Great South Bay Ecosystem-based Management Plan

Prepared by The Nature Conservancy, Long Island Chapter

Prepared for

The New York State Department of State

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EXECUTIVE SUMMARY

Great South Bay (GSB) on the South Shore of Long Island is teeming with life, but it is also degraded compared to historical conditions. Conservation and management measures are needed to preserve and restore the health of the bay.

The Long Island Chapter of the Nature Conservancy (TNC), under contract to the New York State Department of State (DOS), developed this Ecosystem-based Management (EBM) Plan for Great South Bay.

Ecosystem-based Management is a management approach that considers the entire ecosystem, including humans. It promotes ecosystem viability and integrity, biodiversity, sustainability, and social values and principles.

TNC's analysis relies on choosing a set of ecological surrogates, representative species, and groups of species, or habitat types that can represent the ecological status of the biodiversity in Great South Bay. For each surrogate, specific measurable objectives are developed that describe the intended ecological state of Great South Bay with respect to each surrogate. The measurable objectives are achieved through the implementation of strategic actions and action steps described in the plan. Overarching objectives and strategic actions are also developed to address water quality, global climate change, and education.

The surrogates chosen to represent the GSB ecosystem in the plan are:

- Hard clams
- Salt marshes
- Seagrass meadows
- Barrier island complex
- Predatory fishes
- Winter flounder
- Alewives
- Piping plovers
- Horseshoe crabs

This report was originally drafted in 2008 followed by an update in 2012 to each surrogate's current status, strategic actions and action steps. Updates were made to acknowledge accomplishments, adapt to new findings and present recent reports relevant to this plan. Appendices include stand-alone reports on watershed nitrogen loading, hard clam restoration, as well as background information originally gathered in 2007-2008 on the indicators, viability, threats, and monitoring priorities for each surrogate. This report does not contain analyses on how and where the bay supports the social and economic well-being of Great South Bay communities, nor is there a short and long-term cost benefit analyses of recommendations proposed here. This information is called for, but was beyond the scope of this particular report.

Great South Bay

Ecosystem-based Management Plan

TABLE OF CONTENTS

INTRODUCTION

Great South Bay, the largest of Long Island's barrier island lagoons, is one of New York's greatest natural treasures. The coastal, estuarine, and barrier island ecosystems of Great South Bay provide for nationally significant natural resources and habitats that deliver regionally important cultural, recreational, and economic assets and opportunities. Great South Bay (GSB) is teeming with life, but it is also degraded compared to historical conditions. Conservation and management measures are needed to preserve and restore the health of the bay and the services it provides for both people and nature.

The New York Ocean and Great Lakes Ecosystem Conservation Act (2006) calls for an ecosystem-based management approach to safeguard the health and sustainability of New York's coastal ecosystems. In furtherance of the goals of the Act, the Long Island Chapter of the Nature Conservancy (TNC), under contract to the New York State Department of State (DOS), developed this Ecosystem-based Management (EBM) Plan for Great South Bay to serve as a demonstration project for how EBM planning might be implemented throughout New York State.

Ecosystem-Based Management (EBM) is an approach to managing ecosystems that considers the entire ecosystem, including humans. It promotes ecosystem viability and integrity, biodiversity, sustainability, and social values and principles. The six essential elements are: 1) EBM is place-based, reflecting local needs, 2) EBM recognizes the interconnections among components of the ecosystem, 3) EBM requires a scientific foundation for decision-making, 4) EBM provides measurable objectives to direct and evaluate performance, 5) EBM is an integrative process for planning and management of an ecosystem, using adaptive management to respond to new knowledge, and 6) EBM ensures involvement of stakeholders to advance its objectives.

TNC's Conservation by Design process was used to develop the EBM plan. This process assumes that if a set of ecosystem surrogates are protected, the integrity of the overall bay ecosystem will be maintained. This approach should not be interpreted to mean that actions protecting non-surrogate species are discouraged. For details of the process please refer to Appendix I. In addition, material supporting the rationale for threats assessment and strategic action development can be found within respective surrogate sections within Appendix I.

The planning project steering committee chose a set of ecological surrogates that consist of species, and groups of species, or habitat types to represent the ecological status of the biodiversity in Great South Bay. Nine ecosystem surrogates were chosen: hard clams, salt marshes, seagrass meadows, barrier island complex, migratory predatory fishes, winter flounder, alewives, piping plovers, and horseshoe crabs. A detailed description of the selection process can be found in Appendix I - Surrogate Selection. These species represent connectivity among different realms such as the rivers, the bay, and the ocean through their use of these habitats for breeding, foraging, or refugia. The surrogates are used as the basis for setting measurable objectives, developing strategies and measuring effectiveness of environmental management. The expectation is that through focused management actions aimed at maintaining or increasing surrogate viability and mitigating surrogate threats, Great South Bay will be effectively managed.

This document is intended to serve as a starting point to engage stakeholders in a broader discussion of how to make decisions affecting the Great South Bay using the principles of ecosystem-based management. The South Shore Estuary Reserve (SSER) comprehensive management plan (CMP) priorities (improve and maintain water quality, protect and restore the living resources, expand public use and enjoyment of the estuary, sustain and expand the estuary-related economy, and increase education, outreach and stewardship) provide a strong foundation for advancing EBM. The complete SSER CMP may be accessed at: http://www.estuary.cog.ny.us/background-pages/cmp.htm.

THE VISION

The vision for Great South Bay is a healthy, productive, sustainable, and resilient ecosystem that provides a complete set of ecosystem services for the benefit of current and future generations of residents and visitors.

DEMONSTRATION AREA SITE BOUNDARY

The boundaries of the Great South Bay EBM demonstration area (see Figure 1) are defined to establish the geographic focus of the plan. The east and west boundaries demarcated by the Smith Point Bridge and the Robert Moses Causeway were chosen to coincide with those which at the time were being used for the Bluepoints Bottomlands Council's (BBC) hard clam restoration project. Fire Island in its entirety and Fire Island Inlet are included in the site boundaries. The northern boundary was chosen to encompass the watershed of the study area so that land use impacts within the watershed on the bay could be included in the plan; threats to the watershed itself were only considered in the context of the impact those threats have on the bay. The oceanic boundary was delineated to include the impact of the ocean and human activities in the nearshore environment upon the bay. For more information on the Great South Bay a historical, social and ecological review of the Great South Bay is provided in Appendix II.

