eutrophication

Background.



Map demonstrating surface layer nitrogen during 1994- 1995. Source: HydroQual, Inc.

Jamaica Bay is a eutrophic system, receiving large quantities of nutrients that anchor the food chain. Although a moderate to high amount of nutrients are expected in estuaries from natural sources, Jamaica Bay is also subsidized by the nutrient products of the vast human population that surrounds it. Nitrogen is usually the limiting nutrient in estuaries (Rabalais 2002). Nitrogen is the major contributor to eutrophication in Jamaica Bay, with much of it reaching its waters from its four waste water treatment plants (26th Ward, Coney Island, Jamaica, and Rockaway). These plants, together with combined sewer overflow discharges and runoff from subway dewatering made up 92% of the 2005 nitrogen load, with non- point sources such as landfill leachate, groundwater flow, and atmospheric deposition accounting for the remainder (Benotti et al. 2007). It is hypothesized that high nitrogen levels in the Bay lead to increased organic matter (e.g., from phytoplankton and macroalgae production), which in turn can enhance hydrogen sulfide levels in marsh sediments to the point of being toxic to *Spartina alterniflora*, thus contributing to the observed marsh loss (NYCDEP 2007).

Jamaica Bay experiences two annual phytoplankton blooms (Sambrotto 2002), a larger one during winter- spring (February- April) and a lesser one in summer (June- September). Year-round bay- wide surveys have shown that dissolved inorganic nitrogen concentrations are well above the limiting levels for algae growth except in some well- flushed western and southern locations; in fact, in some places these concentrations would need to be reduced by a factor of 10 to become limiting. Nitrate, nitrite, and ammonia levels decrease during the summer bloom but phosphorus levels do not (Sambrotto 2002). Sambrotto (2002) also found that dissolved organic nitrogen equaled dissolved inorganic nitrogen in summer, thereby contributing significantly to the combined nitrogen pool for plant and phytoplankton growth and that carbon is limiting during intense phytoplankton blooms. These phytoplankton blooms can supersaturate dissolved oxygen levels but decaying plankton can lead to occasional hypoxic conditions. Because of the high variability in the timing and intensity of these blooms, the dissolved oxygen levels of the bay are also highly variable but are generally above New York State standards (NYCDEP 2007). In addition to phytoplankton blooms, the green macroalga, *Ulva lactuca*, carpets the tidal flats of Jamaica Bay, a response to high nitrogen loading.

Research Needs.

Nutrients in Jamaica Bay are well monitored at nine stations in the long- term New York Harbor Water Quality survey performed by New York City Department of Environmental Protection (NYCDEP 2004). But the relationships among nutrient enrichment and the biota require further study. How is the current species composition and abundance of the Bay's flora and fauna influenced or controlled by these eutrophic conditions? How different would a less enriched community look like? How does summer stratification of the water column (JABERRT 2002) affect fluxes of nutrients? What effects do major grazers such as menhaden, *Brevoortia tyrannus*, have on phytoplankton abundance (Oviatt et al. 1972)? Waterbirds have a large total biomass for portions of the year, what is their importance in nutrient fluxes (Erwin 1996)?

Is nitrogen enrichment really having a serious deleterious impact on salt marsh vegetation? Studies should be designed to evaluate the role of high nutrients in the allocation of Spartina biomass between above- and below- ground components. Belowground production and associated accumulation of peat contributes to the maintenance of salt marsh elevation in response to rising sea- level. Under high nutrient regimes, allocation of resources to the aboveground component may be greater than under low nutrient regimes, thus decreasing peat accumulation. This hypothesis requires testing in Jamaica Bay as one of several factors that may be contributing to marsh loss.

Further, to evaluate the relationship between marsh loss and nutrient loading, it would be interesting to determine trends of historic loadings of nitrogen to Jamaica Bay, similar to the kind of analysis done for other northeastern US estuaries (Jaworski et al. 1997, Roman et al. 2000), and then relate this to marsh loss trends over the past century (Hartig et al. 2002).

Selected Bibliography for Nutrient Enrichment and Eutrophication.

Benotti, M.J., M. Abbene, and S.A. Terraciano. 2007. Nitrogen loading in Jamaica Bay, Long Island, New York: Predevelopment to 2005. USGS Scientific Investigations Report 2007- 5051.

Erwin, R.M. 1996. Dependence of waterbirds and shorebirds on shallow water habitats in the mid- Atlantic coastal region: an ecological profile and management recommendations. Estuaries 19(2A):213- 219.

Hartig, E.K., V. Gornitz, A. Kolker, F. Mushacke, and D. Fallon. 2002. Anthropogenic and climate- change impacts on salt marshes of Jamaica Bay, New York City. Wetlands 22:71–89.

JABERRT (Jamaica Bay Ecosystem Research and Restoration Team). 2002. Final Report. Division of Natural Resources, Gateway National Recreation Area, National Park Service and Aquatic Research and Environmental Assessment Center, Brooklyn College.

Jaworski, N.A., R. W. Howarth, and L.J. Hetling. 1997. Atmospheric deposition of nitrogen oxides onto the landscape contributes to coastal eutrophication in the northeastern United States. Environmental Science and Technology 31: 1995- 2004.

NYCDEP (New York City Department of Environmental Protection). 2004. 2004 New York Harbor water quality survey regional summary.

NYCDEP (New York City Department of Environmental Protection). 2007. Draft Jamaica Bay Watershed Protection Plan.

Oviatt, C.A., A.L. Gall, and S.W. Nixon. 1972. Environmental effects of Atlantic menhaden on surrounding waters. Chesapeake Science 13:321- 323.

Rabalais, N. 2002. Nitrogen in aquatic ecosystems. Ambio: A Journal of the Human Environment 31:102- 112.

Roman, C.T., N. Jaworksi, F.T. Short, S. Findlay, and R.S. Warren. 2000. Estuaries of the northeastern United States: habitat and land use signatures. Estuaries 23: 743- 764.

Sambrotto, R. 2002. Nitrogenous nutrients and plankton production in Jamaica Bay, NY. Chapter 7.1 *in* Integrated Reconnaissance of the Physical and Biogeochemical Characteristics of Jamaica Bay: Initial Activity Phase. JABERRT Final Report. Division of Natural Resources, Gateway National Recreation Area, National Park Service and Aquatic Research and Environmental Assessment Center, Brooklyn College.

Marine Debris

Background.

Various materials wash onto the shores in Jamaica Bay, a possible result of landfill debris or runoff.

Debris, unfortunately, is common in the highly urbanized environment of the New York Harbor region, including Jamaica Bay. Floating debris, often called "floatables," is carried with the tides and may accumulate in eddies and on windward shores. Indeed, Dead Horse Bay was named for the equine cadavers that were dumped into New York Harbor and that washed into this cul- de- sac in Rockaway Inlet. Unsightly marine debris can have economic impacts on recreation; the perceived health threat from medical waste on New York metropolitan area beaches in 1987 and 1988 caused losses of as much as $4 billion in New Jersey and $2 billion in New York (Steinberg et al. 2004). Large items, such as floating timber, are a hazard to vessels.

The most common smaller debris items found on New York City beaches between 1994 and 1999 (in decreasing abundance) were cigarette butts, plastic food bags and wrappers, plastic caps and lids, plastic beverage bottles, foamed plastic pieces, plastic straws, glass and plastic fragments, and plastic cups and utensils (American Littoral Society 1999). But larger forms of debris can be found, such as abandoned automobiles and tires, concrete rubble, and derelict vessels.

Ecologically, some deleterious interactions between marine debris and organisms are possible in Jamaica Bay. Windrows of debris can form along shorelines and make it difficult or impossible for the beach spawning horseshoe crab to utilize particular reaches of shore and they can hinder the movement of egg- laying diamondback terrapins from the waters to nesting areas on the bay's islands. Debris in the form of fishing line, net fragments, and plastic six- pack can retainers can entangle, choke, and eventually kill fish, birds, and other organisms.

Research Needs.

Large piece of debris located next to the Gateway Marina.

It is not apparent how large of an ecological problem marine debris poses for the wildlife of Jamaica Bay. An inventory of beaches with chronic accumulations of debris is needed. Categorization of that debris might also be helpful in attempting to determine the likely sources of debris. That is, does most of it originate from inside of the bay or outside of the bay, carried through Rockaway inlet? If it comes from inside of the bay, are there apparent chronic sources? Might they be effectively controlled?

Selected Bibliography for Marine Debris.

American Littoral Society. 1999. New York State Beach Cleanup Annual Report. Highlands, Sandy Hook, NJ.

Steinberg, N., D.J. Suszkowski, L. Clark, and J. Way. 2004. Health of the Harbor: The First Comprehensive Look at the State of the NY/NJ Harbor Estuary. A Report to the NY/NJ Harbor Estuary Program. Hudson River Foundation, NY.

Plant Ecology

Background.

The New York City region has a diverse flora made up of northern, southern, and non- native forms, estimated by Clemants ands Moore (2005) as 556 woody species. The flora has been tracked over the past 100 years retrospectively using herbarium samples and recent surveys by the New York Metropolitan Flora project of the Brooklyn Botanical Gardens. Flora of the Gateway National Recreation Area represented in its herbarium appears in GNRA (1997). The vascular plant community of the Wildlife Refuge was characterized by Stalter and Lamont (2002) who inventoried 456 species of 270 genera and 70 families. The largest families were Asteraceae (77 species) and Poaceae (57 species), with the largest genera being *Polygonum*, *Cyperus*, *Aster*, *Panicum*, *Trifolium*, *Carex*, and *Eupatorium*. Among the most notable findings of Clemants and Moore (2005) was that nonnative invasive species are rapidly spreading in the area, while native species are generally in decline.

Research Needs.

Grasslands.

Grasslands at Floyd Bennett Field are divided by the historic runways and serve as valuable habitat to a variety of species.

Maritime grasslands occur in the Jamaica Bay watershed at JFK Airport, Floyd Bennett Field, and islands where sufficient uplands exist (NYCDEP 2007). One grassland at Floyd Bennett Field of 140 acres was restored and is maintained with clearing, mowing, and burning by NPS and the New York City Audubon Society (Cook and Tanacredi 1990). Although greatly reduced in area, the Jamaica Bay grasslands form one of the few sizable examples in the urban core of New York. These grasslands may exhibit high floristic diversity (Luttenberg et al. 1993) with common species including little bluestem, *Schizachyrium scoparium*, switchgrass, *Panicum vigatum*, and seaside goldenrod, *Solidago sempervirens*.

How does the present quality and quantity of grasslands compare with the past? What is their role in ecology of bay system as habitat and a food source? Should the relatively small amount of forest in the system be encouraged at the expense of grasslands? Do restored grasslands function ecologically as do natural ones? How important are the restored and natural grasslands regionally as nesting, feeding, and overwintering areas to the community of grassland birds such as Horned Lark, *Eremophila alpestris*, Eastern Meadowlark, *Sturnella magna*, Savannah Sparrow, *Passerculus sandwichensis*, Bobolink, *Dolichonyx oryzivorus*, and Barn Owl, *Tyto alba*? Stalter (1983) found variable plant communities among New York City landfills, including along Jamaica Bay, with fire and a host of other factors influencing species composition. Are there more unused opportunities for grassland creation such as on the surfaces of closed landfills?

