

National Park Service
U.S. Department of the Interior

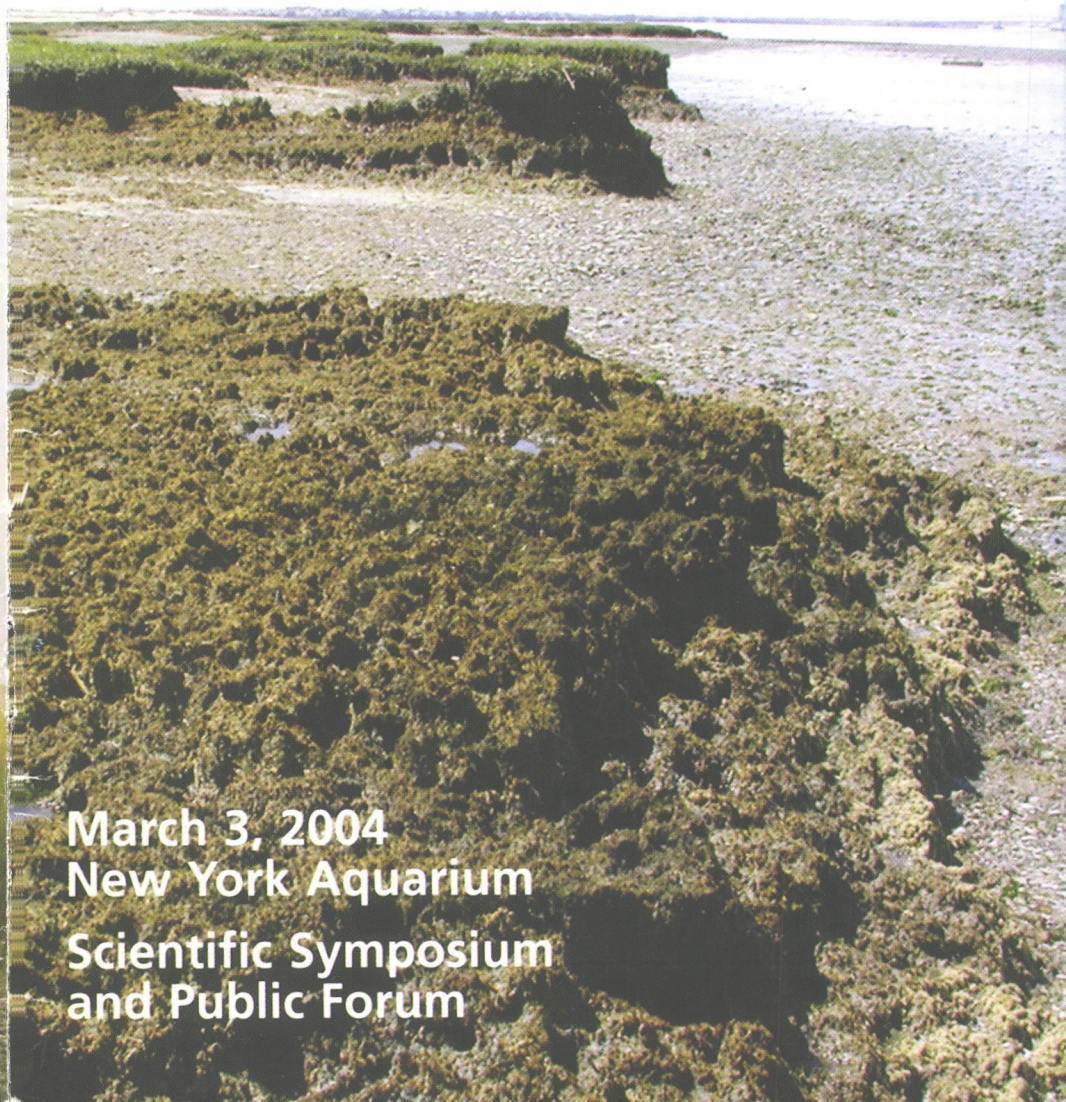
Jamaica Bay Institute
Gateway National Recreational Area



PROCEEDINGS

Jamaica Bay's Disappearing Marshes

Highlighting ongoing research, local and international perspectives and future restoration plans



March 3, 2004
New York Aquarium
Scientific Symposium
and Public Forum

Jamaica Bay's Disappearing Marshes

Proceedings

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Superintendent's Message

Gateway National Recreation Area was established thirty years ago as this country's first national urban park. As such, management of this area revolves around two fundamental objectives. First, we must protect the significant natural and cultural resources that are located within the park. Second, we must create high-quality opportunities for people to enjoy the park without impairing the resources that make the park a special place. Jamaica Bay—with its mosaic of islands, waters, and marshes—is a distinctive part of Gateway and contains some of the most important natural resources entrusted to our care.

Concerns about salt-marsh loss in Jamaica Bay were first brought to the attention of park management by a number of local residents. GIS trend maps developed by other public agencies subsequently validated their impressions. Four years ago, a Blue Ribbon Panel was convened by the National Park Service to discuss this issue. The panel was made up of twelve scientists, all with extensive experience in various aspects of wetland ecology. They concluded that numerous interrelated factors are causing the loss of saltmarshes in Jamaica Bay. Some of the more important factors included: changes in sediment deposition, increased wave action, contamination of bay waters, and sea level rise.

The report of the Blue Ribbon Panel provided a starting point from which the park and park partners could address the issue of wetland loss. Our strategy consists of three kinds of activity, all done at the same time. First, we must carry out targeted research that will help us better understand the causes of wetland loss. Second, we must protect existing wetlands. And third, we must restore degraded or lost saltmarsh.

This strategy is not limited to the wetlands themselves. Jamaica Bay is a remarkably rich ecological system situated within the most populous city in the United States. Ultimately, protection of Jamaica Bay and conservation of its natural resources will depend on how well all of us understand the effect of urban systems on the bay and whether or not we choose to promote environmental health through our decisions and our actions. In other words, basic environmental stewardship is essential to the long-term health of Jamaica Bay.

We have taken the first steps in a long and complex journey. We do not want to misstep and inadvertently worsen the situation through ill conceived or hasty action. However, we must act now to stop salt-marsh deterioration and to restore portions of Jamaica Bay that have already been lost.

We welcome the opportunity to forge a common vision with you regarding the future of Jamaica Bay and to pursue that vision in the interest of the wild things that live in the bay and the millions of people who benefit from this special place as a recreational venue, outdoor classroom, and quiet source of inspiration.

Billy G. Garrett
Superintendent, Gateway National Recreation Area

Introduction

The National Park Service established the Jamaica Bay Science Board as an independent science advisory group to provide guidance and oversight of the numerous scientific investigations of salt marsh loss in Jamaica Bay within Gateway National Recreation Area.

This issue has gained considerable visibility among the scientific community as well as the local public. Understanding the complex causes of marsh loss at Jamaica Bay is critical to developing reasonable, sustainable solutions for the restoration and maintenance of the marshes. This will require the long-term commitment of physical and biological scientists knowledgeable of marine, saltmarsh ecosystems working with federal, state, and local managers to guide research and restoration efforts.

The Board will periodically provide written comments on the ongoing scientific investigations and propose additional research. The first of these is presented below and follows a workshop, *Jamaica Bay's Disappearing Marshes*, focused on saltmarsh loss in Jamaica Bay and held at the New York Aquarium on March 3, 2004. The Board continued their discussions during a Jamaica Bay field trip on March 4, 2004. Comments provided by individual Board members are organized by the general topics discussed at the March 3rd workshop, followed by their recommendations for future investigations and directions.

Editor's note: For the convenience of the reader, the Board's comments have been inserted following each group of related abstracts under each major topic.

Jamaica Bay Science Board



(From Left) Dr. Norbert Psuty, Rutgers University; Dr. Denise Reed, Chair, University of New Orleans; Dr. Susan Peterson, Teal Ltd.; Dr. John Teal, Teal Ltd. and Woods Hole Oceanographic Institution; Dr. Henry Bokuniewicz, Stony Brook University. *Not included in photo:* Dr. P.A. Buckley, USGS Patuxent Wildlife Research Center.

Jamaica Bay Science Board

Biographical Sketches

Dr. Henry Bokuniewicz is a professor of oceanography at the Marine Sciences Research Center, Stony Brook University and also serves as Director of the University's Long Island Groundwater Research Institute. He holds his doctorate from Yale University and has over 25 years experience in the region. He is an internationally recognized expert on coastal processes, estuarine sedimentation, coastal groundwater hydrology and dredging studies. He was also a member of the National Park Service's "Blue Ribbon Panel" for Jamaica Bay.



Dr. Henry Bokuniewicz and Lane Smith

Dr. P.A. Buckley is Senior Research Ecologist with the US Geological Survey and Resident Professor of Ecology at the University of Rhode Island. An avian and coastal ecologist by training, he was the first Chief Scientist for the NPS' North Atlantic Region, is a Fellow of the Explorers Club, Associate Editor of *North American Birds*, and has served on numerous national and international scientific and journal advisory bodies. His research and management interests include coastal ecology, waterbirds and seabirds, avian transmission of Lyme Disease, and ecology of migratory birds. A co-founder of the Waterbird Society, he was its second President and is now Associate Editor of its international journal, *Waterbirds*. He is the author of many research papers and of two highly acclaimed books: *Neotropical Ornithology* ('85) and *Avian Genetics* ('87).

Dr. Susan Peterson is an anthropologist and a partner in Teal Ltd. of Rochester, MA. She has worked full-time as a consultant on wetlands, water and wastewater management issues such as watersheds, jurisdictions, carrying capacity, land use, restoration, construction, technology, permitting, and finance since retiring from Ecological Engineering. Ecological Engineering is a company she co-founded in 1988 that promoted natural systems for wastewater treatment. In the 1970s and 1980s, she was a Marine Policy Associate at Woods Hole Oceanographic Institution. In the mid-1980s she taught and conducted research at Boston University.

Jamaica Bay Science Board

Biographical Sketches

Dr. Norbert Psuty is Professor Emeritus in the Institute of Marine and Coastal Sciences at Rutgers University. He is a coastal geomorphologist with research interests in coastal sediment budgets, dune-beach interaction, estuarine sedimentation, and sea-level rise. He has been at Rutgers University since 1969 and has been conducting research primarily along coastal New Jersey and southern Long Island, with inquiry extending into Mexico, Peru, Portugal, and Spain. His research in the parks has especially focused on coastal dynamics in Gateway National Recreation Area and Fire Island National Seashore in the local area and at Canaveral National Seashore and Gulf Islands National Seashore outside of the region. His recent books include: *Coastal Hazard Management: Lessons and Future Directions from New Jersey* (2002), and *Coastal Dunes: Ecology and Conservation* (2004). He serves on numerous national and international review and editorial panels on coastal and geomorphological topics.



Dr. Denise Reed and Dr. Norbert Psuty

Dr. Denise Reed is a Professor in the Department of Geology and Geophysics at the University of New Orleans. Her research interests include coastal marsh response to sea-level rise, the contributions of sediments and organic material to marsh development, and how these are affected by human alterations to marsh hydrology. She has worked in coastal marshes in northwest Europe, southern Chile and the Atlantic, Pacific and Gulf coasts of the US. She has been involved in restoration planning both in Louisiana and in California, and in scientifically evaluating the results of marsh restoration projects. Denise has served on numerous boards and panels concerning the effects of human alterations on coastal environments and efforts to restore them.

Dr. John Teal received his Ph.D. from Harvard (1955) and studied trophic relationships in a Massachusetts spring. He studied salt marshes at University of Georgia's Marine Institute at Sapelo Island, and went to Dalhousie University in Halifax. He joined Woods Hole Oceanographic Institution where he is now Scientist Emeritus. In addition to research on coastal wetlands, he has worked on effects of hydrostatic pressure on deep sea animals, physiology of large warm-blooded fishes, bird migration over the oceans, oil pollution, wastewater treatment, and restoration ecology. He now consults on constructed wetlands for wastewater treatment, marsh restoration in fresh, brackish and salt wetlands, and cleanup of polluted wetlands and waters. He has been involved since 1993 in a salt marsh restoration project in Delaware Bay that encompasses 32 square miles. He served as president of the Society of Wetland Scientists in 1998-99.

Daytime Agenda

- 9:00 am *Welcome and Introductions*
Billy G. Garrett, Superintendent of Gateway National Recreation Area
Purpose of Symposium
Kim Tripp, Jamaica Bay Institute
Charles Roman, North Atlantic Coast CESU

Documenting Marsh Loss and Site Characterization

- 9:15 am *Jamaica Bay salt marsh maps 1974 to 2002: Base maps for temporal-spatial analysis of salt marsh changes*
M. Kathryn Mellander, GATE
- 9:30 am *Development of salt marsh change detection protocol using remote sensing and GIS*
Y.Q. Wang, URI
- 9:45 am *Subaqueous soil survey in Jamaica Bay*
Richard K. Shaw, USDA
- 10:00 am 15 minute Q & A
- 10:15 am Break

Marsh Development Processes and History of Marsh Development

- 10:30 am *An evaluation of salt marsh accretion and elevation dynamics of Jamaica Bay, Gateway National Recreation Area, New York using the surface elevation table*
Donald R. Cahoon (USGS) and Charles Roman (NPS)
- 10:45 am *Paleoecology and marsh compositional changes over the last millennium, Jamaica Bay, NY*
Dorothy Peteet, Columbia University
- 11:00 am *Are accretion rates and marsh loss decoupled?*
Alexander S. Kolker, Stony Brook University
- 11:15 am 15 minute Q & A

Causes of Marsh Loss: Hydrodynamics and Sediment Flux

- 11:30 am *The waters of Jamaica Bay: Impact on sediment budget*
Arnold L. Gordon, Columbia University
- 11:45 am *Sedimentation history and budgets for the Jamaica Bay estuary-marsh system: Seasonal to decadal dynamics revealed through radiotracer studies*
Steven L. Goodbred, Stony Brook University
- 12:00 pm *Modeling tidal hydrodynamics and sediment dynamics of Jamaica Bay estuary*
Robert E. Wilson, Stony Brook University
- 12:15 pm 15 minute Q & A
- 12:30 pm LUNCH

Daytime Agenda

Causes of Marsh Loss: Mussels, Wrack, Bird Grazing, Organic Pollutants

- 1:15 pm *Erosion and pool formation in a Jamaica Bay fringing marsh:
The mussel berm hypothesis*
David R. Franz, Brooklyn College
- 1:30 pm *Effects of wrack on smooth cordgrass *Spartina alterniflora* survival and recovery
in Jamaica Bay Wildlife Refuge, New York: A progress report*
George W. Frame, GATE
- 1:45 pm *Marsh loss and bird grazing*
Dan Mundy, Ecowatchers
- 2:00 pm *Results of Jamaica Bay pore water chemical analysis including organic priority
pollutants detection in organic sediment grab samples taken along a transect
from PAL/FAL (not presented)*
John T. Tanacredi, Dowling College
- 2:15 pm 15 minute Q & A

Experimental Restoration

- 2:30 pm *Big Egg Marsh experimental restoration in Jamaica Bay Wildlife Refuge,
New York: A progress report*
George W. Frame, GATE
- 2:45 pm *Army Corps restoration plans*
Leonard Houston, US Army Corps of Engineers
- 3:00 pm 15 minute Q & A
- 3:15 pm Break
- 3:30-4:00 pm Future directions and research needs
Comments from Science Board and discussion

Jamaica Bay salt marsh maps, 1974 to 2002: base maps for temporal-spatial analysis of salt marsh changes

M. Kathryn Mellander¹, Abbe L. Schreibman², Fred M. Mushacke³, George W. Frame¹, Nigel Shaw⁴, Charles Roman⁴, Martin Schreibman²

Salt marsh maps were created at Gateway NRA through a partnership with New York State Department of Environmental Conservation (NYSDEC). The maps (works in progress) are the products of one of six salt marsh projects resulting from recommendations of the Blue Ribbon Panel on Jamaica Bay salt marsh loss.