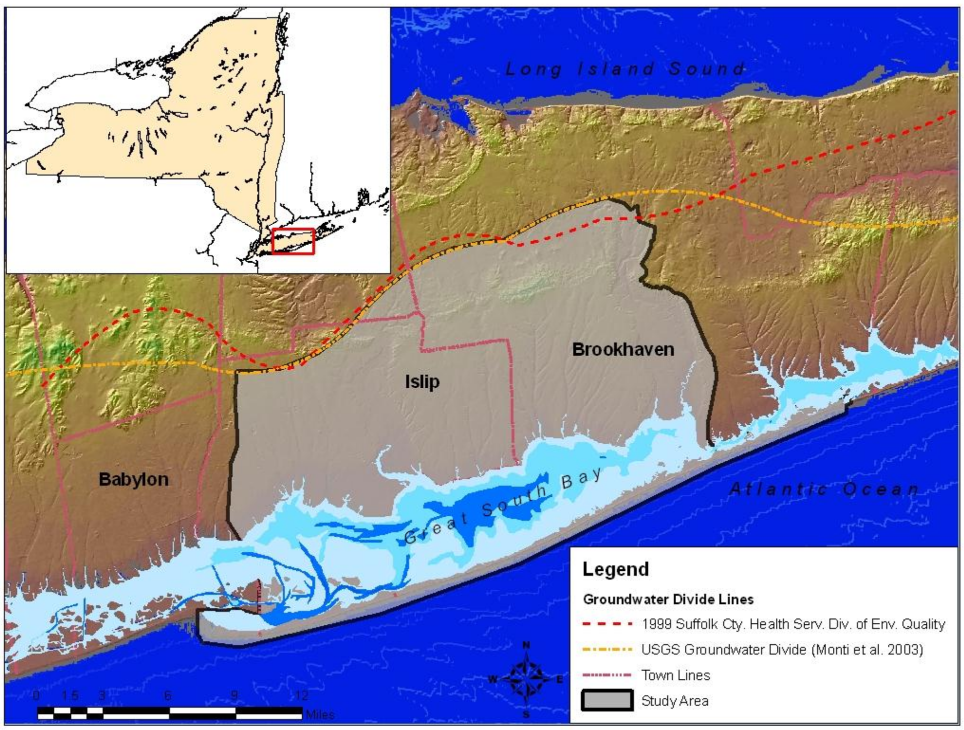

Figure 1. Geographic Boundaries of the GSB EBM Plan.

PROTECT THE SURROGATES, PROTECT THE BAY

Each of the nine surrogate sections begin with an introduction. This introduction briefly summarizes the value of each surrogate to the GSB ecosystem and its current and historic condition. Priority threats, which are those viewed as having a significant influence on the condition of the surrogate, are listed. Specific measurable objectives are developed that describe the intended ecological state of GSB by a specific date. The objectives are achieved through the implementation of the strategic actions and action steps. For each action step a set of

“Responsible Entities” - those having the jurisdictional authority - and “Potential Partners” - those who can beneficially contribute are listed. For more in-depth information on Conservation Action Planning used by The Nature Conservancy, consult the web links provided in Appendix I.

Surrogate: Hard Clams

Introduction

Hard clams (*Mercenaria mercenaria*) are filter feeding bivalves that hold an important current and historical place in the Great South Bay's ecology and the economy and social fabric of its surrounding towns. Ecologically, hard clams and other filter feeding shellfish are "foundation species" or "ecosystem engineers," playing a critical role in the food web through nutrient cycling (Newell 2004), influencing the types and abundance of phytoplankton (Cerrato *et al*. 2004) and zooplankton (Lonsdale *et al.* 2007), enhancing ecosystem stability (Dame 1996), packaging primary planktonic production for deposit feeders and seagrasses (Peterson and Heck 1999), and creating habitat on or around living and dead shells (Coen and Grizzle 2007). There are several other species of suspension feeding bivalves more broadly distributed in the bay, such as the dwarf surf clam; however, their ephemeral nature limits their overall contribution to ecosystem stability.

The Great South Bay hard clam population was historically of significant economic and social importance to residents of Long Island. In the mid-1970s more than half of the entire nation's hard clams came from Great South Bay (Taormina 1981). Clam harvesting employed thousands of residents. Recreational clamming was and still is a popular recreational activity in Great South Bay (Greene 2009).

Historic Distribution and Current Status

Hard clams have been part of the ecosystem since the post-glacial period began, and were harvested by native Americans, European settlers, and modern residents through the 20th century (Taylor 1983; Van Popering and Glancy 1947; MacKenzie 2002). In the 1960s, after the decline of the native oyster and the opening of Moriches Inlet there were several good hard clam recruitment years that coincided with an increase in popularity and price as well as the depletion of clam beds in other Long Island estuaries. As a result, the Great South Bay hard clam fishery became New York State's most economically important commercial fishery. At its peak, it supplied more than 50% (700,000 bushels) of the nation's hard clams (Taormina 1981; McHugh 2001) and supported thousands of harvesters. This fishery was quickly over-capitalized and harvested at unsustainable rates (Bricelj 2009; Greene 2011). Declining abundance of reproductive adults coincided with declining recruitment of juvenile clams and the resulting and lack of available clams combined with the relatively low price of clams today, has reduced recent harvest levels by two orders of magnitude from the 1970s (Greene 2011). Many of the areas that were closed to harvest because of human health concerns were intentionally depleted as part of transplant and relay programs designed to reduce the "attractive nuisance" and provide economic opportunities to struggling baymen.

Brookhaven, Islip, and Babylon have been conducting hard clam surveys for two to three decades. When they were abundant, clams occurred throughout most of the estuary. Today, much of the central bay has very low clam abundance. Pockets of higher clam abundance in Babylon and Brookhaven occur most often in places that are believed to be beneficial to recruitment, survival and growth because of heterogeneous sediments, abundance and efficiency of predators, and clam food quality. Shell beds, largely remnants of the once abundant oyster populations, create a favorable environment for the settlement, growth, and survival of hard clams (Kraeuter *et al*. 1997). Although shell bed habitat has not historically been mapped and quantified, Great South Bay clam diggers have reported that shell beds have been shrinking. These observations are consistent with what is known about the persistence of relic shells in the absence of high volumes of new clam and oyster shell production (Powell *et al.* 2006; Carver *et al.* 2010; Waldbusser *et al.* 2012).

A recent evaluation of the stock recruitment relationship for hard clams in Great South Bay (Kraeuter *et al.* 2005) compared to the current standing stock of hard clams (LoBue 2005) suggests that vast areas of the bay are currently recruitment limited. The central portion of Great South Bay, currently owned by The Nature

Conservancy, which was subject to extensive mechanical harvest, is an order of magnitude more depleted than the adjacent public bottom in Brookhaven town. With the exception of a strong 2007 year class, which settled in and adjacent to spawner restoration areas, recruitment has been poor for well over a decade (survey data presented in Greene 2011). Actively rebuilding the effective hard clam spawning potential has been identified as a major and essential component to the re-establishment of a naturally sustainable hard clam population in Great South Bay (SCHCRWG 2011). Efforts to ramp-up and coordinate (among agency and stakeholders) bay-wide restoration of hard clams accelerated in 2004 with The Nature Conservancy's acquisition of the Bluepoints (see Appendix III) submerged lands and the hard clam rebuilding planning process undertaken by the Bluepoints Bottomlands Council.