Non- Native Plant Species and Invasives.

Phragmites have taken up residence in this decorated derelict boat at Plumb Beach.

Non- native plants are becoming more predominant in the New York City region. Broad patterns of change have been tracked by the New York City Metropolitan Flora project but finer- scale focus on Jamaica Bay is needed. Two species whose ecological effects are controversial but which often are considered invasive and are sometimes controlled are common reed, *Phragmites australis* (Myerson et al. 2000), and purple loosestrife, *Lythrum salicaria* (Hager and McCoy 1998). Phragmites often dominates low salinity marshes. Phragmites also appears to have greater resistance to suppression by wrack cover in Jamaica Bay than other marsh plants (Stalter et al. 2005). Purple loosestrife can crowd out native vegetation in freshwater wetlands. Also, bayberry, *Mryica pensylvanica*, was noted as expanding into grasslands at Floyd Bennett Field in the early 1980s (Rogers et al. 1984). Although a native species, does this shrub remain a threat to grasslands?

Given the many possible vectors, colonization by invasive plants is ongoing in major urban environments. For this reason, regular monitoring is needed. But beyond mere recognition of new occurrences is the need for fundamental assessment of the actual environmental effects of these new species and, particularly, their interactions with other plant and animal species. Another likely important factor in their success is the substrata. Wijesundara (1997) studied vegetation in a portion of Floyd Bennett Field. Of the 125 species he identified, one- third were exotic. He also found that succession was much faster in landfilled areas than in natural substrata. Do such habitats provide colonization avenues for non- native plants?

Because invasive plant species are so prevalent throughout the urbanized Jamaica Bay Unit, removal of all non- native invasives is not a reasonable goal. Therefore, a comprehensive study is needed to identify habitats and our native plant species that are threatened by non- native species, thereby helping to prioritize habitats or specific areas for invasive control.

<u>State- Listed Rare Plants</u>.

Sea beach amaranth, a state listed rare plant, in found along many of Gateway's sandy beaches.

Stalter and Lamont (2002) found 12 species in the Jamaica Bay Wildlife Refuge to be listed as rare in New York State. A rare plant that grows in beach and dune areas of Jamaica Bay is the sea beach amaranth, *Amaranthus pumilis*, which had been thought to be extirpated from New York State until it was rediscovered in 1990 (NYCDEP 2007). Other state- listed rare plants within the Jamaica Bay Unit include Houghton's umbrella sedge, *Cyperus houghtonii*, Schweintz's flatsedge, *Cyperus schweinitzii*, blunt spikerush, *Elacharis obtusa* var. *ovata*, field- dodder, *Cuscuta pentagona*, and smartweed- dodder, *Cuscuta polygonorum*.

The abundance and survival of rare plants is fluid and requires monitoring. Thus, periodic surveying should occur, but because of the possibility for the publicizing of the resultant information to encourage illegal collecting, any such surveying should be performed in conjunction with the National Park Service. Also, research should focus on whether particular plants are rare in this area by nature or because of marginal or declining conditions, or because of competition or predation by nonindigenous species. To facilitate possible re- introduction efforts, it is also important to understand the environmental factors contributing to rarity for specific species.

Fire Management.

The grasslands at Floyd Bennett Field may benefit from a prescribed burn which could prevent the growth of woody shrubs and upland vegetation.

Fire, both naturally- and unnaturally- ignited, is to be expected in an urban wildlife park. Fire can be a threat to homes at the perimeter of the refuge. But fire can also play a regenerative role in nature (TNC 2007). The current policy of NPS is to suppress all fire; despite its regenerative role in nature (exceptions will be forthcoming that will allow the use of management- ignited fire to maintain the restored grasslands at Floyd Bennett Field and elsewhere). Whether and how additional controlled burning should be used, or fire suppression relaxed, is an area for further investigation. Rudnicky and Patterson III (1994) showed that the season of burn can have different results on vegetation communities at Floyd Bennett Field.

Selected Bibliography for Plant Ecology.

Clemants, S.E., and G. Moore. 2005. The changing flora of the New York metropolitan region. Urban Habitats 3(1):192- 210. http://www.urbanhabitats.org/v03n01/nymf_full.html.

Cook, R.P., and J.T. Tanacredi. 1990. Management strategies for increasing habitat and species diversity in an urban National Park. Pages 171- 177 *in* Environmental Restoration: Science and Strategies for Restoring the Earth. Island Press, Covelo, California.

GNRA (Gateway National Recreation Area). 1997. Flora of Gateway National Recreation Area. Division of Natural Resources and Compliance, GNRA. National Park Service.

Hager, H.A., and K.D. McCoy. 1998. The implications of accepting untested hypotheses: a review of the effects of purple loosestrife (*Lythrum salicaria*) in North America. Biodiversity and Conservation 7:1069- 1079.

Luttenberg, D., D. Lev, and M. Feller. 1993. Native species planting guide for New York City and vicinity. New York City Department of Parks and Recreation & Natural Resources Group.

Myerson, L.A., K. Salstonsall, L. Windham, E. Kiviat, and S. Findlay. 2000. A comparison of *Phragmites australis* in freshwater and brackish marsh environments in North America. Wetlands Ecology and Management 8(2- 3):89- 103.

NYCDEP (New York City Department of Environmental Protection). 2007. Draft Jamaica Bay Watershed Protection Plan.

Rogers, G.F., J.M. Robertson, W.D. Solecki, and M.K. Vint. 1984. Rate of *Myrica pensylvanica* (bayberry) expansion in grassland at Gateway National Recreation Area, New York. Gateway Institute for Natural Resource Sciences.

Rudnicky, J.L., and W.A. Patterson. 1994. Prescribed burning studies for grassland habitat maintenance at Floyd Bennett Field, Gateway national Recreation Area, Brooklyn, New York. Final Report, Holdsworth Natural Resource Center, University of Massachusetts, Amherst.

TNC (The Nature Conservancy 2007). Fire, ecosystems & people: threats and strategies for global biodiversity conservation. Tallahassee, FL.

Stalter, R. 1983. The plant communities on four landfill sites, New York City, New York. Gateway Institute for Natural Resource Sciences.

Stalter, R., A. Jung, and A.D. Byer. 2005. Effect of wrack accumulation on salt marsh vegetation, Jamaica Bay Wildlife Refuge, New York City, New York. Ecosystems and Sustainable Development V:451- 458.

Stalter, R., and E.E. Lamont. 2002. Vascular flora of Jamaica Bay Wildlife Refuge, Long Island, New York. Journal of the Torrey Botanical Society 129:346- 358.

Wijesundara, D.S.A. 1997. Phytosociological studies of Floyd Bennett Field, Brooklyn, New York. Doctoral dissertation, City University of New York.

Wildlife Ecology

Background.

Fishing is a primary activity of those that recreate in Jamaica Bay.

An osprey occupies a nest in the Jamaica Bay Wildlife Refuge; one of New York's few natural areas that lies adjacent to John F. Kennedy International Airport.

Despite many environmental issues and the nearby presence of the enormous human population of metropolitan New York, Jamaica Bay is something of an urban oasis for wildlife. Indeed, it is one of the premier birding sites in the nation with more than 325 species recorded in the Refuge alone, including rare visitors from Europe and elsewhere. The bay's population of horseshoe crabs is large and the forage they provide as eggs is intimately tied to shorebird migrations (Castro and Myers 1993). The bay also sits near the confluence of the Hudson River estuary and the New York Bight, a location where many of the 338 fish species recorded by Briggs and Waldman (2002) for New York's marine waters can be expected to be seen. Fishing remains a primary recreational activity on the bay. Jamaica Bay is also one of the few water bodies in the New York region that has sustained a large diamondback terrapin population (Feinberg and Burke 2003). But because they occur in a highly urbanized system, the wildlife of Jamaica Bay also face myriad challenges not felt in more pristine settings. Much habitat loss has already occurred and the bay's important salt marshes continue to shrink. Invasive species crowd out native forms. Contaminants provide sublethal physiological stresses. Feral animals compete with and perhaps prey upon wild animals. Thus, the understanding the wildlife ecology of this urban system is both a substantial challenge and opportunity.

Research Needs.

<u>Diadromous Fishes</u>.

Anadromous alewife.
Source: Washington Department of Fish and Wildlife

Jamaica Bay has limited lotic flow, but Hook and Motts Creeks on its eastern flank might possibly support small populations of the anadromous alewife, *Alosa pseudoharengus*. Surveys should be performed for the presence of adults in spring or for early life stages in spring or summer. Jamaica Bay does serve as a nursery for juvenile, yearling, and subadult striped bass of Hudson River origin (Socrates 2006; Dunning et al. 2006). But the relative importance of the bay to the larger striped bass nursery of the lower Hudson River and other regional bays remains unknown. Other anadromous fishes are spawned in the Hudson River and then outmigrate to coastal waters (Waldman 2006); however, little is known of the importance of Jamaica Bay as a nursery or staging area for such species as alewife, blueback herring, *Alosa aestivalis*, American shad, *A. sapidissima*, and Atlantic sturgeon, *Acipenser oxyrinchus*.

American eel.
Source: National Oceanic and Atmospheric Administration

The American eel, *Anguilla rostrata*, is the only catadromous fish found in Jamaica Bay. Over the past several decades eels have declined dramatically throughout their North American range (Haro et al. 2000). But eels were common in Jamaica Bay and were subject to recreational and small commercial fisheries, most recently for live bait for striped bass. It would be useful to create a baseline of eel distribution and densities throughout the Jamaica Bay watershed for tracking future change and for comparison with other coastal bays. Also, little is known of the degree with which glass eels enter the system from the Gulf Stream. Eels may be subject to environmental sex determination (Krueger and Oliveira 1999); analysis of gender- specific habitat use and size- specific habitat use would help understanding of eel biology in the Jamaica Bay watershed.

Marine Fishes.