The present study is the first of two mapping projects for Jamaica Bay salt marshes. The first, large scale (1:600) mapping of Jamaica Bay salt marsh extents and interior structures over a period from 1974 to 2002, demonstrates loss from the exterior of the salt marsh as well as significant changes in the interior of the marsh during the relatively short period of the project's scope.

The second project, recently begun at the University of Rhode Island, will be the development of a salt marsh monitoring protocol using satellite imagery and automated computer mapping.

The time series portion of the salt marsh mapping project began in 2002. NYSDEC provided scans of 1974 and 1985 low-tide, color-infrared aerial photography to Gateway NRA GIS personnel, who geo-referenced the imagery and used on-screen digitizing techniques (interactive computer mapping from on-screen aerial images) to create salt marsh maps from each set of imagery. To date, maps are nearing comple-

tion for 1974 and 1989, and mapping from 2002 aerial imagery has begun. The maps were digitized at a scale of approximately 1:600, with a mapping classification scheme that provides information on marsh structures (vegetation, mud flats, tidal creeks, etc.) as well as overall extents. The minimum mapping unit is approximately 10-15 square meters.

Examples from the salt marsh maps will be presented, to illustrate the relative complexity of detail and to demonstrate their use as base maps in measuring both internal and external changes in the salt marsh. Spatial analysis techniques available in a GIS will also be demonstrated, as time allows.

1 Division Natural Resources, Gateway NRA, National Park Service

2 Aquatic Research and Environmental Assessment Center, Brooklyn College, CUNY

3 New York State Department of Environmental Conservation, Marine Resources Unit, East Setauket, NY

4 National Park Service, Northeast Region Office, Boston, MA

5 National Park Service, Northeast Region, University of Rhode Island Bay Campus, Narragansett, RI

Work is currently underway to provide maps of Jamaica Bay salt marshes that demonstrate marsh loss and changes from 1974 to 2002. Using geographic information systems (GIS) technology, the maps will provide a base from which to measure ongoing changes of the salt marshes.

Development of salt marsh change detection protocol using remote sensing and GIS

Y.Q. Wang, Mark Christiano

The National Park Service has identified that the loss of salt marsh habitat in Jamaica Bay, Gateway National Recreation Area, warrants the development of a cost-effective, long-term salt marsh change detection protocol that can be applied in a broader coastal region of the northeast United States. This project addresses the creation of such a working protocol. We are using the high spatial resolution QuickBird-2 satellite image, acquired on September 10, 2003, for salt marsh information extraction. The QuickBird-2 satellite image possesses 0.65-meter spatial resolution on its panchromatic band and 2.5-meter spatial resolution on its multi-spectral bands. The high spatial resolution and repeated satellite data acquisition should meet the goal of salt marsh change detection and monitoring.

The extraction of salt marsh information is being conducted in both digital image classification and manual delineation. We adopt the classification scheme used by the Gateway NRA Salt Marsh Mapping project including *Spartina* > 50%; *Spartina* 10-50%; *Spartina* < 10%, and other associated categories. Upon finishing the information extraction, we will be able to compare and validate the agreement between satellite-derived salt marsh information and the delineation result from historical aerial photographs; investigate the effectiveness of salt marsh change detection in a regular time frame with reliable accuracy and in reasonable cost using high spatial resolution satellite data; and develop detailed description of the change detection protocol. As for ground truthing, we have conducted a fieldwork to establish a GPS based Virtual Field Reference Database (VFRDB) for the Jamaica Bay area. The

VFRDB contains GPS-photos that recorded landscape specifics of the photo sites. The VFRDB should also contain typical GPS transect data that recorded the salt marsh variables such as the vegetation, hydrology, soils and sediments, as well as other observable indicators such as nekton and birds. The VFRDB is part of the protocol that will provide benchmark data for long term monitoring and change detection analysis.

Y.Q. Wang and Mark Christiano
Department of Natural Resources Science
University of Rhode Island
Kingston, RI 02881-0804
(401) 874-4345, (401) 874-4561 (fax)
yqwang@uri.edu, m_christaino@mail.uri.edu



Dr. Y. Q. Wang is an associate professor in terrestrial remote sensing at the Department of Natural Resources Science, University of Rhode Island. He received his M.S. and the Ph.D. degree in Natural Resources Management & Engineering at the University of Connecticut in

1992 and 1995, respectively. He was on the faculty of the University of Illinois at Chicago for four years before joined the URI faculty in 1999. His research interests include observing, understanding, and modeling human induced land-use and land-cover change (LULCC). He has been conducting research in the United States, East Africa, and China with funding from NASA, USDA, USAID, UNDP, and the NPS. Dr. Wang teaches introduction and advanced remote sensing classes at URI.

Using recent satellite imagery and historical aerial photographs along with GPS, a protocol to detect long-term changes in salt marshes is under development. By examining the marshes through the high detail photos and satellite image combined with on the ground field work, benchmark data will provide a baseline to detect future changes.

Subaqueous soil survey in Jamaica Bay

Yiyi Wong¹, Richard K. Shaw², Olga Vargas²

Estuarine sediments have traditionally been categorized from a geologic perspective. Recent research has shown that shallow water sediments 1) undergo pedogenic, or soil forming, processes; and 2) are systematically distributed across the subaqueous landscape. A state factor equation describing the variables in subaqueous soil formation has also been established. Traditional soil survey mapping techniques have been applied to estuarine environments in Sinepuxent Bay, MD, Rehoboth Bay, DE, Ninigret Pond, RI, and Taunton Bay, ME. Subaqueous soil survey provides for a more holistic, ecologically oriented substrate characterization and classification system, and a comprehensive soil-landscape model that explains sediment distribution. This work has contributed to a taxonomic amendment to the definition of "soil" to include areas that are submerged by 2.5 meters or less.

A subaqueous soil survey pilot project is planned for Jamaica Bay, beginning in May 2004. A 200 acre portion of Jamaica Bay will be mapped at scale of 1:12,000, in an area which allows for a diversity of landscapes and soil conditions. Detailed bathymetric data will be acquired to prepare a topographic map, which, along with aerial photos, will be used to identify subaqueous landforms. Survey equipment includes bucket and McCauley peat augers for heavier textured and organic substrates, and a vibracoring device mounted on a pontoon boat for sandy samples. Sediment profile descriptions will be recorded to a depth of 1.5 meters, and selected samples will be analyzed in the laboratory for particle size analysis, pH and electrical conductivity, organic carbon and CaCO₃ content, NH₄⁺ and NO₃⁻, acid volatile and chromium reducible sulfides, and trace metals.

Initial interpretive emphasis will be on eelgrass (*Zostera marina*) habitat: is eelgrass present in this area of Jamaica Bay, and (how) do soil conditions affect its distribution? This study will attempt to provide managers of Gateway National Recreation Area with information to determine potential sites for eelgrass restoration, and lead to a better understanding of the relation of subaqueous soil characteristics and distribution to benthic flora and fauna.

**1 Department of Soil Science
College of Agriculture and Life Sciences
North Carolina State University
Raleigh, North Carolina 27695-7619**

**2 USDA Natural Resources Conservation Service
NYC Soil Survey
1000 South Ave
Staten Island, NY 10314**



Olga Vargas
(Olga Vargas presented for
Richard Shaw)

Richard K. Shaw is a Soil Scientist and Project Leader for the USDA-NRCS New York City Soil Survey. Previously (from 1996 to 2002) he served as Soil Survey Party Leader for the USDA-NRCS in Northern New Jersey, conducting soil surveys in Sussex and Essex Counties. From 1979 to 1996 he worked as a lab technician in soil science at Rutgers University, providing technical support for soils related research. He received the B.S. degree in Natural Resource Management from the University of Maine, and the M.S. and Ph.D. degrees from the Department of Soils and Crops at Rutgers.

A study is planned to survey shallow water sediments using soil survey mapping techniques to identify and characterize shallow water soils in a 200 acre portion of Jamaica Bay. This study will potentially help with eelgrass restoration, and with understanding the relationship between shallow water soil characteristics and benthic flora and fauna.

Science Board Comments

Comment:

The new GIS analysis being conducted by the NPS that includes identification of “within marsh” features includes a categorical assessment of vegetation cover. This analysis is very promising and the Science Board should consider the results of this analysis when it is complete using the 2002 photography.

Comment:

The documentation of marsh loss is unequivocal. The question of tidal stage or when the images were taken continually comes up. I do not believe more refined treatment of the tidal stage will affect the overall conclusion (i.e. that there’s been alarming loss of marshland) but it could possibly change the character of the evidence that the tidal creeks are widening. Some test of sensitivity to tidal stage should be made either by multiple images or ground surveys in a small area. In my opinion, the issue of a trend in marsh loss from NW to SE is not yet convincing. Perhaps these new studies can provide better evidence for any trends.

Comment:

Mellander’s photographic imagery analysis was instructive in highlighting the many stages of change in the marsh cover over a 15-year period. Whatever is happening is non-uniform and perhaps with some spatial association (exposure, proximity, sequence). She had data on areas of gain as well as loss, seemingly indicating that conditions do exist for marsh expansion or recovery. Obviously, changes in the following 15-year period will be very instructive relative to the spatial variables.

Comment:

Studies of satellite imagery were very promising. These techniques may provide a more rapid assessment tool for landscape change. The work appears promising. I have some concerns regarding the Virtual Field Reference Database as much of the information it contains relative to the vegetation cover categories appear to be visual estimates rather than real field “reference” data. I recommend that the investigating team strengthen this aspect of the work to provide a more quantitative reference for documenting change on vegetative cover.

Comment:

The detailed aerial and satellite data looked very promising, especially those from the QuickBird-2 images for future imaging. The work of Wang and Mellander should definitely continue.

Comment:

Mellander and Wang’s work on salt marsh mapping, change, remote sensing and GIS is valuable work and needs continuing support. The remote sensing work needs ground-truthing to determine level of vegetative identification. The remote sensing may prove faster, but not better than digitizing aerial photos.

Comment:

Wang unveiled a new source of multispectral information (new to me) in QuickBird 2 that has great monitoring potential at a very reasonable cost. It would seem to be especially valuable in following any restoration effort in the bay.

Comment:

I would not continue to support the sub-aqueous soil survey.

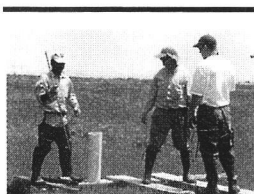
An evaluation of salt marsh accretion and elevation dynamics at Jamaica Bay, Gateway National Recreation Area, New York using the surface elevation table method

Donald R. Cahoon¹, James C. Lynch¹, Charles Roman², George Frame²

Several factors have been identified as potentially contributing to the salt marsh loss at Jamaica Bay, Gateway National Recreation Area, New York, including sediment deficit, sea-level rise, altered estuarine circulation due to dredging, nutrient enrichment, and biotic influences related to water bird and mussel populations, among other factors. We designed a study to determine the accretionary and elevation dynamics of the salt marsh habitats of Jamaica Bay to more fully understand the mechanisms causing wetland loss and to develop effective marsh restoration strategies. Using surface elevation tables (SET) and artificial soil marker horizons, we compared soil elevation dynamics between two marsh islands with different levels of stability; the stable marsh at JoCo and the deteriorating marsh at Black Bank. Preliminary data analyses revealed the marsh at Black Bank had a higher rate of accretion but lower rate of elevation gain compared to JoCo, which is typical of deteriorating marshes located lower within the tidal range. We also evaluated the effectiveness of thin-layer deposition of dredged material at restoring soil elevation of the degraded salt marsh at Big Egg Marsh. Where the marsh had degraded to mudflat, thin-layer deposition effectively restored soil elevation to that of the adjacent vegetated marsh. In contrast, the elevation of the reference marsh continued to decline.

- 1 U. S. Geological Survey
Patuxent Wildlife Research Center**
- 2 National Park Service
Gateway National Recreation Area**

**Address as of March 2004
USGS Patuxent Wildlife Research Center
Beltsville Lab, c/o BARC-East
Building 308
10300 Baltimore
Avenue, Beltsville, MD 20705**



Dr. Donald R. Cahoon is a Research Ecologist with the U. S. Geological Survey, Patuxent Wildlife Research Center located in Laurel, MD. He received

his Bachelor of Arts degree, with Honors in Botany, from Drew University (1972), and MS (1975) and PhD (1982) degrees in Wetland Plant Ecology from the University of Maryland. His professional interests include wetland plant ecology, wetland accretionary processes, and wetland restoration and management. His research program is focused on three objectives: (1) determining the impacts of sea-level rise on long-term marsh stability through evaluations of marsh accretionary processes, (2) identifying the processes of wetland loss, submergence, and soil erosion in both natural and managed coastal marshes, and (3) evaluating the effectiveness of wetland restoration and management techniques. His research approach for measuring wetland elevation dynamics is being used in more than 100 wetland sites in 15 countries. He worked on coastal management and research issues in Louisiana for 19 years

Two marsh islands with different levels of stability were studied to better understand the mechanisms causing wetland loss and to develop effective marsh restoration strategies. Preliminary results showed that the less stable marsh had a higher rate of accretion but lower elevation gain.

Paleoecology and marsh compositional changes over the last millennium, Jamaica Bay, New York

D. Peteet, L. Liberman, P. Higgistson

At the same time that the marshes show documented loss in this century, our research on sediment cores from marshes in Jamaica Bay show striking increases in percentage of organic matter (up to five-fold) since European impact. We have probed depths of marsh sediment throughout Jamaica Bay including the islands of JoCo Marsh, Silver Hole Marsh, Big Egg Marsh, Little Egg Marsh, Yellow Bar Hassock, Stony Creek Marsh as well as the mainland marsh Old Mill Creek. All of the marshes are underlain at depths of 2 m or less by sand. Two cores were analyzed for pollen, macrofossils, and detailed study of sediment composition, and they show striking similarities and intriguing differences. Less than one thousand years ago, the marsh formations began, probably due to protection of the islands by southwestward growth of Rockaway Spit. Salt marsh peat accumulated, and *Trochammina spp.* became the dominant foraminiferal type, followed by other marsh species such as *Milliamina* and *Rotamorphina*. Regional vegetation in both cores shows an increase of *Pinus* (pine) forest compared with *Quercus* (oak) today, possibly signaling a Little Ice Age response. The subsequent rise in *Ambrosia* (ragweed) reflects the forest destruction and the open environment that resulted as Europeans colonized the region. It is only in the uppermost sediments (30 cm) that *Salicornia* seeds are continuously present, suggesting more saline conditions as the marshes erode, or high marsh characteristics. The last century shows a resurgence of the *Quercus*-*Pinus* forest after the decline due to early European influence. Examination of the mass of organic vs. inorganic matter show that the increase in organic matter observed

at JoCo Marsh and Yellow Bar Marsh has primarily been the result of a significant decrease in inorganic deposition on the marshes, although JoCo shows a major increase in organic content in the twentieth century. An increase in the sand size fraction of organics may be attributed to a number of sources in the watershed and estuary, including logging and clearing, fertilization and changes in water quality, or an increase in the production rate of *Spartina*. C-13 and C/N analyses (in progress) will aid in understanding these changes.