Priority Threats

Low spawning biomass
Altered phytoplankton including harmful algal blooms
Current and future harvest
Predation
Declining shell substrate
Elevated nutrient loading

Objective and Recommended Actions

Objective 1: Re-establish the hard clam population in GSB to an average density of 6 clams of greater than 20 mm shell height per square meter by 2020 for the purposes of ecosystem health and enhancement

Strategic Action 1.1: **Actively rebuild the spawning potential of hard clams in recruitment limited areas of the bay**

Action Step 1.1.1: Implement, monitor, and adjust where necessary, approaches laid out in more detail in the 2011 report of the Suffolk County Great South Bay Hard Clam Restoration Working Group (www.gsbclams.org), including:

- Improvements to the utilization of hatchery-born clams
- Improvements to the utilization of spawner sanctuaries
- Predator control
- Substrate enhancement
- Potential opportunities for shellfish restoration collaboration with private shellfish aquaculturists

Potential Partners: GSB townships, DEC, DOS, Suffolk County, TNC, FINS, CCE, Dowling College, shellfish aquaculturists

Strategic Action 1.2: **Monitor and manage the harvest of hard clams in Great South Bay in ways that are consistent with population rebuilding and long-term sustainability**

Action Step 1.2.1 Implement recommendations for adaptive harvest management, monitoring, reporting, and enforcement outlined in more detail in the 2011 report of the Suffolk County Great South Bay Hard Clam Restoration Working Group (www.gsbclams.org), including:

- Harvest target adoption
- Coordinated periodic population surveys
- Standardized collection of harvest statistics
- Coordination of daily harvest limits in consideration of reciprocity agreements
- Coordinated periodic assessments and adaptive management, including recommendations pertaining to commercial clamming permits and permit conditions

Responsible Entities: GSB townships, DEC
Potential Partners: Shellfish harvesters and dealers, FINS, Suffolk County

Strategic Action 1.3: Reduce the susceptibility of Great South Bay to algal blooms that negatively impact hard clams and other shellfish

Action Step 1.3.1: See the Water Quality recommendations starting on page 40.

Recent Actions

Since the original draft of this document was finalized many of the action steps originally outlined in the plan have been taken. These include:

- ✓ The relocation of approximately 5 million additional adult clams into a spawner sanctuary network in central Great South Bay through the end of 2011
- ✓ Monitoring of post-stocking survival and spawning of clams in sanctuaries and adjustment of spawner sanctuary program to maximize success through the end of 2011
- ✓ Brookhaven Town designation of the TNC submerged lands as a Shellfish Management Area in 2009, prohibiting all shellfish harvesting in this area
- ✓ Improvement in coordination and cooperation among towns and TNC on bay-wide shellfish surveys, including expansion into previously under-surveyed areas
- ✓ Digitization, collation, and formatting of town shellfish survey data to improve use for assessment purposes in 2009-10
- ✓ Completion of studies and documentation of the current state of both recreational and commercial hard clam fisheries in Great South Bay in 2008 and 2011 (www.gsbclams.org)
- ✓ Creation of the Suffolk County Hard Clam Working Group, which has resulted in the development and adoption of coordinated interim hard clam harvest management regulations by all three towns, and long-term harvest management recommendations and sustainable yield targets for the entire bay and for each of the three townships (December 2011 – www.gsbclams.org)
- ✓ Partnerships between The Nature Conservancy and local fishermen for targeted whelk trapping in the vicinity of hard clam spawner sanctuary sites in central Great South Bay to increase survival of spawner clams
- ✓ Study by Islip Town of the post release survival of hatchery-born seed clams and development and implementation of plans to increase survival of hatchery seed clams
- ✓ Expansion of monitoring programs as exemplified by the new SUNY-SoMAS water monitoring stations including the new central Great South Bay buoy installed in 2010

Surrogate: Salt Marsh

Introduction

Great South Bay salt marshes are typical of northeastern salt marshes which are described in detail in Niering and Warren (1980), Edinger *et al.* (2002), and Bertness (1999). Salt marshes are among the most biologically productive ecosystems on Earth (Teal 1962; Odum 1970; Valiela *et al.* 1976; Nixon 1980) and they perform many ecosystem services that are highly valued by society. Salt marshes protect estuarine water quality by acting as a sink for land-derived nutrients and contaminants (Valiela 2004; O'Connor and Terry 1972; Teal and Howes 2000; Wigand *et al.* 2004). They are also an important component of the estuarine food web (Boesch and Turner 1984; Houde and Rutherford 1993; Peterson *et al.* 2000; Deegan *et al.* 2001). During high tide, salt marshes provide food and important nursery grounds for shellfish and finfish including many commercially harvested species (Teal 1962; Weisburg and Lotrich 1982; Dionne *et al.* 1999; Able *et al.* 2000; Cicchetti and Diaz 2000). Juvenile menhaden, for example, obtain much of their energy from detritus from marsh plants (Pernell and Peters 1984) and striped bass caught in marsh creeks frequently forage on mummichogs (Able *et al.* 2000). During low tide, salt marshes provide foraging opportunities for terrestrial species, including resident songbirds and shorebirds. Salt marshes also provide valuable wildlife habitat and nesting areas for osprey and obligate salt marsh nesting birds such as the salt marsh sparrow (*Ammodramus caudacutus*) and the clapper rail (*Rallus longirostris*).

In order to keep pace with sea level rise, salt marshes must grow in two directions: vertically and horizontally (Redfield 1965 and 1972). Vertical growth occurs through the accumulation of organic and inorganic sedimentary materials that form the peat substrate (Bertness 1999; Turner *et al.* 2000). Vertical growth allows migration horizontally in places where shoreline hardening and development do not obstruct that landward migration. The fate of salt marshes will depend on whether they are able to grow vertically at a rate sufficient to keep pace with sea level rise and whether they are able to migrate landward without being obstructed by development.

Historic Distribution and Current Status

Coastal salt marshes have been modified by ditching, draining, and filling for the purposes of agriculture, development, and mosquito control. Most of the salt marsh losses in Great South Bay took place prior to 1973 when the New York State Tidal Wetlands Act was enacted, protecting wetlands from infilling and development. Despite this protection, Long Island marshes continue to lose acreage (Mushacke 2007; Peconic Baykeeper 2006; Mushacke 2010; Browne 2009; Ciabetta *et al.* 2009; Ciabetta *et al.* 2010). Accelerating sea level rise, declining water quality, and disrupted sediment supply are some of the potential mechanisms through which these losses may be occurring.

A multi-partnered comprehensive tidal wetlands re-inventory project is underway to assess the quantitative and qualitative changes in wetlands for Nassau and Suffolk Counties as well as partial portions of Queens, Bronx, and Westchester Counties. This initiative, funded by an US EPA Wetlands Development Grant and through a partnership between the New England Interstate Water Pollution Control Commission (NEIWPCC), DEC, and TNC will investigate individual marsh trends as well as trends across and between estuaries. In addition, the project will develop a pilot Marsh Loss Characterization Matrix to help diagnose specific stressors and impacts. It is anticipated that this re-inventory and loss characterization matrix will be completed by the end of 2013.

A number of permanent marsh elevation benchmark stations have been established in the South Shore Estuary to monitor how marshes are growing vertically. In 2002 the NPS and the USGS established Sediment Elevation Table benchmarks in three marshes on the bay side of Fire Island to monitor sediment accretion and marsh elevation. In 2008 the US Fish and Wildlife Service, with the USGS and TNC established additional benchmarks in two marshes near the mouth of the Carmans River. These stations within GSB are part of a large network of stations from NYC to the eastern end of Long Island. All sites have ongoing monitoring to track both surface sediment accretion as well as overall elevation changes. In the event that elevation shortfalls are detected, it can be determined if the elevation deficits are due to aboveground or belowground processes. Belowground processes are more important for maintaining marsh elevation than previously thought (Turner *et al.* 2000; Turner *et al.* 2004). Research is revealing negative impacts on salt marsh function and substrate condition as a result of increased nutrient loading (Turner *et al.* 2009; Turner 2011). This elevated nutrient loading results in marsh grasses allocating more biomass production aboveground at the expense of belowground production. The effect of this shift may hinder their ability to keep up with sea level rise. The reduced network of belowground roots and rhizomes also makes these marshes more susceptible to erosion. Additionally, as nutrient concentrations increase, bacterial decomposition increases reducing the volume of stored organic matter, and the soil strength of the marsh peat (Turner 2011). Additional research investigating the belowground processes of root and rhizome growth, soil respiration and breakdown of stored organic matter are underway.