A wide variety of nekton reside in the waters of Jamaica Bay. The Elders Point Marsh restoration project has an inventory and monitoring protocol for nekton that utilize the marsh. (Above) Coastal Ecologist, Patricia Rafferty, and crew member inventory fish scooped in the net; (Below) Nekton caught in the scoop net.
Source: Patricia Rafferty

Jamaica Bay's geographic location fosters a high diversity of fishes. It is situated at the margin of a major estuary, the Hudson and, hence it seasonally hosts adults and juveniles of its anadromous ichthyofauna (e.g., striped bass, *Morone saxatilis*), it is a coastal bay that is visited seasonally by adults and young of many important temperate marine species (e.g., summer flounder, *Paralichthys dentatus*, bluefish, *Pomatomus saltatrix*, Atlantic herring, *Clupea harengus*), it is one of the sequence of bays on Long Island's south shore that receives young life stages of more tropical fishes carried north each spring and summer by the Gulf Stream (e.g., spotfin butterflyfish, *Chaetodon ocellatus*, grey snapper, *Lutjanus griseus*) and temperate fishes transported from the continental shelf (Morgan 2006), and it is a large and productive enough system itself to support a resident ichthyofauna (e.g., winter flounder, *Pseudopleuronectes americanus*, mummichog, *Fundulus heteroclitus*, silversides, *Menidia menidia*). A fish survey by NPS in 1985- 1986 and 1988- 1989 captured about 75 species (GNRA 1991). Briggs and Waldman (2002) and Waldman et al. (2006) published more extensive lists of fishes found in the marine waters of New York, many of which could be expected to occur in Jamaica Bay.

It is important for the study of the bay's fishes to extend beyond surveys. The survey by GNRA (1991) generated much ancillary information, such as date, location, sample size, and fish length. These data and newly collected data could be analyzed further, perhaps within a multivariate framework, to better characterize the areal and seasonal communities of fishes within the bay, as well as habitat preferences.

It would be useful to document all fishes known from Jamaica Bay and to maintain a master living annotated list. Although broad patterns of seasonal usage are known from sportfisheries and occasional scientific fish surveys, annual, seasonal, and geographic variation within the fish community of the bay is not well described. Neither is Jamaica Bay well characterized as a spawning area versus a nursery for individuals spawned elsewhere that migrate to it (e.g., bay anchovy; Tipton and Hartman 2007). Major spawning locations within the bay, especially for declining species such as winter flounder might be viewed as critical habitat that warrants special protection. The discreteness of resident species in the bay also requires additional study—do winter flounder produced in Jamaica Bay largely remain in the watershed or do they enter the New York Bight? If they do exit the bay, do most home for reproduction? Tools to address this question include traditional mark- recapture, sensitive genetic analyses (Wirgin and Waldman 2004), and elemental composition of otoliths (Thorrold et al. 2001).

The fishes of New York Harbor and Jamaica Bay were found in prior decades to show abnormalities consistent with contaminant stress (e.g., Augspurger et al. 1994). It would be useful to assess fish condition today and to compare it with earlier studies.

Shellfish.

Oyster shell found on Plumb Beach. Is this an oyster from an existing colony, a past colony or from somewhere else completely?

Jamaica Bay once supported large and lucrative shellfisheries, including for oyster, hard clam, softshell clam, and blue crab. But they were closed in 1921 by the New York City Health Department due to the threat of disease from untreated sewage. This threat persists through today; some shellfish may also exceed allowable thresholds for contaminants. Because of these concerns, current shellfisheries are reduced to recreational harvests of blue crab (Briggs 1998) and limited takes of ribbed mussel for bait and chum for angling. Blue crab from Jamaica Bay appears safe for consumption (Skinner et al. 1997a,b) because it is a highly mobile species that forms a broad coastal population, not one that is discrete within Jamaica Bay. However, the bay's large hard clam population makes it attractive to illegal harvest (Waldman 1999), which remains a threat to human health.

Although shellfishing in Jamaica Bay is no longer important, shellfish do play a meaningful role in the ecology of the system. Oysters are no longer important ecologically (and may even be extirpated) but ribbed mussels remain as major filter feeders. Ribbed mussels are found attached to hard structure on mudflats. But they also form part of the firmament of marshes and may even aid in the process of wetlands creation by retaining sediment and organic material among their tight clusters, allowing plants to take root (Rice and Gibbs 1995). However, a contrary view presents a research question—Franz and Friedman (2004) postulated that small berms created by ribbed mussels causes localized ponding that leads to the submergence of saltmarsh cordgrass and eventually, loss of saltmarsh habitat.

If the filtering capacity of the ribbed mussel population of Jamaica Bay is important ecologically, it would be important to know how the loss of salt marsh is affecting the densities of ribbed mussels as salt marsh transforms to mudflats. It also would be useful to determine whether the opening of this habitat to the filtering capacity of subsurface bivalves in addition to mudflat-dwelling ribbed (and blue) mussels is a net loss or net gain of filtering capacity.

Horseshoe Crab.


Horseshoe crab eggs provide essential nutrients to migrating shorebirds.

Jamaica Bay is well known as a major spawning location for the American horseshoe crab, *Limulus polyphemus*. Each spring during full and new moon tides, large numbers of these arthropods clamber onto bay beaches to reproduce. The eggs produced are important for migratory shorebirds, much as for the larger and more famous aggregation that does likewise in Delaware Bay (Castro and Myers 1993).

Plumb Beach in Jamaica Bay is one of the stations monitored annually in New York for abundances and sex ratios of breeders (Sclafani and McKown 2007). In 2000, Botton et al. (2006) quantified spawning activity at five small beaches in Jamaica Bay proposed for restoration and found that availability of suitable shoreline rather than water quality was limiting. Thus, a bay- wide survey of actual and potential spawning locations is needed, as is development of a juvenile recruitment index. An important question is what are the geographic limits of the Jamaica Bay population? What percentages remain in the bay or move out of it? Tagging studies have indicated the species homes to its natal beaches and that most make limited coastal movements but that some journey more than 100 km (Swan 2005). Swan (2005) found evidence of movement between Jamaica Bay and Raritan Bay, New Jersey. Additional tagging to monitor short- and long- scale movements is needed.

Diamondback Terrapin.

A diamondback terrapin ambles away as researchers observe.

The diamondback terrapin, *Malaclemys terrapin*, is the only turtle adapted to salt marshes along the Atlantic coast. This species once flourished in the vast marsh networks of New York Harbor and Long Island but was severely reduced because of harvesting for its meat for soup and because of habitat loss and degradation. Jamaica Bay has served as a refuge for the diamondback terrapin, where it maintains a relatively large population. Russell Burke of Hofstra University maintains an active annual monitoring and research program for the terrapin population of Jamaica Bay. Feinberg and Burke (2003) located nesting activity at three sites in the bay, with as many as 2,053 nests oviposited at the most active site in 1999. But more than 90% of the nests monitored that year suffered depredation from raccoons. Surprisingly, plant roots may also draw nutrition from and kill terrapin eggs (Butler et al. 2004).

The historical presence and abundance of raccoons in the Jamaica Bay system is not definitively known. It also is not clear whether the recent high level of depredation by raccoons, together with other sources of mortality such as plant roots is going to cause the terrapin population to decline, thus, modeling of their interactions might prove instructive. Because they nest on islands, the effects of salt marsh loss will strongly affect terrapins. Terrapins appear to be highly mobile but mostly residential within the bay; the degree of interchange among neighboring populations should be assessed. Terrapins are also vulnerable to directed poaching and bycatch in crab or fishing gear but little is known of the magnitudes of these factors or even if such problems exist. The upland movement of female diamondback terrapins from the water to deposit their eggs is a compelling public nature spectacle. Consideration of the appropriate degree of protection versus encouragement of visitors at these times requires evaluation, as does the management of trampling and vegetation of trails used by these turtles.

A diamondback terrapin burrows into the sand at the Jamaica Bay Wildlife Refuge.

Given the current rate of salt marsh loss, it would be interesting to determine the relationship between this significant change in the Bay habitat and the response of terrapin populations. What is the role of salt marsh habitat in the foraging ecology of the terrapin, as well as avoidance from predation for adult and newly hatched populations?

<u>Other Reptiles and Amphibians</u>.

Jamaica Bay does not contain a high diversity of reptiles and amphibians, but representatives include a number of frogs, toads, snakes, salamanders, and turtles. Many have been introduced. Rhoads et al. (2001) list 14 species observed from the bay area; all are noted as having been introduced. Among them are snapping turtle, *Chelydra serpentina*, Eastern milk snake, *Lampropeltis triangulum*, Eastern hognose snake, *Heterodon platirhinos*, redback salamander, *Plethodon cinereus*, spotted salamander, *Ambystoma maculatum*, Fowler's toad, *Bufo woohousii fowleri*, and spring peeper, *Pseudacris crucifer*. Sea turtles are occasionally seen in the bay, including the federally (endangered) listed Kemp's ridley, *Lepidochelys kempii*, and leatherback turtles, *Dermochelys coriacea*, the federally (threatened) and state listed (threatened) loggerhead turtle, *Caretta caretta*, and the green turtle, *Chelonia mydas* (NYCDEP 2007).

The reptiles and amphibians of the bay region have received little attention as to their ecological role in the system. Periodic monitoring of the Jamaica Bay reptile and amphibian fauna is especially warranted. Because freshwater is limited, freshwater dependent species could become extirpated. Other species could be gained, given how exotic reptiles and amphibians are often kept as pets and pet releases are one of the major vectors for colonizations of these animals. The environs of Jamaica Bay would be an attractive release area for the many pet owning residents of New York City.

The Unit holdings also offer the opportunity for reintroduction of extirpated reptiles and other life forms. This already occurred in Floyd Bennett Field in 1989 for two turtle species in a human- created habitat (Cook 1996). Short- term monitoring indicated different levels of success for the two species; long- term assessment is needed. Additional research on habitat suitability for re- introductions is needed.

<u>Passerine Birds</u>.

A yellow warbler takes a meal the Jamaica Bay Wildlife Refuge.

Jamaica Bay is an important stopover for neotropical migrant birds (which winter in Latin America and breed in North America), in addition to its more residential passerine avifauna. Neotropical migrants have been of considerable global conservation concern following analysis of long- term trend data showed serious declines (Askins 1995). The most numerous neotropical migrant is barn swallow, *Hirundo rustica*. Other common ones include willow flycatcher, *Empidonax traillii*, and yellow warbler, *Dendroica petechia*.

The grasslands at Floyd Bennett Field have been on a regular mowing schedule but is that the best management for this habitat?

Elbin and Koontz (1998) surmised that restored grasslands at Floyd Bennett Field may help increase the population of Savannah Sparrows. Should additional habitats be restored in the Unit, potentially at a cost to other species making use of current conditions? What particular characteristics of restored grasslands are optimal for one or more grassland passerine species? Variables include patch size, distance among patches, floristics, vegetation structure, and the amount of woody vegetation. How are restored grasslands for bird habitat nest maintained—through mowing, haying, controlled burning, or some combination?

Shorebirds.

The piping plover, a federally listed endangered species, regularly nests and breeds on the beaches of the Breezy Point District of the Jamaica Bay Unit.

Tern colonies are common along the shores of Jamaica Bay but have been experiencing a steady decline.