Lamont Doherty Earth Observatory
Rm. 204 New Core Lab
Palisades, NY 10964,
845-365-8420
peteet@ldeo.columbia.edu.



Dorothy Peteet is a Senior Research Scientist at NASA/Goddard Institute for Space Studies, and Adjunct Senior Research Scientist at Lamont Doherty Earth Observatory. Her interests are in paleoecology

and paleoclimate, and she has been recently working in the Hudson River marshes as well as Hudson Valley upland swamps and bogs. She works on Alaskan and Easter Island sites, and tests hypotheses of climate change with her colleagues at NASA/GISS. She also teaches a class entitled "Wetlands and Climate Change" at Columbia University.

Analysis of sediment cores in Jamaica Bay marshes show that marsh formation began less than 1000 years ago. During the intervening time period, the cores reveal many changes in the marshes and regional vegetation that resulted from European impact. Further analysis still in progress will aid in understanding these changes.

Are accretion rates and marsh loss decoupled?

Alexander S. Kolker¹, Aaron Beck, Tamara Kroboth, Steve Goodbred and J. Kirk Cochran.

We present ^{210}Pb derived accretion rates from 3 salt marsh cores from Jamaica Bay, NYC and compare these results to 8 cores from salt marshes in 4 separate oceanographic environments on Long Island. Sedimentation rates over the past century averaged 0.52 cm/yr for a core from Big Egg Marsh, 0.44cm/yr from East High Marsh and 0.28 cm/yr from JoCo Marsh. A detailed analysis using a model assuming a constant flux of ^{210}Pb to the marsh surface suggests that sedimentation rates in Big Egg Marsh have increased during the past 3 decades. However, evidence for changes in the sedimentation rates all the Jamaica Bay cores are not without their ambiguities. The sedimentation rates in these 3 cores are comparable to stable systems elsewhere on Long Island. Our results suggest that marsh loss in Jamaica Bay, and across Long Island, is controlled by complex dynamics which may not be directly linked to sediment accretion. Ongoing work is attempting to explain accretion patterns in terms of long terms of decadal scale changes in storm frequency, sea level and anthropogenic disturbance.

Alex Kolker is a Ph.D. candidate in Marine Sciences at S.U.N.Y., Stony Brook University. He is interested in understanding how coastal ecosystems, such as salt marshes, respond to environmental changes. He uses a variety of techniques from radiochemistry, geochemistry, sedimentary geology and ecology. He received Bachelors in Biology from U.C. Santa Cruz and a Masters in Ecology from Stony Brook. Before coming to Stony Brook he worked in wetlands in Maryland and in Florida Everglades ecosystem



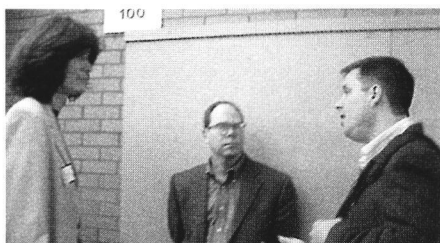
**1 Marine Sciences Research Center,
Stony Brook University,
Stony Brook, New York 11794-5000
akolker@ic.sunysb.edu
631) 632-3076**

Estimates of Jamaica Bay salt marsh growth seem similar to marshes elsewhere on Long Island. There are complex interactions among many factors involved in marsh growth over long and short time periods. As such, recent marsh losses may not involve a simple relationship between sedimentation rates and the rate of relative sea level rise.

Science Board Comments

Comment:

The series of presentations on sediment accumulation (Cahoon, Peteet, and Kolker) are remarkably coherent in their estimation of sedimentation rates in the remaining marsh areas. The rates seem to track sea-level rise records from the Battery remarkably well and seem to indicate that currently vegetated areas are keeping pace with sea-level rise.



Cornelia Schlenk, Kirk Cochran and Steven Goodbred

Comment:

I was impressed by the work on the deep cores and the suggestion that the changes around 1600 the composition of the sediments were associated with the creation of millponds by the European settlers. If possible, more cores should be studied and some cores taken from whatever millpond locations can still be found.

Comment:

Questions remain about the rates of salt marsh decline. Do they vary spatially or temporally? What are the rates in those areas where marshlands are recovering? It is likely that the rates at the Battery are not the best rates for comparison because it is in a different geomorphological setting. The Sandy Hook, NJ setting is more similar because of the barrier spit development and thick accumulations of Holocene sediments.



Dan Cahoon and Jim Lynch

Comment:

Since the initial recommendations of the NPS's Blue Ribbon Panel, urgently needed remediation is moving forward and research has begun to address the principal questions concerning the alarming loss of Jamaica Bay marshland. The research focus is placed properly on the two most likely suspects—relative sea level rise and a deficient sediment supply. One of the striking generalizations of the most recent results is that accretion rates, by and large, are adequate to keep up with an average rate of sea level rise of about 3 mm/yr. Over a period of years, however, the actual submergence rate may be many times this value as sea level oscillates up and down. As shown in the recent presentations, there seems to have been an increase in both the amplitude of fluctuations in the multiyear rate of sea level rise and an increase in the period of fluctuations. Subsidence of the marsh surface, in addition, can be punctuated by, as yet unresolved, interannual events. An observed loss in marsh elevation in 2003 coincided with one of the wettest June's on record.

Comment:

The evaluation of salt marsh accretion using SETs is valuable and needs to continue to be done at reference sites and at any sites where alteration is contemplated.

Comment:

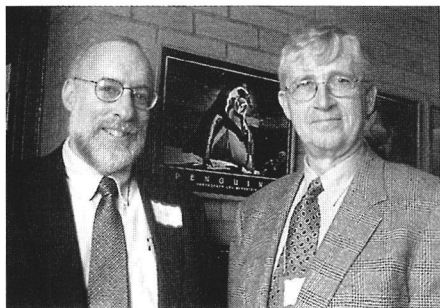
The report of Peteet on paleoecology and marsh compositional changes over the last 1000 years was the best of the day.

Intriguing issues on organic:inorganic fraction of marsh sediment. This needs continuing support.

Comment:

Peteet provided some insight on one of my favorite topics, the temporal perspective on today's events. Her cores showed changes in the sediment quality through time.

Thus, suggesting that the environmental conditions have been altered, or are altering. Jamaica Bay is an embayment, and may have been changing from generally open access to the ocean to closing off by spit or barrier island extension across its entrance, perhaps non-uniformly.



Charlie Roman and David Franz

Comment:

As the presentations by Cahoon, Peteet, and others indicate, the presence of the existing marsh is evidence that it is keeping up with sea-level rise. The additional information offered by these researchers is the rate and variation in rates that are represented in the cores and/or accumulations. They should focus on these rates, the organic/inorganic ratios, the potential periodic and episodic events, and the geographical patterns of accumulations. That is what will provide insight to the spatial and temporal scale of sedimentation in various parts of the bay. I wonder if the reference to the tide gauge at the Battery is the best basis for comparison of the SLR record. The Sandy Hook tide gauge is in a more similar geomorphological setting and has a similar depositional history. It may be a better comparative barometer of inundation during the past century. This is excellent research and should be continued

Comment:

The Kolker presentation on accretion rates and marsh loss decoupled was interesting, it needs to be published, and additional work is likely needed.

The waters of Jamaica Bay: impact on sediment budget

Arnold L. Gordon and Robert W. Houghton

Jamaica Bay offers a unique opportunity to study a complex salt marsh and estuarine environment in an urban setting. During the last 50 years there is a noticeable decrease in the marsh area, perhaps reflecting a change in the source/sink components of the sediment budget. To effectively investigate the causes of this phenomenon requires an understanding of the complex interplay of materials and energy flow within the system and its coupling to its urban surroundings. Here we report on the circulation and stratification of the waters encircling the interior marshes. Multiple sources of freshwater contribute to the Bay are sewage treatment outfalls and surface runoff. There are also indications that filaments of Hudson River water at times enter the Bay through Rockaway Inlet. Jamaica Bay waters are highly stratified during summer, with residual stratification continuing through the winter. Nitrogenous nutrients remain abundant throughout the summer, with periods of suboxic conditions at the sediment-water interface in Grassy Bay. During hyper-eutrophic conditions the phytoplankton appear to be limited by the availability of carbon dioxide. Stratification is highly time dependent with tidal influences having a profound impact on vertical structure throughout the Bay. Jamaica Bay is linked to the coastal ocean via Rockaway Inlet. Strong tidal currents within the Inlet gradually act to replace the waters of Jamaica Bay. Flushing times vary for different portions of the Bay; estimates using two independent methods yield a flushing time on the order of 1 week for the upper 5 meters of Grassy Bay. Terrestrial sediments must cross the relatively deep water ring surrounding the interior marshes. Energetic tidal currents acting within the anthropogenic modified

bathymetry may alter the movement and fate of suspended sediment. For example, Grassy Bay appears to act as a sediment sink, sequestering sediment before they reach the marshes. The source of terrestrial sediment may be expected to be diminished by the 'paving over' of the surrounding land during the 20th century.

Columbia University
Department of Earth & Environmental Sciences
Division of Ocean and Climate Dynamics
Lamont-Doherty Earth Observatory
P.O. Box 1000
Palisades, NY 10964
(845) 365-8325
agordon@ldeo.columbia.edu



Prof Gordon investigates the complex processes that shape the pattern of ocean circulation and mixing and the ocean's interaction with the atmosphere and cryosphere in terms of the ocean's role in governing Earth's climate and its variability. Observational data, drawn from a variety of sources, such as satel-

lites, ocean mooring and drifter time series, ocean temperature, salinity and chemical tracers, plus ocean model data products, provide a quantitative view of how the ocean "works", how it moves heat, water, nutrients and dissolved gases in the horizontal plane and within the great ocean overturning cells. While his research involves field work in remote regions as the Southern Ocean and Indonesian seas, he also devotes effort to investigate the interface of the ocean with the land, within coastal ocean, estuaries and wetlands environments, where there are notable elements of change in response to fluctuating climate conditions and increased urban stresses.

Salt marsh losses in Jamaica Bay are closely connected to energetic water and sediment flow around the marshes. By studying the water dynamics such as tidal flushing, stratification, surface runoff and sources and sinks of sediment in and around Jamaica Bay, a better understanding of the causes of recent marsh losses will begin to emerge.

Sedimentation history and budgets for the Jamaica Bay estuary-marsh system: Seasonal to decadal dynamics revealed through radiotracer studies

Steven L. Goodbred, Jr., J. Kirk Cochran, Roger D. Flood

Sediments in coastal wetlands and shallow estuaries are dominated by fine-grained cohesive material. However, the dynamics of these systems are difficult to successfully understand because of (1) non-linear behavior associated with fine-grained sediment cohesion, (2) biological modifications to the environment (e.g., bioturbation, plant stabilization, etc), and (3) physio-chemical interactions within sedimentary deposits (e.g., role of pollutants and organics in substrate stability). In addition, studies of wetlands require a comprehensive understanding of both the marsh proper and the adjacent estuary system, because the majority of sediments delivered to the marsh surface are derived from sediment resuspension in the estuary. In this way, most creeks and estuaries provide temporary storage for new sediments that are subsequently transported onto the marsh by a combination of waves, tides, and storms.

To fully consider the issues of cohesive sediments and marsh-surface accretion, quantifiable measures of sediment flux, transport patterns, and accumulation rates are needed for the Jamaica Bay marsh-estuary system. In this study, we will use a suite of radioisotope tracers to determine spatial and temporal patterns of sediment movement within the estuary and marsh. Specifically, the inventory of short-lived (monthly), naturally occurring nuclides, ^7Be and ^{234}Th , will be measured throughout Jamaica Bay over several seasons. Both ^7Be and ^{234}Th are strongly particle reactive and bond tightly with sediments in the water column, making them excellent tracers for sediment movement. The radiotracer approach also allows sediment accumulation to

be tracked both through the estuary and on the marsh surface, so that sediment dynamics in subtidal habitats and high marsh environments can be studied in a comprehensive manner. Results are quantifiable and can be used to calculate the total volume of mobile sediments within the estuary, indicating the pool of sediments available for transport onto the marsh surface by waves, tides, and storms. In addition, these approaches will be combined with a high-resolution sonar survey (Flood) and modeling study (Wilson and Flagg) of Jamaica Bay to provide a more comprehensive understanding of estuarine sediment transport patterns.

**Marine Sciences Research Center
Stony Brook University
Stony Brook, NY 11794-5000**

Dr. Steve Goodbred has been an Assistant Professor at Stony Brook University's Marine Sciences Research Center since 1999. He received his M.S. from University of South Florida and his Ph.D. from College of William and Mary in Marine Sciences. His research at Stony Brook has focused on coastal development and the dispersal of sediment within river, delta, and wetland environments in both South Asia and New England. In the New York region, Dr. Goodbred is currently conducting several research projects within the Jamaica Bay, Peconic Bay, and Great South Bay estuaries and salt marshes, which are each under threat from natural and human-induced changes.

Two complementary approaches are being used to evaluate historical and present sediment dynamics in Jamaica Bay. By using radioisotope tracers and numerical modeling, the mechanisms of sediment transport and their relationship to water circulation in the estuary will be elucidated. This dual method will help evaluate which restoration approaches will work best to promote marsh growth.

Modeling tidal hydrodynamics and sediment dynamics of Jamaica Bay estuary

Robert E. Wilson and C.N. Flagg

The overall goal of this project is to determine whether physical alterations to Jamaica Bay have modified the bay's hydrodynamics and thereby its sediment dynamics so that bay wetlands are no longer able to be naturally maintained. We have defined the following objectives for both contemporary and historical bay bathymetry:

1. Description of sediment transport patterns within the bay
2. Quantitative description of horizontal sediment fluxes throughout the bay
3. Quantitative description of sediment accumulation rates and patterns of accumulation of throughout the bay.

We define as a final objective an evaluation of the changes in items 1-3 above from historical to contemporary settings, and an interpretation of these changes in terms of changes in bay hydrodynamics. Hydrodynamic features to be considered include tidal current amplitude, tidally-induced and density-induced and residual current structure, asymmetry in both tidal currents and tidal elevation, salt intrusion and its relationship to water column stratification and vertical mixing.

Our approach is to apply a calibrated 3-D hydrodynamic model to a description of both the present and historic hydrodynamics and sediment dynamics. The model being used is FVCOM which uses an unstructured grid and has wetting and drying capabilities. It is especially well suited for simulations of hydrodynamics and material transport processes in complicated estuarine geometries such as those found in Jamaica Bay.



**Marine Sciences Research Center
Stony Brook University
Stony Brook, NY 11794-5000**

To determine whether physical changes to Jamaica Bay have modified the bay's water and sediment dynamics so that bay marshes cannot be naturally maintained, a 3-D hydrodynamic model will be applied to describe current and historical water and sediment dynamics. The model is well suited to complicated estuarine environments such as Jamaica Bay.

Science Board Comments

Comment:

The researchers examining sediment dynamics using modeling and radionuclide tracers should be encouraged to develop a “sediment budget” for the Bay. If possible this should consider fine and sandy sediments separately.