Priority Threats

Sea level rise
Elevated nutrient loading
Tidal restrictions
Shoreline armoring
Development
Invasive species
Boat traffic
Dredging
Vector control practices

Objective and Recommended Actions

Objective 2: Maintain existing salt marsh acreage from a 2013 baseline constructed from the most recent available height-of-growing-season imagery, increase acreage where possible, and enhance functionality of Great South Bay salt marsh by 2015

Strategic Action 2.1: **Establish adequate land use protections within and adjacent to salt marshes and salt marsh advancement zones that account for sea level rise**

Action Step 2.1.1: Establish and adopt sea-level rise projections, task all state agencies to consider projections in planning, implementation, and permitting of coastal projects, and request that local governments also utilize these official projections when making land use decisions. See the Climate Change recommendations starting on page 44 with a particular focus on sea level projections.

Responsible Entities: NY State Legislature, DEC, GSB Townships

Action Step 2.1.2: Identify salt marsh advancement zones based on sea level rise projections and high resolution topography information.

Action Step 2.1.3: Prioritize vacant and under-developed advancement zones as open space acquisition and easement priorities. Designate and phase in vegetated buffers within and adjacent to advancement zones.

Responsible Entities: GSB Townships, SSER, DOS, DEC

Action Step 2.1.4: Initiate coastal monitoring to survey and map newly flooded areas to identify areas that are being converted to wetlands and should be regulated as such.

Responsible Entities: GSB Townships, DOS, DEC
Potential Partner: NOAA Coastal Services

Strategic Action 2.2: Maintain and expand natural shorelines by discouraging new shoreline hardening structures and phasing out existing non-essential hardening structures on public lands in Great South Bay

Action Step 2.2.1: Based upon habitat value and access to public trust intertidal areas, designate stretches of Great South Bay shoreline where natural shorelines are protected from new shoreline hardening structures, where defunct or dilapidated structures are removed, and where soft alternatives are encouraged if deemed necessary for protection of nearshore coastal infrastructure.

Responsible Entities: GSB Townships, DEC, NPS, DOS

Strategic Action 2.3: Minimize potential impacts of navigational dredging on tidal wetlands

Action Step 2.3.1: Ensure that channel design maximizes sediment transport from one side to the other, is not so close to marsh edges that it serves as a sediment sink and contributes to adjacent marsh loss, and where practicable, dredged sediments are used in ways that benefit adjacent marshes and natural shorelines.

Responsible Entities: GSB Townships, DEC, USACE

Strategic Action 2.4: Assure Vector Control practices will sustain or improve marsh function and sustainability

Action Step 2.4.1: Require all marsh manipulations to conform to the best available science and include measureable goals for increasing marsh function and sustainability (as opposed to mosquito population control) specifically, prohibit activities that may hamper the marshes ability to keep up with sea level rise.

Responsible Entities: DEC, Suffolk County Vector Control

Action Step 2.4.2: Minimize the use of chemical mosquito control agents in salt marshes by only applying them in cases where there is documented disease in the active mosquito population sampled, thus reducing the need for chemical controls for nuisance situations.

Responsible Entities: DEC, Suffolk County Vector Control

Action Step 2.4.3: Design and implement an outreach program to instruct residents on how to eliminate mosquito breeding areas around their homes to reduce the need for chemical controls.

Responsible Entity: Suffolk County Vector Control

Strategic Action 2.5: Restore natural hydrology and sediment regimes in marshes in ways that reestablish native vegetation and improve marsh functionality

Action Step 2.5.1: Survey the suitability (size and orientation) of all culverts to identify those that pose tidal restriction threats to marshes both today and into the future based on sea level rise projections and mitigate unsuitable culverts to restore hydrology and connectivity.

Responsible Entities: DEC, DOT

Strategic Action 2.6: **Enhance and protect the long-term viability of salt marshes by improving and protecting water quality in GSB**

Action Step 2.6.1: See the Water Quality recommendations starting on page 40.

Recent Actions

Since the original draft of this document was finalized many of the action steps originally outlined in the plan have been taken. These include:

- ✓ Calculations of sea level rise projections for the decadal averages (2020s, 2050s, and 2080s) by climate scientists at the Goddard Institute for Space Studies (GISS) on behalf of TNC's Coastal Resilience Project
- ✓ Identification of marsh advancement zones for the 2020s, 2050s, and 2080s for LIS shores with plans to be replicated in GSB
- ✓ Acquisition of contemporary height-of-growing-season infrared imagery by TNC for the last remaining stretch of the NYS marine district that included Great South Bay (Queens/Nassau border to Montauk Point)
- ✓ Secured an US EPA Wetlands Development Grant through a private-public partnership (TNC, NEIWPCC, and DEC) to re-inventory wetlands Long Island-wide and parts of Westchester County and the Queens and Bronx Boroughs. This project will involve re-analysis of 1974 imagery and the construction of a Wetlands Loss Diagnostic Matrix to reveal meaningful patterns of loss that will identify causes of loss
- ✓ Re-instituted the fees associated with tidal wetland permit applications by DEC, however it is recommended that the funds generated by these fees be deposited into the Marine Account of the Conservation Fund to support staff working on tidal wetlands
- ✓ USFWS, USGS, and TNC installed additional marsh elevation benchmarks within GSB watershed, at the mouth of Carmans River, to identify whether marshes are keeping up with sea level rise, to identify whether elevation shortfalls are the result of aboveground or belowground processes
- ✓ Suffolk County adopted a Vector Control and Wetlands Management Long-Term Plan for the purpose of 1) controlling mosquitoes, 2) reducing pesticide use, and 3) managing and protecting wetlands. Pursuant to this plan, the County also developed a Wetland Stewardship Strategy to emphasize marsh health and preservation for all of the County's 17,000 acres of salt marsh.

Surrogate: Seagrass Meadows

Introduction

Seagrasses are temperate marine subtidal rooted vascular plants found in shallow coastal waters in various types of sediment substrate from sand to mud. The two seagrass species in Long Island waters, eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*), grow in beds that form highly diverse and productive ecosystems that provide a wide range of services. Seagrass beds serve as shelter and nursery grounds to hundreds of species from all phyla, including juvenile and adult fish, shellfish, and invertebrates. The plants can contribute significantly to the overall primary productivity of an estuary. Seagrass provides structure for benthic (seabed) communities and can slow down currents, thereby reducing turbidity and increasing sedimentation. The seabed is stabilized by seagrass roots and rhizomes. Seagrass provides oxygen to the water column and takes up nutrients (e.g. nitrogen and phosphorus) during its growing season (spring to fall), re-releasing the nutrients through organic decay. Numerous animals feed directly on seagrass, including fish, waterfowl, sea turtles, and crustaceans.

Eelgrass supports a diverse epiphyte (plants growing on the surface of another plant on which it depends for mechanical support) community, including benthic diatoms and other algae and free-floating macro and microalgae. Other organisms living on blades of eelgrass include protozoans (ciliates, flagellates, and foraminifera), nematodes, and copepods (Perry 1985). Animals living on the blades and at the base of eelgrass shoots include bay scallops, crustaceans, sponges, anemones, bryozoans, tube worms, polychaetes, barnacles, and other arthropods and tunicates (Perry 1985).