Shorebirds represent an important part of the Jamaica Bay avifauna community and are a highly visible, somewhat iconic part of its animal life. Historically, about 44 species of shorebirds have been seen in the bay area. Common migratory shorebirds that breed in the bay include Killdeer, *Charadrius vociferous*, Oystercatcher, *Haematopus palliates*, Willet, *Catoptrophorus semipalmatus*, Spotted Sandpiper, *Actitus macularia*, Greater Yellowlegs, *Tringa melanoleuca*, Ruddy Turnstone, *Arenaria interpres*, and Common Tern, *Sterna hirundo* (USFWS 1997), the latter persisting in seven colonies totaling more than 1000 individuals. Jamaica Bay also contains the only Laughing Gull, *Larus atricilia* colonies in New York State, this species having recolonized the bay in 1979. Jamaica Bay also provides feeding and nesting habitat for the federally- listed endangered Roseate Tern, *Sterna dougallii dougallii*, and the federally- listed threatened piping plover, *Charadrius melodus*, the latter receiving considerable research and management attention (Lauro 2004). Other shorebirds became disproportionately numerous, such as the Herring Gull, *Larus argentatus*, probably because of the nearly unlimited food provided by the landfills when they were still operational (NYCDEP 2007). Indeed, gulls are the only major bird group present year round in the bay in abundance (Burger 1998).

How will the decrease in salt marshes affect the shorebird community in Jamaica Bay and the broader New York Harbor- western Long Island region, both for nesting and feeding purposes? What is the predicted response of the shorebird community to the ongoing conversion of vegetated salt marsh to mudflat, especially with regard to foraging? Can available nesting habitat be enhanced? Is it limiting? Have opportunistic species such as the Herring Gull reached new equilibrium population levels? How does population size of one shorebird species affect the others? Are interactions between shorebirds and humans being managed as effectively as possible, such as between laughing gulls and aircraft at JFK Airport (Brown et al. 1999).

Waterfowl.

Canada geese are just one of the many waterfowl that utilize Jamaica Bay for mating, nesting and fledging young.

The waters of Jamaica Bay are a very important regional wintering area for waterfowl. Mid- winter surveys have shown average concentrations of about 12,000 birds annually. Prominent species include Greater Scaup, Bufflehead, Black Duck, Mallard, Brant, Canvasback, and Canada Goose. Waterfowl concentrations also occur during the spring and fall migration seasons. Waterfowl known to nest in Jamaica Bay include Canada Goose, Black Duck, Mallard, Gadwall, and Ruddy Duck.

The distributions and phenologies of these birds are reasonably well known, but their ecological roles are less so. What foods do they rely on from the bay? What are their effects on these food resources? The importance of Jamaica Bay to their larger populations also should be better defined.

Harbor Herons.

Glossy Ibis feeding along the East Pond at the Jamaica Bay Wildlife Refuge.

Harbor Herons is a catch- all term for the complex of long- legged wading birds, including Great Egret, Snowy Egret, Cattle Egret, Black- Crowned Night heron, Yellow- Crowned Night Heron, Tri- Colored heron, Green- Backed Heron, Little Blue Heron, and Glossy Ibis, that have staged a remarkable recovery in the New York City region, including Jamaica Bay. These birds, numerous in the 1800s, were hunted for their plumage in a fashion craze in the New York Harbor region and then did not recolonize as breeders through much of the 1900s, presumably because of poor water quality and the consequent paucity of prey (Waldman 1999).

But not long after the Clean Water Act was enacted in 1972, regional water quality improved, prey fish abundances rose and the harbor herons began to nest on some of the islands of the harbor, including Pralls, Island of Meadows, and Shooters in the Arthur Kill and North and South Brother in the East River. By 2004 there were 1,700 breeding pairs at seven colonies (Kerlinger 2004). Many of the islands of Jamaica Bay also support colonies of these birds. Canarsie Pol hosts breeding colonies of Great Egret, Snowy Egret, Glossy Ibis, Black- crowned Night Heron, and Tri- colored Heron. However, Cattle Egret had stopped nesting in Jamaica Bay as of 1998 (Brown et al. 2001).

In recent years there have been large abandonments and relocations of New York Harbor islands by these birds. Disruption from human activities has been postulated as a cause for these dramatic changes, but new research supports a process based on the interaction between the Harbor Herons tendency to aggregate and the depletion of local resources (Russell and Rosales 2006). It is important to know what role the bay plays in the larger Harbor Heron community. Is it particularly valuable to certain colonies that nest outside of the bay? And to certain species? It is likely that the different Harbor Heron species have significantly different home ranges and habitat preferences. How do these radii overlap with the bay for those birds nesting in the bay and those that nest elsewhere? What prey do the Harbor Herons favor? Do Harbor herons significantly deplete fish and invertebrates of the bay?

Cormorants.

Double-crested Cormorants rest atop logs in the East Pond of the Jamaica Bay Wildlife Refuge.

From the 1950s to the 1970s, the widespread use in America of DDT, DDE, and other organochlorine contaminants had a deleterious effect on the North American population of Double- crested Cormorants, *Phalacrocorax auritus* (Weseloh and Ewins 1994). In 1974 the species was placed under the protection of the Migratory Bird Act. That action, combined with the effects of the Clean Water Act and possibly, the new winter food source of fish removed from southern U.S. aquaculture facilities caused numbers of Double- crested Cormorants to soar. Although not known to nest near New

York City historically, birds from the north colonized the region in the 1980s. Today they are ubiquitous at its marine and freshwater environs. In 2004 in New York Harbor alone they were known to nest on six islands and three channel markers, totaling about 875 breeding pairs. In 2007, Double- crested Cormorants were found to be nesting in the Elder's Point marshes of Jamaica Bay.

Double- crested Cormorants are highly piscivorous, each consuming approximately one pound of fish per day, although small crustaceans and squid also are taken (Withers and Brooks 2004). Because of this piscivory and large total prey demand at locations where they are numerous, Double- crested cormorants have been blamed by fishermen for decreases in fish stocks. It is important to know what role Jamaica Bay plays in the cormorant community of the New York City and Long Island region. Diet work on the species has shown it to be opportunistic and thus, the prey chosen to be highly site- specific; for this reason it would be useful to characterize cormorant food habits in Jamaica Bay. Although their food habits are well described from freshwater locations, little is known about their diets in estuarine systems (Withers and Brooks 2004).

Raptors.

Osprey frequently nest in nest boxes provided in and around Jamaica Bay.

The Jamaica Bay area sees numerous raptors during the fall migration season with an average of 1570 birds sighted at the raptor banding station at Breezy Point (operated by volunteers on behalf of the Hawk Migration Association of North America). Raptors most frequently seen include Sharp- shinned Hawk, Coopers Hawk, Northern Harrier, Merlin, Kestrel, and Osprey. Although osprey remain on New York's list of threatened species, they have made a comeback in the New York metropolitan region, including in Jamaica Bay. This recovery appears partly due to the dampening of DDT effects on their reproduction and to a recovery of the fish resources they depend upon. Which fishes do they depend upon? How many nesting pair use the bay? Are osprey near their carrying capacity? If not, are they limited by available nesting sites or some other factor? Which other raptors nest in and near Jamaica Bay?

Mammals.

Small mammals are the primary mammalian inhabitants of Jamaica Bay.

The terrestrial mammal fauna of Jamaica Bay is limited to smaller and more cryptic species that can survive in the presence of or nearby large human populations. Rhoads et al. (2001) list as common native mammals that could occur in eastern Jamaica bay as eastern cottontail, *Sylvilagus floridanus*, gray squirrel, *Sciurus carolinensis*, house mouse, *Mus musculus*, white- footed mouse, *Peromyscus leucopus*, meadow vole, *Mircotus pennsylvanicus*, opossum, *Didelphis virginiana*, muskrat, *Ondatra zibethicus*, hoary bat, *Lasiurus cinereus*, red bat, *Lasiurus borealis*, little brown bat, *Myotis lucifugus*, and silver- haired bat, *Lasionycteris noctivagans*, plus two introduced species, eastern chipmunk, *Tamais striatus*, and black- tailed jackrabbit, *Lepus californicus*. But most of these animals are not numerous. The most typical mammals observed in surveys are feral dogs and cats and rats (USFWS 1997). The mostly nocturnal raccoon also is common and has become a serious predator of diamondback terrapin eggs. Marine mammals that sometimes occur in the bay include bottlenose dolphin, *Tursiops truncates*, and harbor seal, *Phoca vitulina*.

The population size of feral mammals and rats and whether they compete with or prey upon native mammals deserves study. The degree of movement and exchange of mammals between the refuge and human- populated areas is unknown. The historical presence of raccoons in the bay has been debated; whether they should be controlled to ease pressure on terrapins requires consideration. Little is known of the bats of the bay beyond which species are found there.

Insects.

The highly diverse insect fauna of Jamaica Bay deserves research focus. Current knowledge is rudimentary. Many taxa are not well inventoried, nor are their distributions in the park well-mapped, if at all. Little is known of the details of insect usage of the area. Phenologies of insect occurrences and life stages should be developed.

A variety of insects reside within Jamaica Bay including butterflies, bumble bees and troublesome "bag worms".

Butterflies in Jamaica Bay have received attention, mainly from the North American Butterfly Association, which reports having observed almost 70 species from the bay. The large broad- winged skipper, *Poanes viator*, has undergone a tremendous population explosion due to its ability to use *Phragmites* as a foodplant. Several regionally rare species are regularly seen at the Refuge, including checkered white, *Pieris protodice*, Appalachian azure, *Celastrina neglectamajor*, and salt marsh skipper, *Ponoquina panoquin*, butterflies. Jamaica Bay is along the autumn coastal migration route for the monarch butterfly, *Danaus plexippus* (Brower 2004), a movement that qualifies as an annual nature spectacle attractive to the public. A lesser known but also dramatic autumn migration of odonates (dragonflies and damselflies) can be seen at the bay; 16 species were identified by Zuzworsky (1996). Whether sufficient stopover habitat exists for these migrations should be assessed. The moths of Jamaica Bay have been systematically surveyed in recent years; as of 2006, 358 species of macro moths and 115 species of micro moths have been identified (Walter 2007). But little is known of their local ecologies beyond their adult phenologies. Finally, what are the major pollinators around Jamaica Bay? Is there evidence of a decline in pollinators, such as recently noted (Cain and Tepedino 2001) for some bees and other pollinators in North America?

Selected Bibliography for Wildlife Ecology.

Askins, R.A. 1995. Hostile landscapes and the decline of migratory songbirds. Science 267:1956- 1957.

Augspurger, T.P., R.L. Herman, J.T. Tanacredi, and J.S. Hatfield. 1994. Liver lesions in winter flounder (*Pseudopleuronectes americanus*) from Jamaica Bay, New York: Indications of environmental degradation. Estuaries17(1B):172- 180

Botton, M.L., R.E. Loveland, J.T. Tanacredi, and T. Itow. 2006. Horseshoe crabs (*Limulus polyphemus*) in an urban estuary (Jamaica Bay, New York) and the potential for ecological restoration. Estuaries and Coasts 29:820–830.

Briggs, P.T. 1998. New York's blue crab (*Callinectes sapidus*) fisheries through the years. Journal of Shellfish Research 17:487- 491.