Comment:

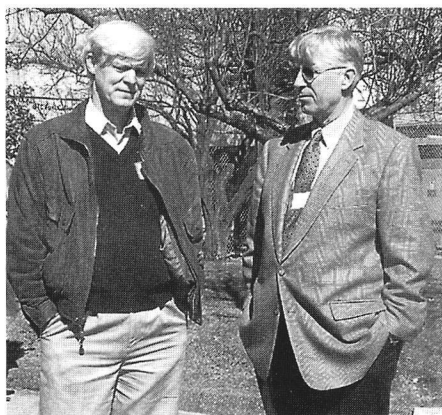
Gordon’s work on the waters of Jamaica Bay and impacts on sediment budget was very interesting and needs continuing support. It would be worthwhile to couple Gordon’s data on sediment budget with Wilson’s hydrodynamic modeling.

Comment:

The radiotracer studies were just recently initiated and are preliminary. I am anxious to see the data.

Comment:

The sidescan sonar imagery of the retention of the dredge scars in the bottom topography is amazing. These views offer insights into the long-term impacts of sediment manipulation in the bay. The technique is a valuable tool to gain detailed information of the bay’s bathymetry. Equally informative are the observations of large areas of sediment accumulations of more than 3 m since the period of dredging. The spatial associations of these negative and positive areas are fundamental to an understanding of vectors of erosion, transport, and accumulation. The sidescan sonar tool can be a fantastic aid in identifying sites for further inquiry and for detailed bottom characterization. Potentially combined with water penetrating LIDAR, these new tools could provide valuable knowledge of the hydrography and pathways in the bay.



Bob Wilson and David Franz

Science Board Comments

Comment:

The sediment budget is a difficult puzzle to piece together. Is there enough sediment coming in to maintain the elevation of the marsh in the face of rising sea level? If there is not, is the deficit from the terrestrial supply or the marine input? If enough is coming in, is it finding its way to the marsh surface where it's needed? One intriguing recent result is the apparent decline in inorganic sediment content continuing since colonial times.

In the past, sediment supply was able to support over 16,000 acres of marshland. At this stage, I would speculate that the 1,000 acres of marsh islands now in Jamaica Bay require some 3,650 metric tons of sediment annually to keep pace with a sea level rise of 3mm per year. I suspect that there is little, new sediment being supplied from the land surrounding Jamaica Bay. Not only is it comprised of sandy sediment left over from the last Ice Age, with little silt and clay in it, but it is also substantially covered with concrete and asphalt. Organisms living in the bay water itself might contribute 2,000 metric tons per year and sewage treatment plants might add about 5,000 metric tons of fine-grained inorganic sediment per year. Much of the mud found in the bay today, however, is probably re-worked accumulation representing sediment trapped between the barrier island and the mainland. Over thousands of years this system has been gradually moving northward as sea level rises, but new sediment is also brought in by the tides. Most estuaries on the East Coast seem to trap suspended sediment imported to them by the tide and Jamaica Bay is no exception. One attempt at a sediment budget required

an input of between 15,000 and 29,000 metric tons per year to bring the debits and credits into balance. A single tide can import 36 metric tons of sediment into the Bay under the right conditions, but conditions vary, some tides will carry in less and some will export sediment from the bay to the ocean.

Like a senior citizen living on a fixed income, marshes have to contend with other drains on their income of silt and clay. Sediment deposited below the low tide level and in dredged channels is a debit amounting to between 6,000 and 15,000 metric tons per year. In Jamaica Bay, another major debit is of our own making. When Kennedy Airport was built in 1946, Grassy Bay was dredged to a depth of over 15 meters to provide 47 million cubic meters of fill for the construction of the airport's foundation. An additional 3.4 million cubic meters was taken in 1958 and 9.0 million in 1962. The dredging operation left a large hole in the bay floor called a "borrow pit." Borrow pits cover over 700 acres more or less. Borrow pits are out of equilibrium with the environment and tend to absorb huge amounts of sediment. A sedimentation rate in Grassy Bay was measured to be about 1.5 centimeters per year. In this case, the borrow pit probably drains some 45,000 metric tons of sediment from the marshlands' annual supply. Such a large sediment sink would be one of the prime suspects in our case of the missing marshland.

Erosion and pool formation in a Jamaica Bay fringing marsh – the mussel berm hypothesis

David R. Franz and Ileana Friedman

The fringing marshes of Jamaica Bay are undergoing rapid bank erosion and interior marsh pond formation, leading to marsh losses. Observations suggested that pool formation, and marsh loss, may be related indirectly to unusually high densities of ribbed mussels (*Geukensia demissa*) which occur at the marsh edge. Interior ponds form when the marsh edge becomes elevated above the marsh surface due to high rates of bio-deposition and sediment trapping by mussels. Reduced drainage of the ponds ultimately leads to *Spartina* death. We refer to this sequence of cause and effects as the “mussel berm hypothesis.” In 2001-2003, sediment collectors were embedded in and above the sediment surface to measure short-term sedimentation rates along a transect normal to the marsh edge. Organic and mineral components of bio-sediments and sediment cores along the transect were determined. End-of-season estimates of *Spartina alterniflora* biomass and condition were made each summer.

Mussel aggregations promote export of bio-sediments. The berm itself may generate bio-sedimentation to the marsh interior by ‘exporting’ bio-sediments landward on the flood tide and trapping sediments on the ebb. High potential rates of accretion imply that sediment trapping, and the biomass of the living mussels themselves, probably are sufficient to account for elevation of the marsh edge (berm formation). On the berm, biosediments produced by mussels are equal or exceed sediments passively trapped by *Spartina*. *Spartina* condition measurements showed that, in the absence of drainage, *Spartina* growth was depressed immediately behind the berm, but recovered up-shore.

Our data indicate that *Spartina* continues to flourish in the upper marsh, and we have no data to indicate that sediment supplies on the fringing marshes are insufficient to maintain healthy *Spartina* growth. However, with current sea level rise, continued edge erosion is rapidly shaving away the fringing marsh system (at least is our study area).

Dr. David Franz
Professor of Biology and
Deputy Chairman for Undergraduate Studies
Brooklyn College CUNY, Brooklyn, NY 11210
Office: 718-951-5700
email: df Franz@brooklyn.cuny.edu

A graduate of Gettysburg College and Rutgers University, Dr. Franz has worked in the coastal zone offshore primarily on benthic ecology and population biology of invertebrates (e.g. amphipods, seastars, surf clams, mussels) and the biogeography of NW Atlantic invertebrates. As a frequent contractor for the USNPS during the last 20 years, his research has included the first complete survey of macrobenthos in the Bay, as well as studies on the effects of landfill leachates, and Kennedy Airport, dietary analyses of Winter Flounders, and the community structure and diversity of intertidal invertebrate communities in Jamaica Bay (JABBERT). In the last 10 years, his research has centered on the population dynamics of ribbed mussels in Jamaica Bay, on the ecological effects of sea lettuce blooms on meiofaunal copepod populations (co-authored with Ileana Friedman), and, in the last three years, the possible role of ribbed mussels on fringing marsh pond formation and marsh erosion. A past president of the New England Estuarine Research Society, and a member of the “Blue Ribbon Committee” appointed by the NPS to evaluate marsh erosion in Jamaica Bay.

Unusually high densities of ribbed mussels (*Geukensia demissa*) along marsh edges form an elevated “berm” caused by bio-deposition and sediment trapping by the mussels. This berm reduces drainage of the marsh leaving interior ponds, which leads to *Spartina* death. Smaller ponds may coalesce to form larger unvegetated areas within the fringing marsh, thus contributing to marsh loss.

Effects of wrack (straw & sea lettuce mats) on Smooth Cordgrass *Spartina alterniflora* survival and recovery in Jamaica Bay Wildlife Refuge, New York: a progress report

George W. Frame¹, Michael D. Byer¹, Martin P. Schreibman²,
William S. Panagakos², Marlen K. Waaijer², M. Kathryn Mellander¹

This is one of six saltmarsh pilot projects funded by National Park Service and New York State Department of Environmental Conservation. Fieldwork began April 2002 on: (1) Observations of wrack distribution and movements, and (2) experimental arrays in which wrack was placed on randomized plots of Smooth Cordgrass (*Spartina alterniflora*) for specified time intervals. Both studies are in the saltmarsh along the western shore of Ruler's Bar Hassock and Broad Channel village.

The observational study used GPS to map wrack mats along 5,000 meters of shoreline. Wrack distribution was re-checked biweekly, and re-mapped with GPS whenever movements occurred. In May 2002, less than 1% of the marsh had wrack, and in May 2003 the wrack was 0.2% cover. During the summer, wrack decayed to only one-third the area of 10 weeks earlier. Bare spots left by the wrack were sparsely recolonized by Common Glasswort (*Salicornia europaea*).

The experimental study established 11 arrays, each containing 7 "treatment" plots and 1 control plot measuring 2m x 2m. Centered within each treatment is a "sample" plot of 1m x 1m, surrounded by a 0.5m-width buffer zone. Smooth Cordgrass densities at the start were 300 to 600 stems/sq.m. In wrack-covered plots, most of the original grass shoots died within 7 weeks of covering, but rhizomes remained alive and new sprouts grew. In plots covered longer, even the rhizomes died, and such plots still remain bare.

Wrack decreases saltmarsh elevation in 3 ways: Wrack kills plants and roots, resulting in subsidence of the peat surface; water-logging and chemical changes keep the site unsuitable for plant regrowth. Wrack floating back and forth abrades the surface, causing erosion and puddling. Bare spots left by wrack sometimes are intensively used by birds, resulting in deeper puddles. All three factors contribute to interior decay and fragmentation of the saltmarsh.

- 1 Division Natural Resources,
Gateway National Recreation Area
210 New York Ave.
Staten Island, NY 10305-5019
- 2 Aquatic Research and Environmental
Assessment Center
Brooklyn College,
City University of New York,
2900 Bedford Ave.
Brooklyn, NY 11210

George W. Frame is a biologist in the Division of Natural Resources at Gateway NRA. Before coming to the US National Park Service, he worked in African national parks where he specialized in conserving wildlife through sustainable economic development in rural communities. He received a B.S. (biological sciences) at University of Alaska, M.S. (wildlife science) at the Co-operative Wildlife Research Unit in Utah State University, Ph.D. (wildlife ecology) at the Ecology Center in Utah State University, and a NATO post-doctoral fellowship in tropical forest conservation.

Mats of decaying straw and sea lettuce (collectively called wrack) are being studied in a Jamaica Bay salt marsh. Results so far show that wrack contributes to salt marsh loss by decreasing marsh elevation by killing marsh grass and by abrading the surface. Wrack contributes to waterlogged roots and chemical changes that keep the site unsuitable for plant regrowth.

Marsh loss and bird grazing

Dan Mundy

The Blue Ribbon Panel concluded that bird eat-out, especially from Brant Geese, may be responsible for the disappearance of salt marshes in Jamaica Bay. We decided to expand our study to include three species of geese that inhabit the bay; Brant Geese (*Branta bembica horta*, October-May), Canada Geese (*Branta canadensis*, year round), and Snow Geese (*Chen caerulescens*, October-April).

Canada Geese are here year round but more numerous in the winter months. They were seen occasionally eating *Spartina*, and for the most part they prefer lawn grass. They have been ruled out as any cause of marsh loss.

Brant Geese usually arrive in Jamaica Bay (1000) during the first week of October. They spend their first weeks flying in and out of the West pond, acclimating themselves with the area. They feed mostly on *Ulva* (sea lettuce) from the bay bottom until this source of food is depleted. They then move out of the bay to feed on all of the perimeter grassy areas. Around April 1st of each year when the *Spartina* starts to grow (and before the *Ulva* forms) some Brant begin to eat the new shoots of *Spartina*. Further observations show that although they cropped these grasses, the *Spartina* continue to grow to normal heights. When the *Ulva* begins to grow (within a couple of weeks) they move out to the mud flats to feed on it.

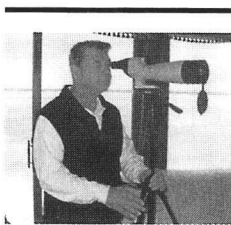
Snow Geese usually arrive around mid-October in large flocks and leave by April first. Our studies throughout 2002 indicated that the snow geese were possibly grubbing in the existing die-off areas, however, the extent of damage was not known. From November 2002 through March 2003 extensive studies indicated they spent a lot of time grubbing at Black Wall and Big Egg Marsh. At Black Wall, which was already severely depleted they caused some additional loss. When the same numbers of geese moved to

Big Egg Marsh they did forage at the roots and rhizomes but this marsh did recover through the growing season. (However these portions of the marsh were in better shape to begin with and this past season was a better growth season throughout the bay.)

Conclusions:

Canada and Brant Geese have no significant effect on marsh loss. Snow geese are a small contributing factor in existing die off areas.

Dan Mundy
56 West 14th Rd
Broad Channel, NY 11693
Tel: 718-634-5032
Email: dmundy5032@aol.com



Dan Mundy is a retired Captain of the NYC Fire Department and a lifelong resident of Broad Channel, Queens, the only inhabited island in Jamaica Bay. He was the first to discover the loss of marshes in Jamaica

Bay in 1995. Together with his concerned neighbors and friends he formed an environmental group called the Jamaica Bay Eco Watchers (JBEW). The JBWE monitor the bays waters and marshes daily throughout the year. They studied and documented these losses for many years and brought this to the attention of the various agencies including the National Park Service Blue Ribbon Panel. They also hosted two of their own conferences on the marsh loss and many of their recommendations are being implemented. They lobbied elected officials and agencies for funding to study causes and to begin restoration projects. The first project, the Big Egg Marsh Restoration, which they participated in has just been completed.

Three geese species (Canada, Brant and Snow) that forage in Jamaica Bay were studied to determine if their foraging contributed to marsh loss. Canada Geese (present year round) were found to feed primarily on lawn grass. Brant (present October to May) feed mostly on sea lettuce and thus have no significant effect on marsh loss. Snow Geese (present October to April) do feed in existing die off areas and are a small contributing factor to marsh loss in those areas.

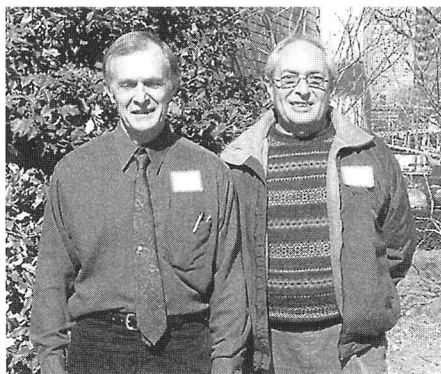
Results of Jamaica Bay pore water chemical analysis including organic priority pollutants detection in organic sediment grab samples taken along a transect from PAL/FAL

John T. Tanacredi and Martin P. Schriebman

Ten sediment samples along a transect line from Pennsylvania/Fountain Avenue landfills into Jamaica Bay, were collected in 2001-2 and analyzed for organic priority pollutants including PCBs, PAHs (9 parent, unsubstituted PAHs), chlorinated pesticides (DDT, DDE) and metals (Cd, Pb, Hg, Zn, Al). Pore waters from these sediment samples were collected and run for specific chemical – nutrient parameters: (i.e. Salinity pH, Nitrate – N, Total -N, Phosphorous, Total – Phosphorous).

Results reveal few detectable (>2 ppb) PAHs, PCBs in samples analyzed – Metal concentrations all exceeded standard levels and pore water analysis did not reveal any anomalous conditions, though there was a large difference in values between total – N and nitrite – nitrate-N probably due to the large presences of dissolved organic material (DOM) in samples. Due to the limited sample numbers, this work was inconclusive as to causation of marsh loss in the immediate vicinity of PAL/FAL. A considerably more intensive investigation is suggested to cover the full array of detectable contaminants from these landfills. This material was not presented at the March 3 meeting.