Because of declines in seagrass habitat throughout Long Island nearshore waters, a seagrass experts meeting hosted by New York Sea Grant and sponsored by DEC, New York Sea Grant, Peconic Estuary Program, Cornell Cooperative Extension, Long Island Sound Study, and The Nature Conservancy was held in May 2007 to get guidance on critical monitoring and research needs to support management (for the full report, see http://www.seagrant.sunysb.edu/Images/Uploads/PDFs/SeagrassMeeting07-Proceedings.pdf). Many of the research recommendations have been completed or are currently underway. Enacted in 2006 and convened in 2008, A NY Seagrass Task force was created to examine the current status of seagrass habitat and make recommendations to the Governor for better management, restoration, and protection of seagrass. The final Task force report and complete set of recommendations can be found at http://www.dec.ny.gov/docs/fish_marine_pdf/finalseagrassreport.pdf. One of the key recommendations of the Task force was that existing authorities need to be strengthened to adequately regulate coastal and marine activities, which threaten seagrass habitat and restoration efforts. The strategic actions and steps below overlap with the NY Seagrass Task force recommendations.

Historic Distribution and Current Status

The expanse of seagrass beds across GSB has decreased by 3,000 acres over a 23 year period. A 1979 benthic survey (Jones and Schubel 1980) found 17,000 acres of seagrass beds located mostly along the south shore of Great South Bay, concentrated particularly in the eastern and western ends of the bay. In 2002, a National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center regional aerial survey found 14,000 acres of seagrass beds in the Great South Bay study area (NOAA 2002). Although the methodologies of these two surveys differ, these data sets represent the best available information on GSB seagrass population trends. Survey results show large increases (approximately 2,300 acres gained in Babylon Township, west of the study area) in the western end of the bay. The relative stability of seagrass acreage within the central part of GSB (Islip Township) is likely tied to the proximity of Fire Island Inlet, which is exposed to more oceanic exchange yielding cooler and clearer waters than the far eastern and western portions of the bay. There has been a loss in the eastern end of the bay (approximately 5,000 acres lost in Brookhaven Town). This has resulted in a net reduction of seagrass acreage found within the study site. While the causes for seagrass loss and gain are currently being investigated, it should be noted that between surveys two major changes occurred: the South West Sewer District

(SWSD) sewage treatment plant discharge to the Atlantic Ocean came online and by the late 1990s commercial shellfish harvesting formerly exerted in the 1970s and 1980s was greatly diminished. These changes may have contributed to the gain in seagrass acreage in the Town of Babylon west of the study area. The Bluepoints submerged lands in central Great South Bay was largely devoid of seagrass, most likely due to mechanical shellfish dredging that occurred throughout the property. Anecdotal evidence showed seagrass returning to some of these areas from 2004 to 2007. Persistent harmful algal blooms and increasing water temperatures since then have reduced the total area covered by seagrass in the bay according to data collected during the annual shellfish survey finding no eelgrass in any samples collected on the Bluepoints property in 2011. Additional losses in the eastern and western bay since 2007 have been reported by agencies and stakeholders. There also appears to be a shift in the species of seagrass in the eastern end of Great South Bay, from eelgrass, *Zostera marina*, to widgeon grass, *Ruppia maritima*, which may be indicative of warmer temperatures and/or reduced light availability (C. Clapp, TNC, direct observation; B. Peterson, SoMAS, personal communication).

Priority Threats

Global climate change
Elevated nutrient loading
Shellfish harvest methods
Boating activities
Shoreline armoring
Toxins

Objective and Recommended Actions

Objective 3: Based upon the most recent bay-wide surveys from 2002 maintain current seagrass acreage in GSB by 2020

Strategic Action 3.1: **Develop and implement a plan to protect and restore seagrass meadows throughout the New York State marine district including GSB**

Action Step 3.1.1: Establish adequate authority for DEC to protect seagrass.

Responsible Entity: NY State Legislature

Action Step 3.1.2: Implement recommendations of the New York State Seagrass Task force related to water quality, direct disturbance, riparian property protection and restoration, boater education, and periodic seagrass mapping (See complete set of Task force recommendations at http://www.dec.ny.gov/docs/fish_marine_pdf/finalseagrassreport.pdf).

Responsible Entities: DEC, GSB Townships, FINS, OPRHP, DOS

Action Step 3.1.3: Distinguish seagrass beds based on their ecological importance and/or their vulnerability to threats that require special protection and develop and implement plans for particular seagrass areas where special conditions apply such as restoration and monitoring activities and/or restrictions on damaging activities.

Responsible Entities: DEC, FINS
Potential Partners: GSB Townships, Commercial and recreational fishermen, SSERC

Action Step 3.1.4: More clearly mark narrow navigation channels that traverse shallow seagrass areas by decreasing the distance between each marker and make charts of seagrass meadows and navigation channels easily available to boaters.

Responsible Entities: USCG, GSB Townships
Potential Partners: USCG Auxiliary, private clubs and organizations such as United Boatmen

Strategic Action 3.2: **Improve water quality conditions to facilitate the persistence and natural recovery of seagrass to the bay**

Action Step 3.2.1: Follow recommendations in the water quality section of this report starting on page 40, as well as Long Island-wide recommendations in the NYS Seagrass Task force Report (specifically action steps aimed at controlling and reducing nutrient, pesticide, and sediment loading to surface and ground water).

Responsible Entities: USEPA, DEC, Suffolk County, GSB Townships, Sewage treatment plants, Private property owners

Action Step 3.2.2: Restore native shellfish beds (See Hard Clams recommendations starting on page 7).

Strategic Action 3.3: **Develop and implement a research program to understand the causes of seagrass loss from direct and indirect impacts and to refine restoration techniques**

Responsible Entities: DEC, DOS, SSERC, GSB Townships, FINS

Recent Actions

Since the original draft of this document was finalized many of the action steps originally outlined in the plan have been taken. These include:

- ✓ Research to assess the effects of low levels of herbicides in ground water found herbicide levels of diuron have sublethal and lethal impacts on eelgrass (B. Peterson , SoMAS unpublished data)
- ✓ Research currently underway to investigate the impact of multiple stressors and genetic diversity on eelgrass population health in GSB and the greater southern New England region (Short *et al.* 2012)

Surrogate: Barrier Island Complex

Introduction

The barrier island complex known as Fire Island defines the Great South Bay's southern boundary and is critical to the overall function of the bay. Fire Island is approximately 31.7 miles (51 km) long and averages about 0.3 miles (0.5 km) in width. The island is bordered by the inlets of Fire Island to the west and Moriches to the east, and is separated from the Long Island mainland by Great South and Moriches Bays. Like other Atlantic barrier islands, Fire Island grades from a primary dune along the ocean to salt marsh along the bay. Inlets cutting through the barrier island once naturally opened, closed, and shifted position but are now maintained permanently at Fire Island, Jones, and Moriches Inlets. These inlets regulate the exchange of ocean waters and the highly productive estuarine waters of the bay. Consistent winds feed the bay's salt marshes and seagrass meadows with a regular dose of sediment to help them keep up with sea level rise. Infrequent breaches and overwashes create new platforms for bayside beaches and sand flats that eventually evolve into seagrass meadows and salt marshes. This "roll-over" process is essential for the long-term viability of the barrier island and bay system (McCormick 1984; Nordstrom 2005; Psuty 2005).