Briggs, P.T., and J.R. Waldman. 2002. Annotated list of fishes reported from the marine waters of New York. Northeastern Naturalist 9:47- 80.

Brischler, J.M. 2005. A study of the striped bass in the Marine District of New York. Completion Report, Anadromous Fish Conservation Act, P.L. 89- 304, Special Report #03- 01 Marine Sciences Research Center, State University of New York at Stony Brook.

Brower, L.P. 2004. Understanding and misunderstanding the migration of the monarch butterfly (Nymphalidae) in North America: 1857- 1995. Journal of the Lepidopterists Society 49:304- 385.

Brown, K.M., J.L. Tims, R.M. Erwin, and M.E. Richmond. 1999. Managing birds and controlling aircraft in the Kennedy Airport- Jamaica Bay Wildlife Refuge complex: the need for hard data and soft opinions. National Park Service, Technical Report NPS/BSO- RNR/NRTR/00- 9.

Brown, K.M., J.L. Tims, R.M. Erwin, and M.E. Richmond. 2001. Changes in the nesting populations of colonial waterbirds in Jamaica bay Wildlife Refuge, New York, 1974–1998. Northeastern Naturalist 8:275- 292.

Burger, J. 1988. Jamaica Bay studies VIII: An overview of abiotic factors affecting several avian groups. Journal of Coastal Research 4:193- 205.

Butler, J.A., C. Broadhurst, M. Green, and C. Mullin. 2004. Nesting, nest predation and hatchling emergence of the Carolina diamondback terrapin, *Malaclemys terrapin centrata*, in northeastern Florida. American Midland Naturalist 152:145- 155.

Cane, J.H. and V.J. Tepedino. 2001. Causes and extent of declines among native North American invertebrate pollinators: detection, evidence, and consequences. Conservation Ecology 5(1): URL: http://www.consecol.org/vol5/iss1/art1/.

Castro, G., and J.P. Myers. 1993. Shorebird predation on eggs of horseshoe crabs during spring stopover on Delaware Bay. The Auk 110: 927- 930,

Cook, R.P. 1996. Movement and ecology of eastern box and painted turtles repatriated to human- created habitat. Doctoral dissertation, City University of New York.

Dunning, D.J., J.R. Waldman, Q.E. Ross, M.T. Mattson. 2006. Dispersal of Age- 2+ striped bass out of the Hudson River. American Fisheries Society Symposium Series 51:287- 294.

Elbin, S.B., and F.W. Koontz. 1998. Status of grassland birds breeding on restored grasslands at Floyd Bennett Field, Gateway National Recreation Area. Final Report, Wildlife Conservation Society.

Feinberg, J.A., and R.L. Burke. 2003. Nesting ecology and predation of diamondback terrapins, *Malaclemys terrapin*, at Gateway National Recreation Area, New York. Journal of Herpetology 37:517- 526.

Franz, D.R., and I. Friedman. 2004. Erosion and pool formation in a Jamaica Bay fringing marsh – the mussel berm hypothesis. Proceedings: Jamaica Bay's disappearing marshes. National Park Service, Gateway National Recreation Area, New York.

GNRA (Gateway National Recreation Area). 1991. Jamaica Bay fisheries survey: 1985- 1986, 1988- 1989. National Park Service.

Haro, A., W. Richkus, K. Whalen, A. Hoar, W.- D. Busch, S. Lary, T. Brush, and D. Dixon. 2000. Population decline of the American eel: implications for research and management. Fisheries 25(9):7- 16.

Kerlinger, P. 2004. New York City Audubon Society's Harbor Herons Project: 2004 Nesting Survey. Curry & Kerlinger, L.L.C.

Krueger, W.H., and K. Oliveira. 1999. Evidence for environmental sex determination in the American eel, *Anguilla rostrata*. Environmental Biology of Fishes 55:381- 389.

Lauro, B. 2004. Habitat enhancement to improve piping plover numbers and visitor access at Breezy Point, New York. Final Report, St. John's University, New York.

Morgan, S.G. 2006. Larval migrations between the Hudson River estuary and New York Bight. Pages 157- 170 *in* J.S. Levinton and J.R. Waldman, editors. The Hudson River Estuary, Cambridge University Press.

NYCDEP (New York City Department of Environmental Protection). 2007. Draft Jamaica Bay Watershed Protection Plan.

Rice, M., and E. Gibbs. 1995. Proceedings of the Third Rhode Island Shellfish Industry Conference. Rhode Island Sea Grant.

Rhoads, J.M., D.J. Yozzo, M.M. Cianciola, and R.J. Will. 2001. Norton Basin/Little Bay Restoration Project: historical and environmental background report. Report to U.S. Army Corps of Engineers.

Russell, G., and A. Rosales. 2006. Sociability leads to instability: a metapopulation model of the heron and egret nesting colonies in New York Harbor. Harbor Herons, Cormorants, and More: Proceedings of the Greater new York/New Jersey Harbor Colonial Waterbirds Working Group. Abstract.

Sclafani, M., and K. McKown. 2007. Horseshoe crab (*Limulus polyphemus*) spawning activity survey protocol for the New York State Marine District. Cornell Cooperative Extension, NY.

Skinner, L.C., R. Prince, J. Waldman, A.J. Newell, and J.Shastay, Jr. 1997a. Chemical Residues in Fish, Bivalves, Crustaceans and a Cephalopod from the New York- New Jersey Harbor Estuary: Dioxins and Furans. New York State Department of Environmental Conservation.

Skinner, L.C., A. Gudlewski, J. Waldman, J. Shastay, and A.J. Newell. 1997b. Chemical Residues in Fish, Bivalves, and Crustaceans from the New York- New Jersey Harbor Estuary: Arsenic, Cadmium and Lead. New York State Department of Environmental Conservation.

Socrates, J.B. 2006. A Study of the Striped Bass in the Marine District of New York State: Juvenile Striped Bass. Completion Report, Anadromous Fish Conservation Act P.L. 89- 304. New York State Department of Environmental Conservation.

Steinberg, N., D.J. Suszkowski, L. Clark, and J. Way. 2004. Health of the Harbor: The First Comprehensive Look at the State of the NY/NJ Harbor Estuary. A Report to the NY/NJ Harbor Estuary Program. Hudson River Foundation, NY.

Swan, B.L. 2005. Migrations of adult horseshoe crabs, *Limulus polyphemus,* in the Middle Atlantic Bight: a 17- year tagging study. Estuaries 28:28- 40.

Thorrold, S.R., C. Latkoczy, P.K. Swart, and C.M. Jones. 2001. Natal homing in a marine fish metapopulation. Science 291:297-299.

Tipton, R.C., and K.J. Hartman. 2007. Distributional ecology of bay anchovy *Anchoa mitchilli* in the Hudson River estuary. American Fisheries Society Symposium 51:227- 249.

USFWS (U.S. Fish & Wildlife Service). 1997. Significant habitats and habitat complexes of the New York Bight watershed. U.S. Fish & Wildlife service, Southern New England, New York Bight Coastal Ecosystems Program, Charlestown, RI.

Waldman, J. 1999. Heartbeats in the Muck: the History, Environment, and Sea Life of New York Harbor. Lyons Press, NY.

Waldman, J.R. 2006. The diadromous fish fauna of the Hudson River: life histories, conservation concerns, and research avenues. Pages 171- 188 *in* J.S. Levinton and J.R. Waldman, editors. The Hudson River Estuary, Cambridge University Press, NY.

Waldman, J.R., T.R. Lake, and R.E. Schmidt. 2006. Biodiversity and zoogeography of the fishes of the Hudson River watershed and estuary. American Fisheries Society Symposium 51:129- 150.

Walter, S. 2007. The Jamaica Bay moth survey: 2006- 2007 update, with highlights of the 2006 field season. Privately issued report.

Weseloh, D.V.C., and P.J. Ewins. 1994. Characteristics of a rapidly increasing colony of double- crested cormorants (*Phalacrocorax auritus*) in Lake Ontario: Population size, reproductive parameters and band recoveries. Journal of Great Lakes Research 20:443- 456.

Wirgin, I., and J.R. Waldman. 2004. Use of nuclear DNA in stock identification: single- copy and repetitive sequence markers. Pages 321- 359 *in* S. X. Cadrin, K. Friedland, and J. R. Waldman, editors. Stock Identification Methods, Elsevier, San Diego.

Withers, K., and T.S. Brooks. 2004. Diet of the Double- crested Cormorants (*Phalacrocorax auritus*) wintering on the central Texas coast. The Southwest Naturalist 49:48- 53.

Zuzworsky, J. 1996. Odonates of Gateway NRA: a preliminary survey. Jamaica Bay Wildlife Refuge, National Park Service.

Warming and Sea Level Rise.

Background

Jamaica Bay is located within New York City, one of the most populated cities in the nation, and within a few miles of Manhattan.

The unique juxtaposition of a National Park and a metropolis generates special challenges for NPS resource managers, with a diversity and degree of human usage beyond that seen in more remote National Parks. But not all of the natural resource management issues facing the Jamaica Bay Unit are urban in nature, they are further compounded by one global phenomenon that is affecting most regions of the world—warming—and another that is affecting all marine coasts—sea level rise. Thus, the Unit holdings and the remainder of the bay serve as an excellent laboratory for the development and testing of strategies to cope with these potentially severe physical stresses on a rich urban ecosystem.

The beaches that allow urban residents to recreate are in danger in the face of global warming.

Hartig et al. (2000) estimated an annual historical sea level rise over the Twentieth Century of 2.7 mm. But it is expected that the rate of sea level change will increase, perhaps doubling in the next 50- 100 years (IPCC 2002). This could mean an increase in mean sea level by 2050 of 12-47 cm (0.4- 1.5 ft). These estimated rises in sea level could accelerate the loss of wetlands and uplands from wave driven erosion and flooding. Warming associated with climate change also is predicted to increase the frequency and severity of major storms and hurricanes. These storms, in conjunction with high sea levels, have the capacity to cause extensive change to the present morphology of Jamaica Bay, including the Rockaway barrier system and inlet.

Research Needs

Because of the potential significant and even catastrophic consequences of climate change to Jamaica Bay and the New York metropolitan region, some forecasting of the magnitudes of effects is occurring (Hartig et al. 2000, Gornitz et al. 2001). However, these forecasts need to be fine- tuned as new data and model refinements occur. Also, predictions concerning the physical environment of the bay need to be extended to the consequences of these changes to the biological realm. Locations within the Unit might also serve as excellent sites for monitoring local sea level rise and its effects.

Selected Bibliography for Warming and Sea Level Rise

Gornitz, V., S. Couch, and E.K. Hartig. 2001. Impacts of sea level rise in the New York City metropolitan area. Global and Planetary Change 32:61- 88.

Hartig, K.E., F. Mushacke, D. Fallon, and A. Kolker. 2000. A wetlands climate change impact assessment for the Metropolitan East Coast Region. Center for International Research Earth Science Information Network. Columbia earth Institute, New York, NY.