1. Dowling College
Department of Earth and Marine Sciences
2. AREAC
Director Brooklyn College
CUNY Grab



George W. Frame and Martin P. Schriebman

Sediment samples from a transect line from Pennsylvania/Fountain Avenue landfills into Jamaica Bay were analyzed for organic pollutants and metals. Low quantities of organics and metals were found, though more intensive investigation is suggested to cover the full array of detectable contaminants from these landfills.

Science Board Comments

Comment:

The data on mussel banks presented by Franz pointed to the potential role of mussels in enhancing sedimentation rates locally, and to their potential effect on ponding waters on the marsh surface. While the study was limited in extent it provided useful insights into the influence of the dense mussel banks on marsh processes.

Comment:

The mussel berm hypothesis is compelling but not causative. Can the nitrogen content of the mussels be identified as to source? If it were all from sewage, that would be very interesting; if it were atmospheric, that would be harder to fix.

Comment:

Little data were actually presented regarding the wrack study and I encourage the investigators to produce a thorough statistical analysis of their findings. The data concerning the extent of wrack coverage however was convincing.

Comment:

We heard that, while wrack is important locally, i.e. on the spots where it settles, wrack covered areas are a very small portion of the total area of the marshes in Jamaica Bay. While the results of the wrack studies should be made available and published in the peer reviewed literature, a wetland journal such as *Wetlands or Estuaries*, further effort on wrack is probably not justified.

Comment:

General results, but no data, were presented indicating wrack is not a likely source of marsh loss. The investigators are encouraged to complete their analysis and report their findings. More research on wrack impacts is likely not needed.

Comment:

Good natural history observations were presented which concluded that geese grazing is not a likely cause of marsh loss. It may, however, locally exacerbate the problem.

Comment:

Frame offered an insight into the problems and issues of restoring marsh in Jamaica Bay. His study design seemed to span some of the spatial variables introduced in the previous presentations. He had information on a variety of conditions and perhaps his data could be coupled with that the directions of spatial change presented by Mellander.

Comment:

There was no presentation on priority pollutants in grab samples along a transect from the Pennsylvania Avenue Landfill/Fountain Avenue Landfill. The abstract contained no data. I would be very interested in the data and reading the research proposal detailing the QAQC, sampling protocol, analytical methods, etc. Work needs to be done, done well, and made generally available.

Big Egg Marsh experimental restoration in Jamaica Bay Wildlife Refuge, New York: a progress report

George W. Frame¹, Michael D. Byer¹, Charles T. Roman², Martin P. Schreibman³, William S. Panagakos³, Marlen K. Waaijer³, M. Kathryn Mellander¹, Mark J. Ringenar¹, James Lynch⁴, Murray Lantner⁵, Chidinma Kanu-Agha¹, Arne Brix¹, Norbert P. Psuty⁶, Jeffrey Pace⁶

During September 2003, sediment was applied to the surface of a 2-acre portion of Big Egg Marsh using a high-pressure jet-spray technique. This marsh, like others throughout Jamaica Bay, NY, is converting from Smooth Cordgrass (*Spartina alterniflora*) meadow to mudflat. The experiment will evaluate jet-spray technique as a means of increasing saltmarsh surface elevation and slowing the process of marsh deterioration. Sediment from an adjacent tidal creek was sprayed on the marsh surface in a layer 2 cm to 50 cm thick, to study optimum target elevation for successful marsh restoration. After sediment application, the area was planted with Smooth Cordgrass and fenced to deter waterfowl grazing. This experiment used a BACI (Before, After, Control, Impact) study design, with environmental monitoring at both the treatment site and adjacent reference site prior to jet-spray application. Monitoring before and after the jet-spraying is comprehensive and includes surface elevation tables (SETs) to evaluate processes associated with marsh elevation change. Randomly-located permanent plots were established to monitor plant species composition, percent cover, stem height, and above-ground biomass. Additional random plots were left unplanted to evaluate success of natural regrowth of Smooth Cordgrass vs. hand planting. To evaluate the success of the experimental restoration in terms of re-establishing a diverse biological community, the monitoring at the treatment site and reference site also includes chemical contaminants, soils, pore-water sulfides, ground water table,

water quality, invertebrates in sediments, invertebrates aquatic and terrestrial, fishes, reptiles, mammals, birds, and changes in topography of the excavated creek. Monitoring will continue for several years post-treatment. This study is one of six saltmarsh pilot projects funded by the National Park Service and by a grant from the New York State Department of Environmental Conservation.

- 1 Division Natural Resources
Gateway National Recreation Area
210 New York Ave.
Staten Island, NY 10305-5019
- 2 Cooperative Ecosystem Support Unit
National Park Service
University of Rhode
Island Bay Campus, South Ferry Road,
Narragansett, RI 02882
- 3 Aquatic Research and Environmental
Assessment Center, Brooklyn College
City University of New York
2900 Bedford Ave., Brooklyn, NY 11210
- 4 U.S. Geological Survey
Patuxent Wildlife Research Center
11510 American Holly
Drive, Laurel, MD 20708
- 5 Environmental Protection Agency, Region Two
290 Broadway, 20th Floor,
New York City, NY 10007
- 6 Sandy Hook Cooperative Research Programs
74 Magruder Road,
Institute of Marine and Coastal Sciences
Rutgers University, Sandy Hook, NJ 07732

An experimental technique of restoring salt marsh was tested in a portion of Big Egg Marsh. The technique involves using a high-pressure jet-spray to spray sediment from the adjacent creek onto the marsh surface. This raises the salt marsh elevation, creating better conditions for marsh grasses to grow and thus slows the erosion of the marsh.

Jamaica Bay Marsh Islands Ecosystem Restoration Project

Len Houston, Chief; Environmental Analysis Branch, U.S. Army Corps of Engineers

The Jamaica Bay Marsh Islands Ecosystem Restoration Project is being undertaken by the USACE in sponsorship with the NYCDEP, the NYSDEC, and the cooperation of the NPS, under the Continuing Authorities Program (CAP) as authorization specifically by Section 1135 of the Water Resources Development Act of 1986, as amended.

In the fall of 2002, the USACE received letters of intent from the project's non-Federal sponsors (NYCDEP and NYSDEC) indicating their interests in sponsoring this project. From that point, USACE staff prepared a Preliminary Restoration Plan (PRP) that determined a Federal interest in addressing the problem and preliminary costs/schedules to develop pilot projects. The group came to consensus and narrowed the study down to four sites; Elder's Point Marsh, Yellow Bar, Black Wall and Black Bank. Initial investigations indicated that the funding limitations under the authority of the Section 1135 Continuing Authorities Program (\$5 million) would necessitate a reduction in pilot projects from the four islands. The project team choose to focus on Elder's Point and Yellow Bar, and have concentrated their efforts on developing alternative plans for these two eroding marsh islands.

Elder's Point is currently comprised of two separate islands, Elder's Point East and Elder's Point West that together make up about 36 acres. Elder's Point was historically one island, but over the last 40+ years, marsh loss in the center of the island severed the connection between the two ends, resulting in two separate islands connected only by mud flat. Yellow Bar is about 77.5 acres and located about 1.5 miles south of Elder's Point. The islands are separated from each other by Pumpkin Patch, Duck Point, and Stony Creek marsh islands.

Currently, USACE is about two-thirds through the feasibility phase and has completed almost all baseline data collection necessary to design the project and be in compliance with local, Statlocal permitse and Federal requirements. Environmental soil borings are still being collected to characterize the presence of any Hazardous, Toxic, or Radioactive materials in the sediments and determine the need for any agricultural additives to support plant growth. New infrared aerial photographs were flown in October 2003. Engineering data that still needs to be collected consists of geotechnical borings and topography/bathymetry on Yellow Bar to determine the type and volume of fill that might be needed to restore eroded areas. Conceptual designs are being developed and the documentation process started to meet NEPA and USACE/NPS requirements as well as state and local permits. We expect to have the first Draft of the Environmental Restoration Report (ERR) in May of 2004. It is expected that on island construction will begin in early Spring 2005.

For the last two years, Len Houston has been Chief, Environmental Analysis Branch, NY District U. S. Army Corps of Engineers. Prior to that for eight years he was Chief, Special Studies section, Environmental Analysis Branch. He also spent ten years as fishery biologist for EAB staff. Houston holds an MS in Marine Science from C.W.Post College, Long Island University and a BS in Biology, Brooklyn College, City University of NY.

A Preliminary Restoration Plan (PRP) focusing on Elder's Point and Yellow Bar marsh is currently about two-thirds through the feasibility phase with most of the baseline data collected. A first draft of the Environmental Restoration Report (ERR) is expected this spring. The project represents the cooperation of many agencies who have contributed to this effort.

Science Board Comments

Comment:

Restoration planning and implementation must build on the increasing understanding of Jamaica Bay marsh dynamics. Data obtained from monitoring of the Big Egg restoration should be synthesized and made available to others planning restoration efforts, including the US Army Corps of Engineers (USACE) as soon as possible. Further reports should be developed as more information becomes available.

Comment:

The Big Egg experimental restoration represents a good start to developing restoration techniques for sediment application and revegetation specific to Jamaica Bay. Suggestions (based on presentation and field trip March 4th) are as follows:

1. Replant several areas this spring – perhaps plots the same size as and adjacent to the unplanted plots. The October planting was not ideal. We want a good measure of natural seeding compared to planting compared to regrowth from vegetation under the sediment layer. The October plugs may/may not survive, but would not be a good data set from which to extrapolate the benefits of using plant plugs.
2. Observe and photograph the area along the bank where the new sediment fell short of the intended restoration area so that the effects of this unintended sediment dispersion can be documented.

3. Share with the scientific advisors the restoration review protocol – sampling, measurements, etc. and projected time frame.

Comment:

In connection with the Big Egg restoration efforts, I would like to see more effort investigating whether or not planting of *Spartina alterniflora* is necessary. It is easy to imagine conditions that would make planting desirable or essential and to imagine conditions that would make it unnecessary and wasteful. It would be nice to understand more. Certainly some spring planting at the Big Egg restoration site would be a good idea.

Comment:

Insufficient information was provided by the USACE to make any direct comment on the nature of their restoration proposals. However, I encourage the NPS to take advantage of the experience and enthusiasm of the Science Board members regarding restoration issues and facilitate an opportunity for Science Board members to discuss the restoration proposals for Elders Point and Yellow Bar with the USACE of Engineers. Restoration opportunities in Jamaica Bay are so valuable that the NPS should use all resources at its disposal, including the time and talent of their newly assembled Science Board, to assist in the development of effective restoration that offers the opportunity for real learning about options for reversing the marsh loss.



Comment:

Houston gave us a view into the USACE's efforts to transfer sediment within the Jamaica Bay system. The USACE is looking into restoration and other cost-effective ways to 'rebuild' habitats. They will be moving sediment. They are interested in creating new wetlands. The challenge will be to bring the emerging knowledge of wetland distributional characteristics in Jamaica Bay to the design table of the USACE.

Comment:

We need to know a lot more about the USACOE proposals for their restorations. I suggested that they look into the way cranberry growers spread sand, with little water content, which could reduce the need for dikes round the restoration sites. I hope they will plan to use ecological engineering. All of the restorations need to have a stated adaptive management program.



M. Kathryn Mellander

Comment:

The USACE presentation was very interesting. I would like to know more of the techniques (sediment and vegetation) and assumptions used in their planning. I am particularly interested in incorporating ecological engineering and adaptive management into their protocols to reduce capital, operation and maintenance costs. I am concerned about the potential failure of restoration efforts if sediment application techniques result in highly compacted soils.

Comment:

We need to confirm that all restorations have a program for observing/data collection post construction.

Future Directions and Research Needs

Nutrients

Comment:

One of the areas of investigation recommended by the Blue Ribbon panel in 2001 which has yet to be pursued in detail is the assessment of nutrient inputs to the bay. An inventory of the sources of nutrients, both surface and groundwater is essential to understanding the role of eutrophication in the marsh loss problem and guiding future management decision.

Comment:

Existing and proposed research appears to be adequately addressing sedimentation/elevation change rates within existing marshes. Not currently being addressed is the role of below ground biomass in contributing to vertical soil development. This is of particular interest in Jamaica Bay due the potential role of nutrients in changing the root: shoot ratio and the unanswered question of whether such a change in ratio actually reduces below ground production. This study should examine marshes at various elevations and in different substrate types (e.g., sandy, fine sediment, mussel dominated).

Comment:

- 1) High nutrient levels in the Bay may be a major cause of marsh deterioration. The first step in testing this should be a nitrogen budget for the Bay using whatever data are available locally and data from other, similar areas if local data are unavailable. The first attempt for a budget will tell us if local measurements for groundwater or landfill exudates, for example, are necessary. If the budget indicates nitrogen levels are extreme, then measurements of aboveground and belowground biomass should be made in the Bay and compared with a similar

but less polluted bay elsewhere on Long Island but with a similar tidal regime.

This will indicate whether or not eutrophication in the Bay results in less peat formation potential and less ability to keep up with sea level changes. The other aspect of eutrophication effect could be the stimulation of peat decomposition, resulting in more rapid substrate loss.

- 2) A corollary hypothesis is that the sediment loss occurs down to basement. If it is mostly basement sand, that would explain deeper losses and deeper holes as one moves from land out into the Bay. Coupled with this is the stimulation of mussel populations by a high level of nutrients stimulating phytoplankton production. As marsh breakup proceeds, the mussels move into the marsh and create dams, which further enhance marsh breakup by ponding water on the marsh surface.

Comment:

Two important new issues were raised in discussion of the most recent results. One was the need for studies of sediment geochemistry. Eutrophication, the high production of chlorophyll and *Ulva* will be reflected in the sediment geochemistry and the quality of the substrate to support marsh vegetation. Such information is lacking at this time. The other was the issue of groundwater inputs.

Comment:

We need nutrient data. First an inventory or accounting of what comes in by air, sewage, leachate, groundwater, and other sources is needed. A model should then be developed.

Elevation – Information Need

Comment:

More extensive information on intertidal elevations is needed. This will be essential to long-term modeling of bay dynamics and understanding patterns of change. LIDAR data should be obtained if it is not already available, supplemented by ground surveys. Current hydrodynamic modeling is likely limited by good topographic coverage, and future restoration efforts will require both models and the elevation data for effective planning.

Groundwater Flux

Comment:

Groundwater fluxes deserve attention; especially as it might influence marsh subsurface compaction. The salt marsh that developed in Jamaica Bay over thousands of years was subjected to unprecedented changes in groundwater conditions with the urban development and consequent water supply infrastructure in Brooklyn and Queens. Jamaica Bay sits on a coastal plain, unconsolidated aquifer some 400 m thick. The recharge area feeding freshwater to the bay is limited by the glacial moraine that cuts across Queens and Brooklyn to the Narrows. Streams were always minor ones so that the natural freshwater supply to the marsh is discharged directly as groundwater.

Before, World War I, prior to the completion of its upstate reservoirs, New York City drew potable water from Brooklyn and Queens. Groundwater was taken from the uppermost (Glacial) aquifer and ponds. After 1920, however, the reserves of the deeper aquifers were tapped by the Jamaica Water District and pumpage increased steadily to

tens of million gallons per day by the mid 1950's. The sewer system prevented diffuse surface recharge. Consequently the water table was depressed and seawater penetrated into the aquifers under Jamaica Bay.