Fire Island provides critical habitat for several rare and endangered species, and serves as a migratory corridor for birds, turtles, and marine mammals. Fire Island also encompasses vital coastal wetlands essential to water quality, fisheries, and the biological diversity of coastal, nearshore, and terrestrial environments.

Fire Island was designated a National Seashore on September 11, 1964 "for the purpose of conserving and preserving for the use of future generations certain relatively unspoiled beaches, dunes, and other natural features within Suffolk County, New York, which possess high values to the Nation as examples of unspoiled areas of great natural beauty in close proximity to large concentrations of urban population." (P.L. 88-587, "An Act to Establish the Fire Island National Seashore and for Other Purposes" (September 11, 1964)). The eastern half of the National Seashore encompasses the Otis Pike Wilderness Area. Established in 1980, it is the only federally designated wilderness in the state of New York. Outside of the Wilderness Area, most of the remaining natural areas are small, scattered remnants that comprise the interstitial spaces between island communities occupying the western half of Fire Island, as well as natural areas within Smith Point County Park and Robert Moses State Park.

Historic Distribution and Current Status

Fire Island has a well-developed beach on the ocean side and is dominated by a variety of dune features on its surface, reaching elevations of 36-42 feet (11-13 meters). Much of the island is undeveloped and retains a wide array of coastal dune forms in a near natural condition. There are 17 small, primarily seasonal residential communities, concentrated on the western portion of Fire Island, that have significantly altered the landscape and its geomorphological processes.

The sediments comprising Fire Island were initially deposited at the end of the last Ice Age 18,000 years ago. There are two source types: glacial till (boulders to clay-sized material) exposed at least 30 miles (48.3 km) to the east of Fire Island, near Montauk Point, and glacial outwash sand that was deposited offshore by meltwater. During the period of sea level rise that accompanied glacial retreat over the past 18,000 years, waves have eroded, transported, and re-deposited coastal sediments. Sea level rise during glacial periods slowed about 9,000 years ago and is believed to have formed ancestral barrier islands, which were augmented about 4,000 years ago when further sea level rise favored accelerated growth of barrier island environments (Schwab 2000). These barriers are now migrating shoreward in response to the most recent increases in relative sea level rise rates. This effect is more pronounced in the east where steeper offshore slopes lead to higher frequency of inlet formation (FINS 2003).

The fundamental causes of shoreline change at Fire Island are longshore transport, cross-island transport, and dune development, all caused by waves and wind (both day-to-day and storm generated), and rising sea levels. Inlets, overwash, and dune migration deliver sediment from the ocean to the bay where it forms substrate that evolves into tidal flats, marshes, and beaches. These sediment inputs allow barrier islands to maintain themselves as they migrate landward under the influence of sea level rise. Structures located on the dunes can prevent or interfere with these processes, increasing susceptibility to storms and eliminating natural habitat (Psuty 2005).

Large storm events such as tropical storms, hurricanes with high wind speed, extratropical storms, and nor'easters are large contributors to the formation and continued development of the Fire Island shoreline. These storms generally cause rapid beach erosion, dune displacement, and coastal flooding. In addition, these storms generate responses by the US Army Corps of Engineers and other government entities, altering the shoreline either in response to the storm or in an effort to prevent future storm impacts.

Many hurricanes and nor'easters have affected Fire Island during the past 75 years. Among the most significant was the Great Hurricane of 1938 (September 21st), also known as "The Long Island Express." The storm produced winds that reached 200 mph, generated 16 foot-high (4.8 meter) high breakers, overwashed one third to one half of the island, and created about 12 new inlets (McGinty 2004). The "Ash Wednesday" storm of March 6, 1962 was a major extratropical nor'easter that resulted in more than 50 washovers. The US Army Corps of Engineers constructed emergency shore protection measures with a project known as Operation Five High (named for the five consecutive tidal cycles that occurred with the storm). Over 2.2 million cubic yards (1,700,000 cubic meters) of material were used to rebuild more than 23 miles (37 km) of beaches and dunes (USACE 2008). Beaches were raised to an elevation of about 12.3 feet (3.75 m) above mean low water. About 1.8 miles (3.0 km) of dune and 7.02 miles (11.3 km) of eroded beach were quickly restored. Most recently, in December 1992, overwashes occurred at Atlantique, Old Inlet, and Smith Point County Park (McGinty 2004).

Currently the barrier island system seems to be increasingly unstable, driven by the accelerating rate of sea level rise and a potential depleted sediment supply from the glacial outwash source (Pendleton 2004). Sea level rise will change the baseline sea level on which storm surge will operate, perhaps leading to increased severity of flooding due to an increase in the distance into the barrier island to which storm surge will reach. For example, if the 1938 hurricane occurred in 2004, it would be imposed upon a sea level nearly 9 inches (21.3 cm) higher than in 1938, thereby having a much more devastating flood effect (Psuty 2005). Areas of low elevation along Fire Island will experience the effects of sea level rise sooner than the areas of higher elevation. A general encroachment of water along all of the margins is expected, narrowing the barrier island and therefore diminishing the protective capacity of the island (Pendleton 2004). The Coastal Resilience future scenarios mapper (http://coastalresilience.org/geographies/long-island-sound/future-scenarios-map) can be used to visualize the potential impacts of various levels of sea level rise and storm events on the communities and habitats of the barrier island (for more information on the Coastal Resilience project please see the Climate Change chapter).

Sea level is projected to rise by 5-10 inches (12.7-25.7 cm) in the 2020s, 19-29 inches (48.3-73.7 cm) by the 2050s and 41-55 inches (104.1-1389.7 cm) by the 2080s (NYSERDA 2010). As the mean sea level rises, elevated storm surges can result in more extensive flooding events, breaches, and over washes.

Priority Threats

Disruption of natural sediment regime
Shoreline armoring
Development

Objectives and Recommended Actions

Objective 4: By 2015, adopt policies which, to the extent practicable, manage for levels of natural sediment transport necessary for the long term movement and integrity of the barrier island in response to increasing rates of sea level rise

Strategic Action 4.1: **Preserve newly-formed tidal wetland and island habitat, including flood tide deltas and peninsulas formed by barrier island breaches and overwash**

Action Step 4.1.1: Proactively clarify the legal disposition of potentially new upland and tidal wetland areas created along and/or adjacent to the bay-side of the barrier island that can occur during breach and overwash events. If necessary proactively adjust laws and regulations to assure the preservation of the natural integrity of such areas through management as protected open space.

Responsible Entities: NY State Legislature, DEC, GSB Townships

Strategic Action 4.2: **Amend coastal policy to acknowledge the value of breaches and overwash in terms of ecological integrity and long term viability of the barrier island**

Action Step 4.2.1: Amend the Breach Contingency and inlet management plans and associated permits to accommodate the persistence of breaches in natural areas, and evaluate the feasibility of allowing for the opening of new inlets and closing of existing inlets in consideration of the long-term integrity of the barrier island, overall bay health, and water quality as well as property protection and navigation.

Responsible Entities: DEC, USACE, DOS

Action Step 4.2.2: Ensure the natural movement of sediments is maintained by developing standards for inlet and marina dredging and maintenance that are consistent with natural movement of sediments and establishing a suite of engineering alternatives that represent best management practices for sediment bypassing.