IPCC (Intergovernmental Panel on Climate Change). 2002. Climate Change 2001: synthesis report. Watson, R.T. et al. (editors). Cambridge University Press, Cambridge, UK.

Social Sciences

Background.

Jamaica Bay is the ultimate urban water body, a watershed that sits surrounded by many millions of people. Such a unique setting creates intense social stresses which challenge the agencies charged with protecting the bay and managing its resources. In such a situation there is a constant tension between attempting to allow as much and as varied public usage as possible while making sure that the very characteristics that attract the public are not subsumed in the process. There also is an ongoing challenge for managers to understand who is using the refuge, and how. The possibilities for, and diversity of, interaction with the refuge are more extensive in a vast urban region where there is such a great range of cultures and social groups, in addition to a variety of interests ranging from the refuge's cultural resources, to viewing its wildlife, to hiking, boating and fishing. Then there is the problem of illegal uses of the park, including poaching of its natural resources. Wildlife managers often claim that they manage people, not wildlife, and this is nowhere truer than for a system where the role of humans is maximized. But the social sciences have not been well addressed through the history of the Jamaica Bay Wildlife Refuge, despite its offering of itself as a rich virtual laboratory for human interactions with the resources of a highly urban national park.

Research Needs.

A young visitor utilizes Riis Beach.

Who uses the bay and the refuge, and how, are major questions. Demographic analysis should proceed across many possible social strata: age, gender, ethnicity, religion, occupation, socioeconomic class, and visit purpose. Where do visitors come from and how do they distribute themselves (in relation to these strata) once they arrive? How often do they return? How do they travel? What are the main access sites for various activities undertaken? What is the economic value of these visits to businesses around the bay?

Visitors to the Jamaica Bay Wildlife Refuge are often avian enthusiasts.

Once at the refuge, how do visitors perceive the experience? Are visitation levels sufficiently low that crowding is not felt? What is the "social carrying capacity" of the refuge by region and activity (Manning et al. 1996)? Does the fact that the refuge is in an urban setting alter expectations (and thus, the experience) of visitors for the numbers of people encountered? Are there substantive user conflicts? If so, how might they be lessened?

Camping at Floyd Bennett Field is a unique opportunity in such an urban setting.

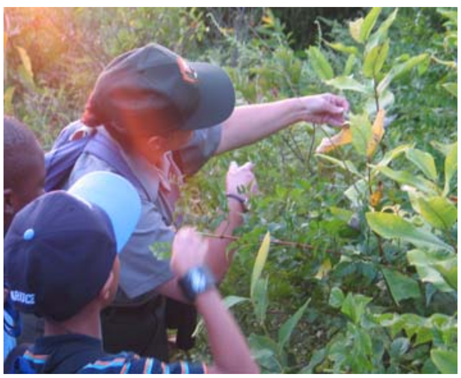
Although Jamaica Bay is situated in a great metropolitan region, it is more readily accessible to people living in the neighborhoods nearby. What is their present perception of the bay? Has it changed for the better or worse? What is their perception of the Unit and its management by NPS?

Public pride in ownership of its own resources can only help conservation efforts. How can a greater sense of stewardship for Jamaica Bay be promoted for the public? Does the public have enough input into management actions undertaken? Does it receive enough information about the state of the bay and the threats posed to it? How has media reporting on Jamaica Bay changed over the years?

School groups attend educational programs presented by interpretive rangers as well as scientists.

The Jamaica Bay Unit of NPS offers enormous educational opportunities. What is the role of education in fostering concern for the bay? Can the connections between agencies that manage the bay and nearby school systems be strengthened? The refuge can be thought of as a highly convenient "outdoors classroom." But is it possible for a child in nearby elementary schools to graduate having never experienced a field trip to the refuge? Conversely, how can the notion of Jamaica Bay be brought into the classroom (Sullivan et al. 2005)? How should outreach to teachers be strengthened?

Ranger led school groups learn about nature while experiencing it first hand. Should there be more education for teachers to aid in the education of school aged students?



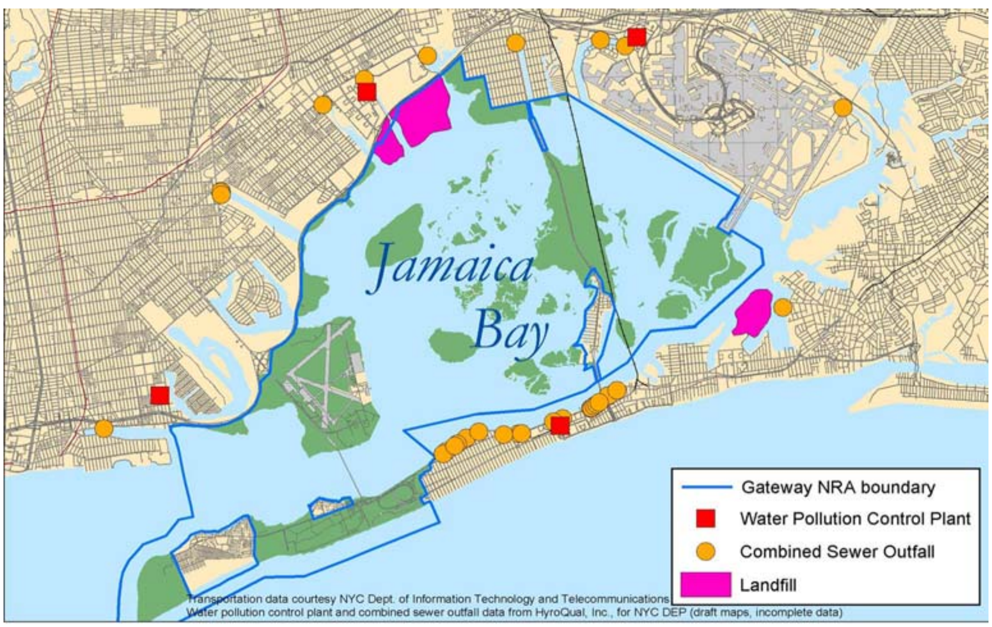
A ranger educates children on an interpretive tour during the Jamaica Bay Institute BioBlitz.

The Research Coordinator of the Research Learning Center, the Jamaica Bay Institute, gives an educational talk to a school group. At what point do such large groups begin affecting the very resource they are learning about?

Should there be field trips, classroom lectures, and workshops for teachers alone to inspire them and instill knowledge of the ecosystem? Is there a need for a manual or textbook for teachers on the bay and how to use it as an educational tool? Is there a need for additional scientific guidebooks, annotated photographic collections (e.g., Tanacredi et al. 1992), and identification keys? If so, should they be oriented towards the scientist or the amateur naturalist? More ambitiously, is there sufficient information and need for a single atlas of the natural resources of the Jamaica Bay Unit and the remainder of the bay?

One possible educational strategy that deserves consideration is the idea of capitalizing more fully on the "nature spectacles" that occur in the system. Jamaica Bay is host to an upland migration of nest- building diamondback terrapins, of horseshoe crab spawning aggregations on its beaches, of an autumnal monarch butterfly migration, of various bird migrations and overwintering aggregations, and of nearby gatherings of seals. All of these are followed by knowledgeable aficionados and some support interpretive programs by NPS and others. Increasing visitation to some of these spectacles might threaten them. But is there room to increase visitation and enthusiasm for the bay by casting the refuge as the scene for great and interesting seasonal animal abundances at a time when such viewings are becoming rarer in the biodiversity- challenged U.S.? Also, can some of these creatures, such as horseshoe crabs be used effectively as iconic emblems to symbolize the bay, much as sturgeon are being used on signs to signify the Hudson River?

Harvest of bay resources also raises social issues. How aware are anglers of fish consumption health advisories? And how seriously do they acknowledge them? Is there variation by class, race, ethnicity or other demographic variables? Burger et al. (1993) surveyed people fishing on the catchment basins of the Wildlife Refuge. Of the 154 groups interviewed, only 19% believed the waters or fish were contaminated or unsafe, despite state warnings to the contrary. How much subsistence fishing occurs today? How well do anglers adhere to fish harvest regulations such as length and catch limits? How much directed poaching of fish and shellfish occurs in the bay? How do these harvests reach consumers and do overt illnesses occur from pathogen-bearing shellfish? Sportfishing in Jamaica Bay also takes place through the commercial operations of charter and party boats. How important are these harvests? Are fishing regulations followed on these vessels?



Map of sewer outfalls and water pollution control plants that contribute to the issues of edible bycatch in Jamaica Bay. Source: NYC Department of Environmental Protection

Jamaica Bay has also been home to "baymen" who earn a living or who derive some income from legal harvests of fish and shellfish (for bait and chum). How many persist in these activities, what do they harvest, and how much? Baymen often have the most intimate contact and experience with their bays and often are keen observers of natural phenomena and changes wherever they are found. Should their knowledge be perpetuated while still available through collection of their oral histories?

Jamaica Bay has received some attention as an historical entity, such as the recent annotated collection of photographs published as a book by Hendrick (2006), but a deeper examination of the environmental history of the system would be of use and of interest to resource managers and the public. Historical analysis could be partly map- based, as now being performed for Manhattan Island in the Manhattan project where ecological conditions in 1609 are being characterized (Sanderson 2005). Prehistoric and historic analysis also is possible through sediment core analysis, such as performed at JoCo Marsh for a window of 2000 years (Peteet and Lieberman 2002; Peteet et al. 2006).

There also are research questions concerning the management of Jamaica Bay and the Wildlife Refuge. Who are all the stakeholders? A high number of federal, state, city, and Long Island town agencies have some oversight responsibilities for the bay and other regional waters (Suszkowski and D'Elia 2006). But the boundaries among these entities are not always clear. The responsibilities of each of these entities need to be fully characterized, and in relation to the others. Is there substantial and wasteful overlap? Are there gaps among them? Analysis of how the bay is managed is needed. Moreover, what are the NGO's that have an interest in the bay and what is their role in the stewardship of the bay and in influencing the policies of these agencies? How successful have they been in meeting their own goals?

NPS has responsibilities to manage the refuge. But how well NPS meets this need deserves further evaluation. Would the agency benefit from more precise definitions of these responsibilities? Are there internal redundancies and gaps in responsibilities among various branches of the Jamaica Bay Unit? With limited resources available, how should research priorities within NPS be set? Are protocols and permitting requirements (GNRA 2001) for outside researchers as simple and welcoming as possible or are they bureaucratically dissuasive? The Jamaica Bay Unit also contains cultural assets that attract visitors. These include Fort Tilden and Floyd Bennett Field, an airport important in the history of aviation. How well are these resources managed? Is the potential interplay between the cultural and natural resources of the refuge being used to full advantage?

Selected Bibliography for Social Sciences.

Burger, J., K.Staine, M. Gochfeld. 1993. Fishing in contaminated waters: knowledge and risk perception of hazards by fishermen in New York City. Journal of Toxicology and Environmental Health 39:95- 105.