Contamination of groundwater reserves by both sea salt and anthropogenic pollutants eventually caused the city water supply to be shifted over about the last 40 years to upstate surface water sources. Recent isotropic results, presented in this workshop, now show that water in the bay includes an inmixing of water from the Catskills, about 150 gallons per person per day feed through the sewage treatment plants. With this new source available, groundwater pumpage stopped; water tables rose (causing serious flooding problems, by the way, subways and the basements of buildings constructed when the water table was artificially lower). Seawater was pushed further out from the aquifer under Jamaica Bay. The potential impacts of these changes on the salt marsh has not been investigated.

Sediment Budget

Comment:

The issue of sediment budget is very important. We need a handle on what is available and what are its transport vectors (thus circulation is important).

Water Quality

Comment:

We did not learn very much about water quality at the gathering. It would seem to me to be an important variable in supporting or driving change (negative as well as positive). These areas of inquiry are directed to what is occurring.

Future Directions and Research Needs

History of Marsh Development

Comment:

We also need to look at the history of change. That is not so easily accomplished. At a minimum, Mellander should expand her photo analysis as much as possible to get some idea on the steps of change in wetland extent. If possible, the images should be analyzed to represent the shoals as well as the wetlands. Any of the submarine topography visible on the imagery should become part of the data matrix and possibly a part of the QuickBird 2 as well.

Experimental Restoration

Comment:

The wetland restoration program is also very important. There needs to be experimentation in restoration methods on small sites to provide some direction for the larger restoration projects. Restoration is a goal apparently identified by both the NPS and the USACE, and other agencies. It is an essential component of the management program and there needs to be research in support of the conditions accompanying restoration. As presently constituted, the experimental design of the restoration project relates recovery to elevation, exposure, depth of burial, and plantings. Monitoring of the results, both positive and negative, and identification of other variables should continue. Importantly, there needs to be a bridge created whereby the results of the Big Egg Marsh experiment are conveyed to the Corps so that their restoration effort can benefit from the experience. There is a unique opportunity to provide guidance to the Corps' wetland restoration program in Jamaica Bay. The NPS should take advantage of it.

Gateway National Recreation Area General Management Plan

Comment:

There was brief mention during the March 3 meetings of a process to update the General Management Plan for Gateway National Recreation Area. It is crucial that such updates incorporate the most current scientific understanding regarding the Jamaica Bay marsh loss issue. The Science Board should play a key role in the review of any aspects of the plan which address the marsh loss issue and should be regularly briefed on the status of the update process.

Documenting Marsh Loss and Site Characterization

Comment:

When DEC's 2002 change analysis becomes available, it will be very valuable. It will tell us lots of things to investigate and explain.

Comment:

The geomorphology in the photos was impressive as it showed the shifting of shoals. Will researchers bring it all together? How much of this change is occurring on top of those morphological features? We need good bathymetric data to determine that.

Causes of Marsh Loss: Hydrodynamics and Sediment Flux

Comment:

Submarine groundwater discharge affects salinity and nutrients, and there are non-trivial rates of seepage there. But we need to know if this is controlling surface eutrophication.

Comment:

We need to look at the sediment biochemistry.

Comment:

I think we were all very impressed with the progress that has been made on many issues since spring 2001. Some important issues have yet to be addressed including nutrient loading and its effect on plant growth dynamics. Additional basic data on elevations will be critical for both increased understanding of the loss processes and future restoration planning. I believe the Science Board is keenly interested in providing whatever insights we can into future restoration planning and Gateway's future plans for the system.

Marsh Development Processes and History of Marsh Development

Comment:

It was surprising to see that there is sediment accretion. What is behind the subsidence? (It happens in undisturbed marshes, as well.) We don't know if it is a sediment supply issue or not.

Comment:

What has been the natural development of these marshes? Researchers have done stratigraphic cores, but we need more. A place to potentially do it is in Hempstead Bay where there is less degradation.

Comment:

We have only measured where there were marshes. Why is a marsh that's not there, gone? This is like trying to do an autopsy without a body.

Comment:

Other researchers at URI did coring in Jamaica Bay to look at hurricane overwash. Maybe this work would fit in.

Future Directions and Research Needs

Areas of research identified during or after the individual presentations by presenters, science board members and other attendees of the day session:

1. Continue elevation monitoring; develop a long-term record showing elevation trajectories.
2. Relate marsh and mudflat surfaces to sea levels.
3. Using isotopes, determine carbon/nitrogen ratios, carbon sequestration and biomarkers.
4. Assess relationship between sedimentation and marsh loss through short term (1 year) and long term (10 year) analyses.
5. Investigate sediment energy budget of the system.
6. Determine significance of storm events on sedimentation and water properties.
7. Get data on tidal elevation; investigate how vertical mixing in a two-layer system varies over annual tidal cycles.
8. Investigate fate of marsh sediments during winter when there is no vegetation.
9. Design mussel berm experimental area to see where this technique breaks down.
10. Look at sediment microbial dynamics. Determine if a layer of organic carbon enhances the microbial oxygen demand.
11. Determine effect of eutrophication on the growth of bacteria and decomposition rate of peat.
12. Determine the growth habit of *Spartina* under increasing nitrogen conditions.
13. Discuss desirability or feasibility of cutting off nitrogen to the Bay.
14. Determine effects of the technique of adding dredge material to the surface to restore marshes.
15. Investigate amounts of chlorine and naphthalene discharged into the Bay, possibly from jet fuel; look for suitable biomarkers for these compounds.

Introduction

The evening session was designed to provide the general public with an update on the marsh loss issue and how it is being addressed in Jamaica Bay. More than 150 people attended the forum held at the NY Aquarium.

Evening Agenda

- | | |
|---------|--|
| 7:00 pm | <i>Welcome and Introductions</i>
Billy G. Garrett, Superintendent of Gateway National Recreation Area |
| 7:10 pm | <i>Rapid coastal marsh loss across the globe: Local causes, regional consequences and science challenges</i>
Denise J. Reed, Blue Ribbon Panel |
| 7:30 pm | <i>Overview of ongoing projects in Jamaica Bay Wildlife Refuge: Responding to Blue Ribbon Panel recommendations</i>
David E. Avrin, NPS |
| 7:40 pm | <i>Wetland evaluation dynamics and sea-level rise: Are the salt marshes at Jamaica Bay staying ahead of the curve?</i>
Donald R. Cahoon, USGS |
| 7:50 pm | <i>Collaborative evaluation of the present and historic sediment dynamics of Jamaica Bay, NY (Gateway National Recreation Area)</i>
Steven L. Goodbred, Jr., Stony Brook University |
| 8:00 pm | <i>Big Egg Marsh experimental restoration in Jamaica Bay Wildlife Refuge, New York: A progress report</i>
George W. Frame, NPS |
| 8:10 pm | <i>Future salt marsh restoration plans</i>
Len Houston, US Army Corps of Engineers |
| 8:20 pm | <i>Q & A with panel and scientists</i>
Moderator, NPS |
| 9:00 pm | <i>Summary, acknowledgements and future directions</i>
Billy G. Garrett, Superintendent of Gateway National Recreation Area |

Rapid coastal marsh loss across the globe: local causes, regional consequences and science challenges

Denise J. Reed

The rapid loss of coastal marshes can be readily distinguished from natural changes in dynamic coastal landscapes. While erosion of marsh edges in wave exposed areas is common place, massive interior degradation or sudden decreases in the size of marsh areas have been identified in many parts of the world. In some cases, disease or extreme environmental conditions are finally identified as the cause but many times the immediate cause of the loss is attributed to a complex combination of human-induced and natural stresses. Rapid marsh loss is an important issue, not only because it changes the landscapes we are familiar with and enjoy, but because it can disrupt established food webs, reduce habitat for already at-risk species, expose important infrastructure to wave attack, and, in many cases, as it appears irreversible without major intervention. The challenge to scientists in Jamaica Bay, and many other places experiencing similar problems, is to tease apart the contributing factors, identify which can be remedied, which must be lived with, and which courses of action provide the best opportunity for reversing, or at least stemming, the loss.



Denise J. Reed has been a Professor at Department of Geology and Geophysics at the University of New Orleans, Louisiana since 1998. Her research interests include sediment dynamics in coastal wetlands with emphasis on sediment mobilization and marsh hydrology, both natural

and altered, as factors controlling sediment deposition, and the response of coastal marshes to sea-level rise. Her recent research includes sediment dynamics and tidal wetland restoration in Louisiana and the Sacramento-San Joaquin delta. Dr. Reed is a member of the Chief on Engineers Environmental Advisory Board and has served on many regional and national panels considering issues related to coastal management. She earned her BA. and Ph.D. in geography from the University of Cambridge, United Kingdom.

Denise J. Reed
Professor, Department of Geology & Geophysics
University of New Orleans
New Orleans, LA 70148
Phone 504 280 7395
FAX 504 280 7396
djreed@uno.edu

Large scale and sudden decreases in size of marsh areas can cause economic and ecological disruptions for communities (both human and ecological) that benefit from marsh environments. The challenge is determining the contributing factors (human and natural) and deciding the best actions to take to manage the impacts and reverse the loss.

Overview of ongoing projects in Jamaica Bay Wildlife Refuge: responding to Blue Ribbon Panel recommendations

David E. Avrin¹, George W. Frame², Charles T. Roman³

Based on a trend analysis of historic aerial photography, the NY State Department of Environmental Conservation documented a significant loss of *Spartina alterniflora* saltmarsh within Jamaica Bay. Wetland loss from 1924 to 1974 was 780 acres due to direct dredging and filling (prior to wetland protection legislation) and 510 acres due to other reasons. Since 1974 there has been an accelerated loss of wetland, for reasons unknown. Apart from the pre-1974 dredge-and-fill losses, the annual losses due to "other reasons" were 10 acres/year during 1924-1974, 26 acres/year during 1974-1994, and 44 acres/year during 1994-1999. The accelerating annual loss may now be 50 acres/year. The area of saltmarsh islands in Jamaica Bay decreased from over 2200 acres in 1924 to about 1000 acres today.

The park convened a Blue Ribbon Panel of scientists that included salt marsh experts in May 2001, to evaluate the likely causes of these dramatic changes, and to recommend short and long-term actions. The panelists described several factors that may be contributing to the marsh loss, including sediment deficit, sea level rise, altered estuarine circulation due to dredging, nutrient enrichment, and biotic influences related to waterbird, mussel, and seaweed populations. It is probable that many or all of these factors are acting together and contributing to the marsh loss at Jamaica Bay.

The Blue Ribbon Panel suggested that in the short-term, the National Park Service initiate a number of investigations to increase understanding of the causes of marsh disappearance and to demonstrate the feasibility of managing the marshes. The investigations currently underway within Jamaica Bay in-

clude: (1) Experimental marsh restoration utilizing a thin layer spraying technique, (2) Investigation of the impact of wrack and sea lettuce mats on the marshes, (3) Investigation of chronology of marsh development through a peat coring technique, (4) Development of a long-term marsh monitoring program utilizing GIS technology, (5) Investigation of role of contaminants and water chemistry in the health of the marshes, (6) Investigation of the impact of waterfowl, (7) Investigation of sediment transport within Jamaica Bay. The National Park Service will use information derived from these studies to work with other public agencies to direct future actions.

- 1 **Jamaica Bay Unit**
Gateway National Recreation Area
Bldg. 69, Floyd Bennett Field
Brooklyn, NY 11234
- 2 **Division Natural Resources**
Gateway National Recreation Area
210 New York Ave.
Staten Island, NY 10305-5019
- 3 **Cooperative Ecosystem Support Unit**
National Park Service, University of
Rhode Island Bay Campus, South Ferry Road
Narragansett, RI 02882

Presently the Assistant Superintendent of Operations for the Jamaica Bay Unit of Gateway NRA, Avrin has worked for the National Park Service for over 25 years. He holds a B.S. in Wildlife Biology from Rutgers University and M.S. in Resources Management from University of Michigan.

Due to an apparently accelerated loss of marsh acreage since 1974, a Blue Ribbon Panel of scientists and marsh experts was convened to evaluate the likely causes of the marsh loss and to make recommendations for short and long-term actions. The panel described several factors that may be contributing to the marsh loss and suggested that a number of investigations be initiated to increase understanding of the causes of marsh disappearance and to demonstrate the feasibility of managing the marsh losses.

Wetland elevation dynamics and sea-level rise: are the salt marshes at Jamaica Bay staying ahead of the curve?

Donald R. Cahoon

A significant loss of *Spartina alterniflora* salt marsh has been documented for Jamaica Bay, Gateway National Recreation Area, New York, and the rate of loss has accelerated since 1970 even though direct human impacts (e.g., fill activities) have been diminished by regulatory protection. Several factors have been identified as potentially contributing to the salt marsh loss, including sediment deficit, sea-level rise, altered estuarine circulation due to dredging, nutrient enrichment, and biotic influences related to water bird and mussel populations, among other factors. We designed a study to determine the accretionary and elevation dynamics of the salt marsh habitats of Jamaica Bay to more fully understand the mechanisms causing wetland loss and to develop effective marsh restoration strategies. Using surface elevation tables (SET) and artificial soil marker horizons, we compared sediment elevation dynamics between two marsh islands with different levels of stability; the stable marsh at JoCo and the deteriorating marsh at Black Bank. We also evaluated the effectiveness of thin-layer deposition of dredged material at restoring soil elevation of the degraded salt marsh at Big Egg Marsh. Data collection, which began in summer 2002, is ongoing. Preliminary data analyses will be discussed.

U. S. Geological Survey
Patuxent Wildlife Research Center

Address as of March 2004
USGS Patuxent Wildlife Research Center,
Beltsville Lab, c/o BARC-East, Building 308, 10300
Baltimore
Avenue, Beltsville, MD 20705



Dr. Donald R. Cahoon is a Research Ecologist with the U. S. Geological Survey, Patuxent Wildlife Research Center located in Laurel, MD. He received his Bachelor of Arts degree, with Honors in

Botany, from Drew University (1972), and MS (1975) and PhD (1982) degrees in Wetland Plant Ecology from the University of Maryland. His professional interests include wetland plant ecology, wetland accretionary processes, and wetland restoration and management. His research program is focused on three objectives: (1) determining the impacts of sea-level rise on long-term marsh stability through evaluations of marsh accretionary processes, (2) identifying the processes of wetland loss, submergence, and soil erosion in both natural and managed coastal marshes, and (3) evaluating the effectiveness of wetland restoration and management techniques. His research approach for measuring wetland elevation dynamics is being used in more than 100 wetland sites in 15 countries. He worked on coastal management and research issues in Louisiana for 19 years prior to moving to Laurel, Maryland in 2001.

A study using surface elevation tables (SET) and artificial soil marker horizons compared sediment elevation changes between two marsh islands with different levels of stability to get a better picture of the causes of marsh loss in Jamaica Bay. The study is also evaluating the effectiveness of depositing dredged sediment to restore a degraded marsh.