Responsible Entity: DEC

Strategic Action 4.3: **Develop a suite of land use tools, best management practices, and post-storm redevelopment planning strategies as the preferred tools available to protect sea side development by 2015**

Responsible Entities: DOS, DEC, SEMO

Strategic Action 4.4: **Prevent new development and minimize redevelopment that will impede cross-island sediment transport**

Action Step 4.4.1: Develop capacity to fully implement and enforce the provisions of the Coastal Erosion Hazard Area law to minimize the inappropriate siting of new development and prevent the rebuilding of structures in hazard areas.

Responsible Entities: DEC, GSB Townships with delegated authority under the law

Action Step 4.4.2: Develop post-storm recovery plans that are FEMA-compliant, involve significant post-storm land protection, and would trigger federal funding for voluntary property acquisition.

Responsible Entities: SEMO, GSB Townships, SC Parks Department, SC Office of Emergency Management

Action Step 4.4.3: Develop a program to acquire property outright from willing sellers in the most vulnerable locations of Fire Island and encourage prioritization of public acquisition of vulnerable coastal properties pursuant to FIMP.

Responsible Entities: Suffolk County, GSB Townships

Recent Actions

Since the original draft of this document was finalized many of the action steps originally outlined in the plan have been taken. These include:

- ✓ Currently in progress: Amendment of FEMA policy to discourage new development or post storm re-development in areas of high ecological value or high risk

Surrogate: Predatory Fish

Introduction

Seasonal migration of animals between the ocean and Great South Bay strongly influence the bay's community composition, food web dynamics, productivity, and energy transfer (both within the bay and between the bay and the ocean). Great South Bay hosts numerous migratory species including shorebirds, waterfowl, invertebrates, marine and diadromous fish, turtles, and seals. A suite of four predatory fish common in Great South Bay (bluefish, *Pomatomus saltatrix*; striped bass, *Morone saxatilis*; weakfish, *Cynoscion regalis*; and summer flounder, *Paralichthus dentatus*) were selected as a surrogate representing these seasonal migrants because of their abundance, large biomass, apex role in the food web, and socio-economic value. This suite of species utilizes the bay for spawning (weakfish) and as a juvenile nursery and adult foraging area (all four species). These species were also chosen as a surrogate because New York State government representatives and agencies are active participants in the development and implementation of the Atlantic States Marine Fisheries Commission and Mid-Atlantic Fishery Management Council fishery management plans for these four species.

Although there is a role for placed-based actions to benefit the conditions experienced by these coastal migrants while they are in Great South Bay, as well as to address desired uses of these resources and localized human use conflicts, it has long been recognized that effective management of migratory populations of harvested fish is most appropriately conducted through cooperative plans that span the migratory range of the population. Habitat and water quality recommendations found elsewhere in this report are important for attracting these species to, and sustaining them while they are in the vicinity of Great South Bay. In addition, migratory forage species that also use Great South Bay as spawning and nursery areas (such as Atlantic menhaden, Atlantic silversides, sand lance, and bay anchovy) are also important for sustaining migratory shorebirds, sea birds, marine mammals, and coastal and highly migratory fish, while they are in nearby oceanic waters.

Historic Distribution and Current Status

No estimates exist for the annual trends in seasonal abundance of any of these species in Great South Bay. There is some historically interesting geographically-specific catch and fishery effort data for the region. For example, a report prepared by T. H. Bean at the Smithsonian Institute for the New York Fish Commissioners in 1888 describes the annual catch of these four species from Bellport to Islip as 10,000 pounds of striped bass, 150,000 pounds of flounders (presumably winter and summer flounder combined), 200,000 pounds of bluefish, and 300,000 pounds of weakfish. The report further describes a large fishing fleet of 300 boats employing 600 men, utilizing 100 gill nets, 13 trap (pound) nets, 1,300 fyke nets, 5,000 eel pots, 15 large seines, and many lines, tongs, and rakes (NYT 3-8-1891). It also describes the occurrence of other predatory fish (sharks 8-10 feet (2.5-3.25 m) in length), which today would be considered very uncommon (Bean 1891). Records of recreational landings from the late 1950s show that summer flounder and winter flounder were the two most important sport fisheries in Great South Bay and comprised 90% of the catch from 1956 to 1960 (Briggs 1962). Over a million and a half summer flounder were taken on average from June to September during these years. Bluefish ranked third in the recreational catch and striped bass and weakfish were among the top ten (Briggs 1962).

The shallow waters of Great South Bay and Long Island's other barrier island lagoons do not readily lend themselves to the trawl methods used to conduct fishery independent surveys in Long Island Sound, Peconic Estuary, and Atlantic Ocean. Similarly, fishery dependent reporting does not currently have the statistical precision needed to distinguish the origin of commercial or recreational harvest amounts down to geographic areas the size of Great South Bay.

Official population assessments for these species are conducted on a coast-wide basis by the National Marine Fisheries Service and the Atlantic States Marine Fisheries Commission and annual commercial and recreational harvest estimates can be broken down by state. In addition to the National Marine Fisheries Service northeast and mid-Atlantic trawl surveys, coast-wide population estimates often incorporate smaller different geographically specific population surveys. Although the individual abundance indices generated from specific geography's often show similar long-term species specific abundance trends in the same stock area, this is not always the case. Sometimes surveys within a stock's range will show divergent trends. Abundance of these species in Great South Bay during any given year is a result of a combination of factors including the overall size and age structure of the population, regional oceanographic and climatologic conditions, and conditions specific to Great South Bay. Population assessments and fishery management programs for these four species are regularly updated and available at online sources such as ASMFC.org. A summary of these species specific assessments in this document would become dated in less than a year, thus interested readers are advised to reference the most updated assessments. In general, as of the drafting of this report, bluefish, summer flounder, and striped bass have all undergone stock rebuilding in response to changes in coast-wide harvest management and all three are at or near their species specific target population biomass. Weakfish, however, is considered depleted to about 3% of its unfished biomass. In addition, it is believed that unknown factors are contributing to elevated natural mortality rates of weakfish, further hindering a recovery of this population.

In some cases, even in the absence of unified coast-wide action, state-specific, or even estuary specific actions may be appropriate and in the best interest of the natural resources and the people of New York State. There are valid reasons to consider estuary specific harvest management regulations such as the existing seasonal ban on gill netting weakfish in Great South Bay during the weakfish spawning season. These types of placed based decisions are appropriate for providing place based protections for spawning aggregations and essential habitats and are also useful for addressing place based social and economic concerns and/or localized human use conflicts. However, plans for which the goals are to influence the population-wide abundance of migratory species represented in this surrogate are most appropriately developed and implemented at the geographic scale of the population's range. The multi-species nature of this particular surrogate, combined with the coastal migratory nature of these species and the existence of current interstate fisheries management agreements limits the utility of providing Great South Bay specific harvest management recommendations for this surrogate in this report.

The four species in this surrogate interact with each other and there is some uncertainty if population biomass targets of all these predatory species can be achieved and sustained simultaneously.