GNRA (Gateway National Recreation Area). 2001. Scientific research and collecting manual. National Park Service.

Hendrick, D.M. 2006. Images of America: Jamaica Bay. Arcadia Publishing, Mount Pleasant, SC.

Manning, R.E., D.W. Lime, and M. Hof. 2006. Social carrying capacity of natural areas: theory and application in the U.S. National Parks. Natural Areas Journal 16(2):118- 127.

Peteet, D.M., D. Cabiniss Pederson, D. Kurdyla, and T. Guilderson. 2006. Hudson River Paleoecology from marshes: Environmental change and its implications for fisheries. American Fisheries Society Symposium 51:113- 128.

Peteet, D., and L. Lieberman. 2002. Paleoenvironmental history of Jamaica Bay marshes, New York. Chapter 7.3 *in* JABERRT. Final Report. Division of Natural Resources, Gateway National Recreation Area, National Park Service and Aquatic Research and Environmental Assessment Center, Brooklyn College.

Sanderson, E.W. 2005. Urban legend: discovering Manhattan's wetlands. National Wetlands Newsletter 27(1):1,15- 17.

Sullivan, J.C., T. O'Neill, and J.R. Finnerty. 2005. Bringing the urban environment into the classroom: learning from an estuarine mesocosm. Urban Habitats 3(1):134- 157. http://www.urbanhabitats.org/v03n01/classroom_abs.html.

Suszkowski, D.J., and C. F. D'Elia. 2006. The history and science of managing the Hudson River. Pages 313- 334 *in* J.S. Levinton and J.R. Waldman, editors. The Hudson River Estuary. Cambridge University Press, New York, NY.

Tanacredi, J.T., J. Pallias, and A. Scaglione. 1992. A photographic inventory of diatoms: Jamaica Bay. National Park Service, Gateway National Recreation Area.

THE FOLLOWING INFORMATION IS AVAILABLE ONLINE AT
HTTPS://SCIENCE1.NATURE.NPS.GOV/RESEARCH/AC/RESEARCHINDEX

APPLICATION PROCEDURES AND REQUIREMENTS FOR SCIENTIFIC RESEARCH AND COLLECTING PERMITS

United States Department of the Interior
National Park Service

POLICY AND GENERAL REQUIREMENTS

The National Park Service (NPS) welcomes your interest in considering national parks for your research site. The NPS is responsible for protecting in perpetuity and regulating use of our National Park areas (parks, monuments, battlefields, seashores, recreation areas, etc.). Preserving park resources unimpaired and providing appropriate visitor uses of parks require a full understanding of park natural resource components, their interrelationships and processes, and visitor interests that can be obtained only by the long term accumulation and analysis of information produced by science. The NPS has a research mandate to provide management with that understanding, using the highest quality science and information. Superintendents increasingly recognize that timely and reliable scientific information is essential for sound decisions and interpretive programming. NPS welcomes proposals for scientific studies designed to increase understanding of the human and ecological processes and resources in parks and proposals that seek to use the unique values of parks to develop scientific understanding for public benefit.

When is a permit required?

A Scientific Research and Collecting Permit is required for most scientific activities pertaining to natural resources or social science studies in National Park System areas that involve fieldwork, specimen collection, and/or have the potential to disturb resources or visitors. When permits are required for scientific activities pertaining solely to cultural resources, including archeology, ethnography, history, cultural museum objects, cultural landscapes, and historic and prehistoric structures, other permit procedures apply. The park's Research and Collecting Permit Office or Headquarters can provide copies of NPS research- related permit applications and information regarding other permits. Federally funded collection of information from the public, such as when formal surveys are used, may require approval from the Office of Management and Budget.

NPS superintendents may authorize their staff to carry out official duties without requiring an NPS research and collecting permit. NPS staff must comply appropriately with professional standards and with all conditions normally associated with scientific research and collecting permits issued by the park. All other natural and social science research and data collection in a park requires a Scientific Research and Collecting Permit and will be allowed only pursuant to the terms and conditions of the permit.

Additional required permits, approvals, and agreements

In some cases, other federal or state agency permits or approvals may be required before NPS staff can process an application for a Scientific Research and Collecting Permit. Examples include U.S. Fish and Wildlife Service threatened and endangered species permits and migratory bird permits and approvals by an Institutional Animal Care and Use Committee. It is the responsibility of the principal investigator to provide NPS with copies of such permits when they submit an application. Applicants are encouraged to contact park staff to determine if additional permits may be required in conjunction with a proposed study.

Separate agreements between the investigator and NPS are required when proposed studies or collected specimens are intended to support commercial research activities.

Who may apply?

Any individual may apply if he/she has qualifications and experience to conduct scientific studies or represents a reputable scientific or educational institution or a federal, tribal, or state agency.

When to apply?

We recommend that you apply at least 90 days in advance of your first planned field activities. Projects requiring access to restricted locations or proposing activities with sensitive resources, such as endangered species or cultural sites, usually require extensive review and can require 90 days or longer for a permitting decision. Simple applications can often be approved more quickly.

How and where to apply?

An individual may obtain application materials via the Internet (find “Research Permit and Reporting System” at http://science.nature.nps.gov/research or through www.nps.gov) or by contacting the park in which the work will be conducted. Addresses for NPS areas are listed on the NPS Internet web site (www.nps.gov) or may be obtained by contacting the NPS Public Affairs Office via telephone number 202- 208- 4747. All application materials must be submitted to the NPS area in which you plan to work. You may submit this information via Internet or traditional postal service.

Study proposals

Applications for Research and Collecting Permits must include a research proposal. Proposals must include, as appropriate, all elements outlined in the separate document *Guidelines to Researchers for Study Proposals*.

Review of proposals

Each proposal will be reviewed for compliance with National Environmental Policy Act (NEPA) requirements and other laws, regulations, and policies. The superintendent may also require internal and/or external scientific review, depending on the complexity and sensitivity of the work being proposed and other factors. You can expedite review of your proposal by providing photocopies of existing peer reviews, or by providing names, mailing addresses, and email addresses of persons that you wish to recommend to review your proposal. Specific details about the review process may be included with the application materials provided by that park.

Facilitating a favorable decision

The superintendent makes a decision to approve a research and collecting permit based on an evaluation of favorable and unfavorable factors (see examples, below), and on an assessment of perceived risks and benefits. While park managers will work with applicants to arrive at a mutually acceptable research design, there may be activities where no acceptable mitigating measures are possible and the application may be denied.

The time and effort required to review the permit application and accompanying study proposal will be proportional to the type and magnitude of the proposed research. For example, a single visit for a non- manipulative research project will often require a relatively simple proposal and the permitting decision should be relatively fast. A highly manipulative or intrusive investigation, however, with the potential to affect non- renewable, rare, or delicate resources, needing detailed planning or logistics, would receive more extensive review. Some of the predisposing factors that influence permitting decisions are outlined below.

Favorable factors

The proposed research:

- contributes information useful to an increased understanding of park resources, and thereby contributes to effective management and/or interpretation of park resources; provides for scheduled sharing of information with park staff, including any manuscripts, publications, maps, databases, etc., which the researcher is willing to share;
- addresses problems or questions of importance to science or society and shows promise of making an important contribution to humankind's knowledge of the subject matter;
- involves a principal investigator and support team with a record of accomplishments in the proposed field of investigation and with a demonstrated ability to work cooperatively and

safely, and to accomplish the desired tasks within a reasonable time frame;
- provides for the investigator(s) to prepare occasional summaries of findings for public use, such as seminars and brochures;
- minimizes disruption to the park's natural and cultural resources, to park operations, and to visitors;
- discusses plans for the cataloging and care of collected specimens;
- clearly anticipates logistical needs and provides detail about provisions for meeting those needs; and
- is supported academically and financially, making it highly likely that all fieldwork, analyses, and reporting will be completed within a reasonable time frame.

Unfavorable factors

The proposed research:
- involves activities that adversely affect the experiences of park visitors;
- shows potential for adverse impact on the park's natural, cultural, or scenic resources, and particularly to non- renewable resources such as archeological and fossil sites or special-status species (the entire range of adverse impacts that will be considered also includes construction and support activities, trash disposal, trail conditions, and mechanized equipment use in sensitive areas);
- shows potential for creating high risk of hazard to the researchers, other park visitors, or environments adjacent to the park;
- involves extensive collecting of natural materials or unnecessary replication of existing voucher collections; requires substantial logistical, administrative, curatorial, or project monitoring support by park staff; or provides insufficient lead time to allow necessary review and consultation;
- is to be conducted by a principal investigator lacking scientific institutional affiliation and/or recognized experience conducting scientific research; and
- lacks adequate scientific detail and justification to support the study objectives and methods.

Park response

The principal investigator should receive notice of the approval or rejection of the application by written correspondence via mail, electronic mail, or facsimile. If modifications or changes in a study proposal initially deemed unacceptable would make the proposal acceptable, the park may suggest them at this time. If the application is rejected, the applicant may consult with the appropriate NPS Regional Science Advisor to clarify issues and assess the potential for reconsideration by the park.

Permittee response

If your permit request is approved by the park, you will receive a copy of the permit that you must sign and return to the park via mail or fax. Once the park receives a copy of the permit that you have signed, appropriate NPS officials will validate it and return an approved copy to you. You must carry a copy of the approved permit at all times while performing your research or collecting in the park.

Permit stipulations

General Conditions (requirements and restrictions) will be attached to all Research and Collecting Permits issued. These conditions must be adhered to by permit recipients. Additional Park- specific Conditions may also be included that address unique park resources or activities. An NPS permit is valid only for the activities authorized in the permit. The principal investigator must notify the NPS in writing of any proposed changes. Requests for significant changes may necessitate re- evaluation of the permit conditions or development of a revised proposal.

Access permit requirements

Some NPS areas require access permits for off- road travel, camping, and other activities. Access to many areas is limited and popular destinations can be booked several months in advance. Please contact the park's Research and Collecting Permit Office to obtain information on any needed access permits.

Research products and deliverables

Researchers working in NPS areas are required to complete an NPS Investigator's Annual Report form for each year of the permit, including the final year. The NPS maintains a system enabling researchers to use the Internet to complete and submit the Investigator's Annual Report. NPS staff will contact permit holders near the beginning of each calendar year to request the prior year's report and explain how to access and use the system. Investigator's Annual Reports are used to consistently document accomplishments of research conducted in parks. Principal investigators are responsible for the content of their reports. NPS staff will not modify reports received unless requested to do so by the principal investigator responsible for the report.

Park research coordinators may request copies of field notes, data, reports, publications and/or other materials resulting from studies conducted in NPS areas. Additional deliverables may be required of studies involving NPS funding or participation.