Collaborative evaluation of the present and historic sediment dynamics of Jamaica Bay, NY (Gateway National Recreation Area)

Steven L. Goodbred, Jr., Robert Wilson, J. Kirk Cochran, Charles Flagg, Roger D. Flood

A new collaborative project between two research groups at the Marine Sciences Research Center, Stony Brook University has begun to investigate the sedimentation and physical circulation patterns of Jamaica Bay. The overarching goal of the collaborative study is to understand and quantify sediment dynamics in the Jamaica Bay estuary-marsh system as related to recent large-scale losses of vegetated wetlands. Specifically, the individual study components will (1) establish a seasonal sediment budget for Jamaica Bay using various natural and anthropogenic radioisotopes and (2) determine the water circulation patterns as they are presently and compared with pre-human disturbance using numerical models. A major benefit of this combined field and modeling approach is that it allows the research groups to independently verify results based on both direct measurements of sediments and computer modeling outputs.

The radiotracer and modeling studies proposed here are both stand alone, but there are major benefits to gain from their combined approach. First, the radiotracer study will determine the rates, patterns, and distribution of sediment accretion/erosion within the marsh-estuary system. This is critical to understanding the system's overall sediment budget relative to the deficit in marsh-surface accumulation. However, the radioisotope study cannot directly account for mechanisms of transport and their relationship to estuarine circulation. Herein lies strength of the proposed modeling study, which will evaluate sediment transport pathways based on physical circulation. Thus, the

two approaches are complementary, investigating both sedimentary process (via modeling) and sedimentary products (via radiotracers). In terms of restoring Jamaica Bay marshes, the radiotracer study will determine whether the current volume of sediments moving into and around Jamaica Bay could be sufficient for marsh stabilization (given altered circulation patterns). The modeling study can then suitably forecast how modifications to Jamaica Bay bathymetry would redistribute this mobile sediment in favor of marsh accretion.



**Marine Sciences Research Center
Stony Brook University
Stony Brook, NY 11794-5000**

In order to provide a better understanding of Jamaica Bay sediment transport patterns, several radioisotope tracers will be used to determine sediment movements in space and time. This approach allows for the tracking of sediment accumulation in the marsh and provides quantifiable measurements of sediment sources available for deposit on marsh surfaces.

Big Egg Marsh experimental restoration in Jamaica Bay Wildlife Refuge, New York: a progress report

George W. Frame¹, Michael D. Byer¹, Charles T. Roman², Martin P. Schreiber³, William S. Panagakos³, Marlen K. Waaijer³, M. Kathryn Mellander¹, Mark J. Ringenary¹, James Lynch⁴, Murray Lantner⁵, Chidinma Kanu-Agha¹, Arne Brix¹, Norbert P. Psuty⁶, Jeffrey Pace⁶

During September 2003, sediment was applied to the surface of a 2-acre portion of Big Egg Marsh using a high-pressure jet-spray technique. This marsh, like others throughout Jamaica Bay, NY, is converting from Smooth Cordgrass (*Spartina alterniflora*) meadow to mudflat. The experiment will evaluate jet-spray technique as a means of increasing saltmarsh surface elevation and slowing the process of marsh deterioration. Sediment from an adjacent tidal creek was sprayed on the marsh surface in a layer 2 cm to 50 cm thick, to study optimum target elevation for successful marsh restoration. After sediment application, the area was planted with Smooth Cordgrass and fenced to deter waterfowl grazing. This experiment used a BACI (Before, After, Control, Impact) study design, with environmental monitoring at both the treatment site and adjacent reference site prior to jet-spray application. Monitoring before and after the jet-spraying is comprehensive and includes surface elevation tables (SETs) to evaluate processes associated with marsh elevation change. Randomly-located permanent plots were established to monitor plant species composition, percent cover, stem height, and above-ground biomass. Additional random plots were left unplanted to evaluate success of natural regrowth of Smooth Cordgrass vs. hand planting. To evaluate the success of the experimental restoration in terms of re-establishing a diverse biological community, the monitoring at the treatment site and reference site also includes chemical contaminants, soils, pore-water sulfides, ground water table, water quality, invertebrates in sediments, invertebrates aquatic and terres-

trial, fishes, reptiles, mammals, birds, and changes in topography of the excavated creek. Monitoring will continue for several years post-treatment. This study is one of six saltmarsh pilot projects funded by the National Park Service and by a grant from the New York State Department of Environmental Conservation.

- 1 Division Natural Resources
Gateway National Recreation Area
210 New York Ave.
Staten Island, NY 10305-5019
- 2 Cooperative Ecosystem Support Unit
National Park Service
University of Rhode
Island Bay Campus, South Ferry Road,
Narragansett, RI 02882
- 3 Aquatic Research and Environmental
Assessment Center, Brooklyn College
City University of New York
2900 Bedford Ave., Brooklyn, NY 11210
- 4 U.S. Geological Survey
Patuxent Wildlife Research Center
11510 American Holly
Drive, Laurel, MD 20708
- 5 Environmental Protection Agency, Region Two
290 Broadway, 20th Floor,
New York City, NY 10007
- 6 Sandy Hook Cooperative Research Programs
74 Magruder Road,
Institute of Marine and Coastal Sciences
Rutgers University, Sandy Hook, NJ 07732

An experimental technique of restoring salt marsh was tested in a portion of Big Egg Marsh. The technique involves using a high-pressure jet-spray to spray sediment from the adjacent creek onto the marsh surface. This raises the salt marsh elevation, creating better conditions for marsh grasses to grow and thus slows the erosion of the marsh.

Environmental projects in Jamaica Bay

Len Houston, US Army Corps of Engineers

The New York District (NYD) has focused much effort under new authorizations on Jamaica Bay, in keeping with its designation by The Harbor Estuary Program (HEP) as a target habitat of special concern. The NYD completed a 1994 Reconnaissance (Recon) report that recognized the tremendous regional and national significance of the Bay. New York City Department of Environmental Protection (NYCDEP) also recognized the importance of bringing back the diversity and productivity of the Bay, and signed a Feasibility Cost-Sharing Agreement (FCSA) in 1996 to identify and recommend restoration actions.

The Feasibility Study identified a wide variety of alternative restoration opportunities. Thirteen areas of interest were identified, consisting of modeling studies to determine what effect, various features, such as borrow pits, runways, channels and bridges had on water flow and flushing rates of the Bay. Other areas were designated for habitat restorations, including several with planned Combined Sewage Overflow (CSO) facilities that would greatly improve water quality and thereby the success of any restoration project. Restoration sites are currently completing their design phase with a draft Feasibility Report scheduled for completion in the spring of 2004.

New York City Parks Department (NYCP) received New York State Environmental Bond funds to construct two of the restoration projects located on their land. These are being completed and constructed under the Corps Continuing Authority Program (CAP). Gerritsen Creek would result in restoration of approximately 32 acres of rare coastal grasslands and 40 acres of previously filled salt marsh adjacent to the city's new environmental center in Marine Park.

More recently the Jamaica Bay Ecowatchers documented the problem of central marsh losses in Jamaica Bay. A NYSDEC evaluation

of historical maps confirmed an extensive and apparently accelerating loss of marsh from the central islands of the Bay, with most islands suffering extensive losses over small periods of time. A Blue Ribbon panel of experts was assembled by the NPS in 2001 to look into the problem and possible solutions. The panel recommended pilot projects to begin restoring some of the habitat lost while the longer-term investigations tried to uncover the underlying causes. NYCDEP requested that the Corps initiate a CAP study to implement one or more of the pilot restoration options.

The CAP study began in December 2002. It is progressing under direction of an interagency team that consists of senior Corps staff, NYCDEP, NYSDEC, the National Park Service (NPS), and New York State Department of State (NYSDOS), which has Coastal Zone Management oversight for the Bay. A PRP was approved in March, 2003 and the ERR has centered on two sites, Yellow Bar and Elders marsh, as pilot projects. Plans call for using material dredged from the Federal entrance channel instead of purchasing and transporting material to the sites. The team is working quickly to have its plans completed and all necessary agreements and funding in place by Fall 2004.

Len Houston, Chief; Environmental Analysis Branch
U.S. Army Corps of Engineers
New York District, 26 Federal Plaza; NY, NY 10278
212-264-2122
Leonard.Houston@usace.army.mil

The Corps, who had been working on a number of habitat restoration projects in the Bay already, was asked by the city (NYCDEP) and the State (NYSDEC) to form a partnership to implement some of the pilot projects recommended by the Blue Ribbon Panel. The partners assembled an interagency team, including Gateway, to accomplish this. Elders Point and Yellow Bar are the first sites under this effort.

Public Session

Question & Answer Portion



Q: This is a question for Len Houston. In one of your early slides, you showed 10 sites, one of which was Bayswater State Park. Yet, when you went through your inventory of sites, you omitted any discussion of it.

A: I omitted any discussion on any of the sites in any detail.

Q: Can you give a little background on Bayswater?

A: From what I remember, there is a two-fold goal there: to restore some of the salt marsh and to protect the shoreline from further erosion. The plans are currently being designed now.

Q: KeySpan is spending \$125 million to clean the Coney Island Creek on their property which is contaminated with coal tar. The agent that's dangerous is benzene. Right now they are throwing sheets around it and they are going to dig it out and clean out the Creek. Are there any plans with the Army Corps to help KeySpan and the community to try to create an ecosystem back on that site? Is this something we can talk about?

A: That's really outside the scope of this meeting, but I'd be happy to talk with you about it afterwards.

Q: I have a question about Marine Park and Gerritsen Creek area. You say you are digging out part of that area. Can you explain where the soil is going to go, in relation to the trail?

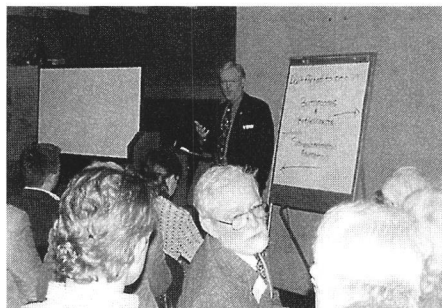
A: It's going to go into the interior loop area. The trail comes along the shoreline, gets to a certain area, and then loops back.

Q: So, in between the trail itself. How high do you expect that to be?

A: It depends on how low they need to get the elevation, so that will tell us how much material is available. If it has to cover the trail, then the trail will be moved or even brought through that area. It might even be a nice place to bring the trail through a coastal grassland.

Q: Big Egg is showing negative elevation. Have you been able to tell if sea level rise or subsidence is the problem?

A: The marsh elevation is going down in both the mudflat area reference sites and the sprayed area. That's not relative to sea level, there's a subsidence process going on there. What it is, we're not sure yet. We need to get more data.



Q: What about wave action from boat traffic? Has that been eliminated? Is anybody doing any research on that? It seems like such an obvious thing, but I didn't see it in any of the diagrams.

A: It was not identified as a primary short-term research project. It is still something that is under consideration, but it is not something we are actively investigating right away.



Q: I think it should be. There was a high speed ferry that went to Inwood for one or two summers. It had to go at a slow speed in the Bay and threw a 10' high wake. And recreational boats are getting larger and larger and throwing larger and larger wakes.



Q: At the restoration site where the planting was done last October, what happens if it doesn't grow starting next month? Will it be replaced? The planting was done very late.

A: First of all, planting 20,000 plants was kind of an insurance. We really do expect a lot of the original grass that was on the site to regrow through the thin layer of sediment. Even if all the 20,000 plantings die, I think we are going to get a lot of grass regrowth. We are going to be looking at that, trying to separate out how much of the grass that appears this May is regrowth from the old stuff or coming from what was planted. If all that fails, we can't leave a bare surface, and would have to find the means to plant more plants.

Q: What about the concept that the land shape changes and stretches out into the water have changed over a relative period of time and that's changed a lot of the tidal and circulation dynamics of these back bay and estuary areas that seem to have these complex issues? Has anyone addressed or modeled that?

A: That is part of the study that Stony Brook University will be doing. They will be using computer models to look at predredging flow, what the system looked like 200 years ago, compared to post dredging and look at those changes. Also, since most of the bathymetry from the current NOAA chart was done shortly after dredging 30 to 50 years ago, this newer technology for mapping the seafloor will look at differences and changes. In many places we see dramatic changes. But, in fact, some areas like the perimeters of the marshes haven't changed at all in 50 years.

Public Session

Question & Answer Portion

Q: Specifically, there are some bulkhead lines that have been changed over the course of the years that might play into this issue of where the shorelines originally were and how far they have moved and how much things have tightened up in the channels. There used to be also some tidal grist mill activities a hundred or so years ago. Those types of historic activities need to be addressed because that had to do with the way that we had the fingers extending inland, and the flow of freshwaters, and so on, over the low lying land areas into the surface waters.

A: Yes, we've started picking Dan Mundy's brain. We're putting together a wonderful history of Jamaica Bay. Getting from point A to point B has involved a lot of successive steps and it will be key to understanding how each piece has impacted those long-term changes. Looking up into the creeks and the adjacent land development hopefully will be something we can get at along the way.



Eugenia Flatow and Dave Avrin

Q: What about the sewage treatment plants? From what I understand, the three of them pump about 300 million

gallons of freshwater daily plus thousands of gallons of chlorine into the water. How much have you been looking at this and how much of an effect can that have? I heard you say that freshwater stays on top and lands on the marsh with chemicals in it. How badly does that affect the marsh?

A: Some initial runs on the computer model, as well as some field data, suggest the system is very sensitive to the amount of freshwater input that sets up this two-layer flow. If you had a very shallow system that would be all mixed up and you'd have sediment and everything going through the whole water column. Getting these measurements isn't always as easy as we might hope.

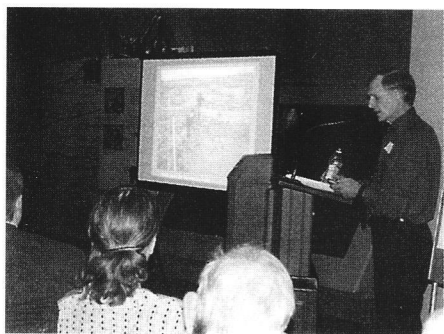
Q: Would taking this freshwater into the deeper ocean help the Bay a little bit?

A: Potentially. I understand that is something that is being considered, both for the nutrient loadings to the system and the freshwater.

Q: I'm looking for clarification. Is the effect of the pace of tidal flushing or flooding causing a mass wasting of the sediment for everything to slide into the Bay?

A: One thing we thought is that mud is pretty slippery stuff, and that perhaps the dredging around the perimeter of the Bay...In fact there are areas where there are nearly vertical walls, the dredging moving into shallow areas. We did not so far see any significant signs of mass wasting. Essentially if those vertical walls would slump down, you'd lose marsh that way. However, that doesn't mean there is not some

sort of subsidence of marsh surface. Basically, if you take a semi-fluid medium and you remove the retaining walls, essentially that surface could subside or spread out some. Hopefully this will come out in Don Cahoon's surface elevation tables, if this is an important process. We don't know.



George Frame at Podium

Q: We've heard a lot of controversy about the flushing time of Jamaica Bay. Does it flush in 30+ days or 7 days? Has that finally been resolved?

A: Based on several different measures, it appears that flushing time more on the order of about a week is significant. You get some indication from the current velocities through there. And when water is moving through the system at several feet per second, that tends to enhance the flushing time. Although, we did see an area by Grassy Bay where the current did slow down significantly. So, it's hard to say. One thing that hasn't been looked at is when you get far up on in water on the backside of the embayment, if the residence time may increase significantly there.

Q: Some of the data you'll be collecting over the next year or two will shed some light on that, I assume.

A: Yes, that's right. Some of the modeling will confirm that. Each step will add layer upon layer of information, and each one has its own issues and compromises. But as you look at these different approaches that are entirely unrelated to one another and they are giving you similar answers, you really start to develop a picture that you're fairly confident with.