Privacy Act and Paperwork Reduction Act

NPS regulations (36 CFR 2.1) prohibit possessing, destroying, injuring, defacing, removing, digging, or disturbing from their natural state in any form animals, plants, paleontological, or mineral resources. NPS regulations (36 CFR 2.5) require researchers wishing to conduct research involving acts prohibited by other regulations, such as CFR 2.1, to obtain a specimen collection permit. The National Parks Omnibus Management Act of 1998 (Public Law 105- 391) encourages use of parks for science, encourages publication of the results of research conducted in parks, and requires that research conducted in parks be consistent with park laws and management policies. This law also requires that research be conducted in a manner that poses no threat to park resources or public enjoyment. National Park Service Management Policies state that research activities that might disturb resources or visitors, that require the waiver of any regulation, or that involve the collection of specimens may be allowed only pursuant to terms and conditions of an appropriate permit.

The information you submit in your Application for a Scientific Research and Collecting Permit will be used by park managers to determine whether or not to issue you a Scientific Research and Collecting Permit. The information you submit in your Investigator's Annual Report will be used by park managers to inform resource management decision- makers, park visitors, the public, and other researchers about the objectives and progress results of your research.

Parks and park records are public assets. The information you submit in your Application and in your Investigator's Annual Report is not confidential and will be in the public record and available to the public. If you want to receive and maintain a Scientific Research and Collecting Permit, you must respond to both the Application and Investigator's Annual Report collections of information. If you do not respond to the request for information in the Application, you will not be considered for a Scientific Research and Collecting Permit. If you have received a Scientific Research and Collecting Permit and do not respond to the request for information in the Investigator's Annual Report, your permit may be revoked and you may be denied future permits.

The Application for a Scientific Research and Collecting Permit and the Investigator's Annual Report are two parts of one complete process dealing with conducting scientific research and collecting in a unit of the National Park System. The total public reporting burden involved in electronically completing the collection of information process for a single scientific research and collecting activity in a unit of the National Park System includes the burden of reading the informational documents associated with these two information collection forms plus completing and submitting one Application form (approximately 45 minutes), plus the burden of signing and mailing an issued permit back to the park (approximately 15 minutes), plus the burden of completing one associated Investigator's Annual Report form (approximately 15 minutes). Some applicants will experience an additional burden of photocopying and mailing attachments (approximately 15 minutes). Other applicants will experience an additional burden of coordinating with a specimen repository (approximately 30 minutes). The total public reporting burden experienced by a successful permittee for electronically completing this process for a single scientific research and collecting activity in a unit of the National Park

System thus is estimated to range between 1.25 and 2.0 hours per year. The total public reporting burden experienced by an unsuccessful applicant for electronically completing this process is estimated to be about 45 minutes per year because the unsuccessful applicant will not be required to complete the Investigator's Annual Report, mail a signed permit, or respond to other portions of the process. The few applicants who complete these forms manually are expected to experience a somewhat larger annual reporting burden. Direct any comments you may have regarding this burden estimate or any other aspect of this information collection process or of its two forms to the Office of Information and Regulatory Affairs of OMB, Attention Desk Officer for the Interior Department, Office of Management and Budget, Washington, DC 20503; and to the Information Collection Clearance Officer, WASO Administrative Program Center, National Park Service, 1849 C Street, N.W., Washington, DC 20240.

The following information will be asked for to successfully complete the application process:

- Contact information about the applicant. *(Required)*
- Project title. *(Required)*
- Purpose of study. *(Required)*
- Study start and end dates *(Required)*
- Identification of any federal funding agencies.
- Location of activity in the park.
- Method of access.
- Names of co- applicants.
- If you are collecting specimens, contact information of repositories.
- A copy of the study proposal.
- A copy of all peer reviews.

GUIDELINES TO RESEARCHERS FOR STUDY PROPOSALS

United States Department of the Interior
National Park Service

Your proposal should include each of the required information items listed below, in enough detail that an educated non- specialist can understand exactly what you plan to do. If you have already prepared a relevant proposal for a funding application, work plan, formal agreement, or similar document, then your original proposal likely will satisfy National Park Service (NPS) proposal requirements. The primary area where new information may be necessary concerns the ability of the park to assess what, if any, impacts your research may have on park resources. You should compare your original proposal to these guidelines to be certain that you have provided all the required information. If additional information is required, you can provide it in a cover letter or supplement to your proposal, as appropriate. If a required topic does not apply to your proposed study, simply list the topic and write "not applicable."

The length of your proposal depends primarily on the complexity of the work planned. In some cases, a proposal may consist of a couple of pages for a study expected to have no significant impact on park resources or visitor experiences. However, proposals for lengthy or complex research problems, for extensive collecting, and for work with special status species or sensitive cultural resources are typically longer, more detailed, and well- organized. Incomplete, disorganized, or illegible proposals may be returned for revision.

I. INTRODUCTION

A. **Title**

B. **Date of proposal**

C. **Investigators -** Provide the name, title, address, telephone number, FAX number, email address, and institutional affiliation of the principal investigator and the name and affiliation of all additional investigators listed in the proposal.

D. **Table of contents** - Recommended for long or complicated proposals.

E. **Abstract** - Provide a brief summary description of the proposed project. Include up to five keywords that can be used by the NPS to quickly identify the proposal subject (for example, microbiology, geology, ecology).

II. **OVERVIEW** - Summarize the proposed project by describing in general the problem or issue being investigated as well as any previous pertinent research.

A. **Statement of issue** - Describe the issue to be investigated and its importance and relevance to science and to the park. Provide relevant background information that clarifies the need for the project and why it is valuable for the research and/or collecting to be conducted in the park.

B. **Literature summary** - Summarize the relevant literature regarding the issue, problem, or questions that will be investigated.

C. **Scope of study** - Describe the overall geographic and scientific scope of the project.

D. **Intended use of results** - Describe how the products will be used, including any anticipated commercial use.

III. **OBJECTIVES/HYPOTHESES TO BE TESTED** - Describe the specific objectives of the proposed project. Where appropriate, the objectives should be stated as specific hypotheses to be tested.

IV. **METHODS** - Describe how the proposed methods and analytical techniques will achieve the study objectives or test the stated hypothesis/question. Provide pertinent literature citations.

A. **Description of study area** – Clearly describe the study area in terms of park name(s), geographic location(s), and place names. Provide maps, park names, or geographic coordinates as appropriate. Indicate whether your work will take place in an area designated or managed as “wilderness” by the NPS.

B. **Procedures** - Describe the proposed study design that addresses the stated objectives and hypotheses. Explain the methods and protocols to be employed in the field and laboratory.

C. **Collections** - Describe the type, size, and quantity of specimens or materials to be collected, sampled, or captured, and your plans to remove them from the collecting site. If you are aware specimens of the proposed types already exist in a repository, explain why additional collecting is necessary. Provide scientific nomenclature where possible. Provide information on all other applicable federal or state permits where required.

D. **Analysis** - Explain how the data from the study will be analyzed to meet the stated objectives or test the hypotheses. Include any statistical techniques or mathematical models necessary to the understanding of the analysis.

E. **Schedule** - Provide a schedule that includes start of project, approximate dates or seasons of fieldwork, analysis, reporting, and completion dates.

F. **Budget -** Briefly outline the expenses associated with this project and identify your expected funding source(s). Include the anticipated costs pertaining to the cataloging of collected and permanently retained specimens or materials.

V. **PRODUCTS**

A. **Publications and reports** - Describe the expected publications or reports that will be generated as part of this study.

B. **Collections** – Describe the proposed disposition of collected specimens or materials. If you propose that the NPS lend the specimens or samples to a non-NPS institution for long- term storage, identify that institution and give a brief justification for this proposal.

C. **Data and other materials** - Describe any other products to be generated as part of the project, such as, photographs, maps, models, handouts, exhibits, software presentations, raw data, GIS coverages, or videos, and the proposed disposition of these materials. If data are to be collected from the public as part of this study, provide a copy of the data collection instrument (survey, questionnaire, interview protocol, etc.).

VI. **LITERATURE CITED** - Include full bibliographic citations for all reports and publications referenced in the proposal.

VII. **QUALIFICATIONS -** Provide a background summary or curriculum vitae for the principal investigator and other investigators listed in the proposal. Identify their training and qualifications relevant to the proposed project and their ability to conduct field activities in the environment of the proposed study area. Describe previous research and collecting in NPS areas, including study and permit numbers if available.

VIII. **SUPPORTING DOCUMENTATION AND SPECIAL CONCERNS** - Provide information on the following topics where applicable. Attach copies of any supporting documentation that will facilitate processing of your application, such as other required federal and state permits, copies of peer reviews, letters of support and funding commitments, and certifications. Collection of information from the public when federal funds are used may require approval from the Office of Management and Budget (OMB). Upon your request, the NPS Social Science Program will advise you on steps needed to obtain this OMB approval.

A. **Safety** - Describe any known potentially hazardous activities, such as electrofishing, rock climbing, scuba diving, whitewater boating, aircraft use, wilderness travel, wildlife capture, handling or immobilization, use of explosives, etc.

B. **Access to study sites** - Describe the proposed method and frequency of travel to and within the study site(s). Explain any need to enter restricted areas. Describe duration, location, and number of participants for planned backcountry camping.

C. **Use of mechanized and other equipment** - Describe any field equipment, markers, or supply caches by type, number, and location. You should explain how long they are to be left in the field. Explain the need to use these materials in restricted areas and the alternatives that were considered.

D. **Chemical use** - Identify any chemicals and hazardous material that you propose using within the park. Indicate the purpose, method of application, and amount to be used. Describe plans for storage, transfer, and disposal of these materials and describe steps to remediate accidental releases into the environment. Attach copies of Material Safety Data Sheets.

E. **Ground disturbance** - Describe the type, location, area, depth, number, and distribution of expected ground- disturbing activities, such as soil pits, cores, stakes, or latrines. Describe plans for site restoration of significantly affected areas.

   Proposals that entail ground disturbance may require an archeological survey and special clearance prior to approval of the study. You can help reduce the extra time that may be required to process such a proposal by including identification of each ground disturbance area on a USGS 7.5- minute topographic map.

F. **Animal welfare** - For vertebrate species that require review by your Institutional Animal Care and Use Committee (IACUC) according to the Animal Welfare Act, please include a photocopy of the study protocol, and IACUC review form and approval.

   For vertebrate species not requiring IACUC review, describe your protocol for any capture, holding, marking, tagging, tissue sampling, or other handling of these animals (including the training and qualifications of personnel relevant to animal handling and care). Please discuss alternative techniques considered and outline any procedures to alleviate pain or distress. Include contingency plans to be implemented in the event of accidental injury to or death of the animal.

G. **NPS assistance** - Describe any NPS field assistance you would like to receive to complete the proposed study, such as use of equipment or facilities or assistance from staff.

H. **Wilderness "minimum requirement" protocols** - If some or all of your activities will be conducted within a location administered by the NPS as a designated, proposed, or potential wilderness area, your proposal should describe how the project adheres to wilderness "minimum requirement" and "minimum tool" concepts. Refer to the park's wilderness management plan for further information.