Q: Does the depth of Rockaway Inlet play a role in the faster-than-expected flushing?

A: Almost certainly. It also plays a role in the amount of water moving in and out of the Bay, the rate at which it moves, and also this two-layer flow. Essentially, as you deepen the Inlet and embayment itself, it allows the freshwater to sit on top of the seawater without forcing. Basically, if you picture waves mixing up the water column, they only reach to a certain depth. In shallow water, that mixes the whole thing, but in a deep water column, it doesn't. And that de-coupling can be important in estuarine dynamics.

Public Session

Question & Answer Portion

Q: I have a question about the restoration technique. We heard in one of the presentations that dredging most likely altered the dynamic of the Bay by deepening certain channels and possibly the rate at which sediments are moving through the Bay. But the restoration technique, if I understand it correctly, actually uses dredging to return sediment back to the area we're trying to improve. Is there a real effect to that dredging or are there better techniques?

A: We talked about two restorations: one actual and one planned. The idea with the Big Egg marsh restoration (and yes, it did use dredging) was that this was a demonstration project to test the feasibility of thin-layer spreading. If we could have brought the material in and not needed to dredge, we probably would have taken that approach. But from a cost standpoint there was no way we could do that. So, our intent wouldn't be to do additional dredging if we could avoid it.



Jack Mattice, Billy Garrett and John Hnedak



Olga Vargas and Mark Christiano

Q: Has anyone considered using microbes that eat pollution, that eat dangerous chemicals in the soil? There is a big technology out there that has been proven to clean soil by using these microbes. Has anyone been looking at that as an option, to mix in with the soil or estuary before spraying? There is a person here from an organic farm who knows about this.

A: I know that this technology is being used for oil spills and things like that, but I'm not aware that it would be appropriate here. We can talk afterwards.

Q: Are there any plans to discuss these problems on TV to reach a larger audience? You'd get much more support.

A: There have been a few very short pieces on television about this. We'd like to try it. We could use help from anyone who might have contacts with PBS.

Q: What work is planned for Hawtree Creek?

A: I believe that might be a combination of shoreline restoration and dredging some blockage to the entrance to the channel to improve water flow.



Jay Tanski, Dave Taft and Dave Avrin

Q: It was mentioned that they were monitoring fish and other species in the surrounding area to see what effect the restoration would have on them. Are you aware of negative effects that this would have on diamondback terrapins or other things that live at the site?

A: We are monitoring terrapins at the experimental restoration site. During the dredging operations we had to watch that there were no terrapins near the dredge. We didn't see any there. On the upper side of the marsh, we saw one terrapin walking and two that had been eaten by gulls. I don't know of any negative effects that this restoration is going to have on the terrapin population. Terrapins pass through the salt marsh to go to higher areas to lay eggs. They feed down in the salt marsh along the banks and in the little drainage lines, normally. So, this maintains a good habitat for them. If we just let it go turn to mudflat, then it won't be good for them.

Q: Has anybody addressed nitrogen in any of these studies? That is, the increased amount of nitrogen that's been put in the Bay over the last ten years from the DEP. It correlated very strongly with the time period in which the marsh saw its worst demise. It was mentioned that the Blue Ribbon Panel, and our group the Eagle Watchers, had brought it up the same time we brought up the marsh problem. We brought up the fact that we're having these tremendous algae blooms. Last year was the first year the DEC forced the DEP to reduce the nitrogen levels. And we saw somewhat of a reduction in the algae blooms.

A1: There is the possibility of looking at that as an issue in the future, but I don't believe it's happening at this point.

A2: I'd like to add that these algal blooms that have been reported in the last couple years have not been in just Jamaica Bay. They are widespread throughout the state of NJ, also. So, it seems like it might be more related to climatic changes of some sort.

A3: I've been to the brown tide conferences further east and it seems they are ahead of us in looking at nitrogen. I know there are a lot of factors, but once the DEP had to reduce nitrogen last year, our records indicated we had the best year in over ten years in terms of secchi readings and visual clarity of the water. So, it might be a factor.

Jamaica Bay's Disappearing Marshes

March 3 Daytime Session Attendees

Adamo, Doug
Gateway NRA

Alvarez, Melissa
USACOE

Antenen, Susan
The Nature Conservancy

Avrin, Dave
Gateway NRA

Bergfors, Robbin
NYC Parks and Recreation

Bernick, Andy
College of Staten Island

Bokuniewicz, Dr. Henry
Stony Brook University

Branca, Barbara
New York Sea Grant

Brash, Alex
NYC Parks and Recreation

Buckley, Dr. P.A.
University of Rhode Island

Burg, David
Wild Metro

Byer, Mike
Gateway NRA

Cahoon, Don
USGS

Cochran, Kirk
Stony Brook University

Couch, Steve
USACOE

Cuzzolino, Kathleen
Gateway NRA

Feller, Michael
UNC Parks and Recreation

Flatow, Eugenia
Soil and Water Conservation District

Foley, Mary
NPS

Frame, George
Gateway NRA

Francoeur, Laura
Port Authority

Franz, David
Brooklyn College

Garrett, Billy
Gateway NRA

Gilmore, Sue
Gateway NRA

Goodbred, Steve
Stony Brook University

Gordon, Arnold
Columbia University

Gornitz, Vivian
Columbia University

Grayson, Christine
Gateway NRA

Hartig, Ellen
Columbia University

Hnedak, John
Gateway NRA

Houston, Len
USACOE

Kaplan, David
NYC Parks and Recreation

Knoesel, Edward
Port Authority

Kolker, Alexander
Stony Brook University

Lancos, John
Gateway NRA

Lynch, Jim
USGS

Mattice, Jack
New York Sea Grant

McLaughlin, John
NYC DEP

McLetchie, Kate
Stony Brook University

Mellander, Kathryn
NPS

Mooney, Liz
Gateway NRA - Volunteer

Mundy, Dan
Jamaica Bay Ecowatchers

Mushache, Fred
NYS DEC

Ngene, Shandrack
Kenya Wildlife Service

Olijnyk, Chris
Gateway NRA

Panagakos, William
Brooklyn College

Peteet, Dorothy
Columbia University

Petersen, Dr. Susan
Watershed Systems

Psuty, Dr. Norb
Rutgers University

Rafferty, Patricia
Fire Island National Seashore

Reed, Dr. Denise J.
University of New Orleans

Ringenary, Mark J.
Gateway NRA

Roman, Charles
NPS

Schlenk, Cornelia
New York Sea Grant

Schreibman, Dr. Martin S.
Brooklyn College

Shaw, Richard K.
USDA-NRCS

Sinkecich, Steve
USFWS

Smith, Lane
New York Sea Grant

Soller, Chris
Gateway NRA

Steimle, Frank
NOAA

Taft, David
Gateway NRA

Tai, Bill
NYC Parks and Recreation

Tanski, Jay
New York Sea Grant

Teal, Dr. John
Woods Hole Oceanographic Institute

Tripp, Kim
Gateway NRA

Vargas, Olga
USDA - NRCS

Waaiker, Marlen K.
Jamaica Bay Guardian

Wang, Yeqiao
URI

Will, Bob
USACOE

Williams, Brian P.
USACOE

Wilson, Robert
Stony Brook University

Zahn, Steve
NYC DEP

Zozworsky, John
Gateway NRA

Zuller, Aviva
NY/NJ Baykeeper

Contacts

National Park Service Personnel

Dave Avrin

Assistant Superintendent - Park Operations
Jamaica Bay Unit
Gateway National Recreation Area
Headquarters - Bldg 69
Floyd Bennett Field
Brooklyn, New York 11234
phone: 718-338-3625
fax: 718-338-3876
Dave_Avrin@nps.gov

Chris Soller

Acting Superintendent
Jamaica Bay Unit
Gateway National Recreation Area
Headquarters - Bldg 69
Floyd Bennett Field
Brooklyn, New York 11234
phone: 718-338-3605
fax: 718-338-3876
Chris_Soller@nps.gov

Billy Garrett

Acting General Superintendent
Gateway National Recreation Area
210 New York Avenue
Staten Island, New York 10305
phone: 718-354-4665
fax: 718-354-4764
Billy_Garrett@nps.gov

John Hnedak

Director of Resource Management
Gateway National Recreation Area
210 New York Avenue
Staten Island, New York 10305
phone: 718-354-4522
fax: 718-354-4515
John_Hnedak@nps.gov

Doug Adamo

Chief, Division of Natural Resources
Gateway National Recreation Area
210 New York Avenue
Staten Island, New York 10305
phone: 718-354-4510
fax: 718-354-4548
Doug_Adamo@nps.gov

George Frame

Biologist
Gateway National Recreation Area
210 New York Avenue
Staten Island, New York 10305
phone: 718-354-4546
fax: 718-354-4548
George_Frame@nps.gov

Kim Tripp, NPS

Research Coordinator
Jamaica Bay Institute
Gateway National Recreation Area
Headquarters - Building 69
Floyd Bennett Field
Brooklyn, New York 11234
phone: 718-338-3688
fax: 718-338-3876
kim_tripp@nps.gov

Charles Roman, NPS

Research Coordinator
University of Rhode Island
Narragansett, Rhode Island 02882
phone: 401-874-6886
charles_roman@nps.gov

M. Kathryn Mellander, NPS

GIS Specialist
210 New York Ave
Staten Island, NY 10305
phone: 718-354-4525
kathryn_mellander@nps.gov

Researchers and presenters from other institutions, agencies and organizations

Donald R. Cahoon

US Geological Survey
Patuxent Wildlife Research Center, Beltsville Lab
c/o BARC-East, Building 308
10300 Baltimore Avenue
Beltsville, MD 20705
phone: 301-497-5523
fax: 301-497-5744
donald_r_cahoon@usgs.gov

David R. Franz

Professor of Biology and Deputy Chairman for
Undergraduate Studies,
Brooklyn College CUNY
Brooklyn, NY 11210
phone: 718-951-5700
df Franz@brooklyn.cuny.edu

Ileana Friedman

Adjunct Instructor, current graduate student
Biology Department,
Brooklyn College CUNY
Brooklyn, NY 11210
phone: 718-951-5700
friedmanile@aol.com

Steven L. Goodbred, Jr.

Asst. Professor of Marine Geology
Marine Sciences Research Center
Stony Brook University
Stony Brook, New York 11794-5000
phone: 631-632-8676
fax: 631-632-8820
sgoodbred@notes.cc.sunysb.edu
<http://msrc.sunysb.edu/people/goodbred.htm>

Arnold L. Gordon

Lamont-Doherty Earth Observatory
Of Columbia University
Palisades NY 10964
agordon@ldeo.columbia.edu

Robert W. Houghton

Lamont-Doherty Earth Observatory
Of Columbia University
Palisades NY 10964
houghton@ldeo.columbia.edu

Len Houston

USACOE
New York District, COE
Environmental Analysis Branch
26 Federal Plaza
New York, NY 10278
phone: 212-264-2122
Leonard.Houston@usace.army.mil

Alexander Kolker

Stony Brook University Graduate Student
Marine Sciences Research Center
Stony Brook University
Stony Brook, NY 11794-5000
phone: 631-632-3076
kolker@msrc.sunysb.edu

Dan Mundy

Ecowatchers
56 West 14th Rd
Broad Channel, NY 11693
phone: 718-634-5032
dmundy5032@aol.com

Dorothy Peteet

Columbia University
Lamont-Doherty Earth Observatory
204 New Core Lab
61 Route 9W - PO Box 1000
Palisades, NY 10964-8000
phone: 845-365-8420
peteet@ldeo.columbia.edu

Martin P. Schreiberman

AREAC
Director Brooklyn College, CUNY
Brooklyn College CUNY
Brooklyn, NY 11210
martins@brooklyn.cuny.edu

Richard K. Shaw

Soil Scientist
USDA-NRCS; NYC Soil Survey
1000 South Avenue
Staten Island; NY 10314;
phone: 718-761-1657
fax: 718-761-2290
richard.shaw@ny.usda.gov

Contacts

John Tanacredi

Dowling College
Department of Earth and Marine Sciences
Oakdale, Long Island
New York 11769-1999
tanacrej@dowling.edu
phone: 631-244-3394

Olga Vargas

USDA Natural Resources Conservation Service
NYC Soil Survey
1000 South Ave
Staten Island, NY 10314

Yeqiao Q. Wang

Associate Professor in Terrestrial Remote Sensing
Department of Natural Resources Science
University of Rhode Island
Kingston, RI 02881-0804
phone: 401-874-4345
fax: 401-874-4561
yqwang@uri.edu

Robert E. Wilson

Marine Sciences Research Center
Stony Brook University
Stony Brook, New York 11794-5000
phone: 631-632-8689
rwilson@notes.cc.sunysb.edu

Yiyi Wong

Department of Soil Science
College of Agriculture and Life Sciences
North Carolina State University
Raleigh, North Carolina 27695-7619

Science Board Members

Henry Bokuniewicz

Stony Brook University
Department of Marine Sciences
211 Endeavor Hall
Stony Brook, NY 11794-5000
631-632-8674
henry.bokuniewicz@stonybrook.edu

P. A. Buckley

Coastal Institute
University of Rhode Island
Kingston, RI 02881
401-874-4201
pabuckley@gso.uri.edu

Susan Peterson

Watershed Systems
241 Duchaine Boulevard
New Bedford, MA 02745
508-763-2390
sbptrsn@attbi.com

Norbert Psuty

Rutgers University
19 Green Hills Road
East Brunswick, NJ 08816
phone: 732-708-1462

Denise J. Reed

Professor, Department of Geology & Geophysics
University of New Orleans
New Orleans, LA 70148
phone: 504-280-7395
fax: 504-280-7396
djreed@uno.edu

John Teal

Woods Hole Oceanographic Institution
Woods Hole MA, 02543
Mailstop: 35
Phone: (508) 289-2323
jteal@whoi.edu

Mission Statements



Gateway National Recreation Area

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.



New York Sea Grant

New York Sea Grant is a cooperative program of the State University of New York, Cornell University and the National Oceanic and Atmospheric Administration. Our mission is to address critical coastal issues through high quality research, outreach and education so that New Yorkers may contribute to decisions that better conserve, utilize and rehabilitate their coastal resources.



NEW YORK AQUARIUM

New York Aquarium

New York Aquarium — *Where the City meets the Sea*—is the only aquarium in New York City and part of the largest network of metropolitan wildlife parks in the country. New York Aquarium holds a special place in the mission of the Wildlife Conservation Society — *To Save Wildlife and Wild Places Around the Globe*. Driven by a vision of a world where people understand the critical role oceans play in human survival, our programs strive to encourage people to place a high personal priority on the protection of marine and freshwater ecosystems and the rich diversity of aquatic wildlife, which they sustain.



PROCEEDINGS

Jamaica Bay's Disappearing Marshes

*Highlighting ongoing research, local and international perspectives
and future restoration plans*

March 3, 2004

New York Aquarium

Assistance provided by New York Sea Grant

Special thanks to the New York Aquarium

FRONT COVER

Black Bank Marsh is an example of a deteriorating marsh which shows erosion down to the underlying mineral sediment (gray area) and marsh peat (foreground).

Photo courtesy Don Cahoon, USGS

BACK COVER

In an experimental restoration technique using a high-pressure jet spray, a thin layer of sand is applied to the surface of Big Egg Marsh in September 2003.

Photo courtesy of National Park Service, Gateway National Recreation Area