In general, maintenance of several predator species at target abundance levels will require maintenance of a robust base of forage species. As an essential link between primary productivity and production of economically valued fishes, proper management of forage species is a critical element in ecosystem-based fishery management. Where they exist, traditional single species sustainability targets for forage species should be updated to account for the ecological role that forage species serve by being in high abundance (Smith *et al.* 2011). This is currently in the process of happening for Atlantic Menhaden for which a coast-wide fishery based population rebuilding effort is expected to be underway by 2013.

Priority Threats

Fishing related mortality
Altered predator regime
Food supply
Reduction of habitat
Climate change

Objective and Recommended Actions

Objective 5: By 2020, more closely integrate and align fishery management plans and actions with marine, estuarine, coastal, and riverine habitat management to better account for and meet the ecological needs of managed fish species throughout their life cycles; Coordinate the development and implementation of multiple single species fishery plans with a more cohesive fishery management program that strives to: balance simultaneous goals for multiple species, places, and human uses, maintain and if possible expand fishing opportunities, and reduce by-catch, discard mortality, and other waste

Strategic Action 5.1: Improve knowledge to more confidently assess and manage the range of harvested fishery resources in New York State, including Great South Bay

Action Step 5.1.1: Develop, implement, and support with adequate staffing a comprehensive fishery independent monitoring program for under-represented areas in New York State waters, including Great South Bay.

Responsible Entity: DEC
Potential Partner: ASMFC

Action Step 5.1.2: Modernize fishery catch and harvest reporting options to include electronic reporting. Improve and enforce reporting requirements for under-reported commercial fisheries such as those that occur for forage species harvested for the bait trade. Utilize new marine sport fish registry database to improve recreational catch and harvest statistics and to seek stakeholder input on regulatory proposal options. Improve spatial precision in all catch and harvest reporting down to the estuary specific geographic scale. At a minimum all reporting should be at Atlantic Coastal Cooperative Statistics Program (ACCSP) precision and accuracy standards.

Responsible Entities: DEC, ASMFC, ACCSP, NMFS

Action Step 5.1.3: Develop and institute a comprehensive fishery observer program focused on the gear types and areas where the greatest by-catch, discard mortality, and habitat disturbances are believed to occur. Update fishery plans with new information with the goal of minimizing by-catch, discard mortality, and habitat degradation.

Potential Partners: ASMFC, NMFS, DEC

Action Step 5.1.4: Improve and update the understanding and documentation of the social and economic importance of recreational, commercial, and for hire fisheries for different regions of New York State's marine district, including GSB, to provide more clarity concerning the potential benefits and impacts of future regulatory decisions concerning fisheries, habitat, and water quality.

Strategic Action 5.2: More thoroughly account for inter-species interactions, habitat and by-catch impacts, and species ecosystem services into the fishery assessment and management programs

Action Step 5.2.1: Until more holistic ecosystem-based fishery assessments and management plans become fully adopted by ASMFC and MAFMC, adopt more precautionary approaches and set biological management targets that strive to keep forage species at high abundance.

Responsible Entities: DEC, NY voting representatives on ASMFC and MAFMC

Action Step 5.2.2: Through the ASMFC Habitat Committee and the Atlantic Coast Fish Habitat Partnership, document state-wide trends in the quantity and quality of essential fish habitat for incorporation into fishery assessments and develop incentives to protect and restore these habitats for the benefit of fish and fisheries.

Responsible Entities: DEC, NY voting representatives on ASMFC and MAFMC, NMFS

Strategic Action 5.3: Assure that overfishing is not occurring for any species in NYS (and GSB) where significant recreational and/or commercial fishing occurs

Action Step 5.3.1: Consider new Fishery Management Plans for harvested yet unregulated species such as northern puffer.

Responsible Entities: DEC, ASMFC

Action Step 5.3.2: Expand the amount of staff and resources available for Marine Conservation Law Enforcement and explore new ways to maximize their coverage, expand participation from local (County and town) law enforcement, and expand fair prosecution of offenses.

Responsible Entities: DEC, District attorneys and judges
Potential Partners: County Marine Police, Town harbor masters and bay constables, FINS Park Rangers, USCG, OPRHP

Action Step 5.3.3: Expand the use of electronic media and electronic mailing lists generated through DEC commercial, and for hire permits, and the recreational sportfishing registry to solicit input from and disseminate information to fishermen to improve compliance with fishing regulations.

Responsible Entity: DEC

Surrogate: Winter Flounder

Introduction

Winter flounder, *Pseudopleuronectes americanus*, is an economically important fish distributed from Labrador to Georgia. It is a dominant member of the demersal fish community from the Gulf of Maine to the Chesapeake Bay, and is nearly ubiquitous from Massachusetts to New Jersey (Bigelow and Schroeder 1953). Winter flounder is managed as three distinct stocks in the United States: Gulf of Maine, Georges Bank, and the Southern New England/Mid Atlantic stock (SNE/MA). Except for the Georges Bank stock, adult winter flounder typically migrate from areas offshore to inshore estuaries in the late fall and early winter to spawn (ASMFC 2005). Adults spawn from winter to spring, depositing adhesive egg masses on the bottom (Bigelow and Schroeder 1953). Development occurs over a period of two to three months. Temperature is believed to be an important factor in the timing of reproduction and in the survival of eggs (Williams 1975). Following hatching, juveniles remain on the bottom for five to six weeks during metamorphosis. Young-of-the-year reside in natal estuaries for their first year (and sometimes beyond) (Topp 1967). As temperatures rise in spring and summer, most adults move back offshore to deeper waters (ASMFC 2005).

Winter flounder had historically been one of the most abundant of the marine fish that utilize Great South Bay as a spawning ground and nursery (Schreiber 1973; Monteleone 1992). Consequently, it has contributed significantly to the secondary productivity of the estuary and played a central role in the estuarine food web. In the early life history stages, winter flounder serves as prey to piscivores and as predator to small invertebrates; as adults they prey on larger invertebrates.

Historic Distribution and Current Status

No historic or current abundance estimates exist for winter flounder in Great South Bay. Existing data show that winter flounder was once very abundant in the Bay, both with respect to other fish and in absolute numbers. For example, Briggs (1962) estimated that from 1956 to 1960 nearly 1.5 million winter flounder were taken from Great South Bay annually in the recreational fishery; these numbers increased to an average of 2.6 million fish from 1961 to 1963 (Briggs 1965). More recently, Monteleone (1992) found winter flounder larvae to be the most abundant larval fish in the Bay with estimated peak densities of 34 fish per cubic meters of water - two times higher than the next most abundant fish (bay anchovy). Furthermore, Monteleone (1992) regarded these values to be underestimates.

Regional abundance indices of winter flounder come from DEC trawl (Peconic Bay) and beach seine (western bays) surveys and the Connecticut Department of Environmental Protection (CT DEP) Long Island Sound trawl survey. In Peconic Bay, abundance indices of all age classes (adults, age 0 and 1) show increasing trends from an average of 6.1 fish per tow in 1985 to 31.4 fish per tow in 1993 (DEC unpublished data). Since 1993, however, this index of abundance has declined to levels below or comparable to the mid-1980s (it is important to note that these trawl survey data are dominated by young of the year and one year old fish) (DEC unpublished data; NEFSC 2003). Similarly, the winter flounder abundance index from the CT DEP Long Island Sound trawl survey (1984 to present) increases in the late 1980s and early 1990s, then declines (with the exception of good year classes from 1996 to 1998) (CT DEP 2005). The Long Island Sound spring survey index in 2004 was the lowest on record and is currently only 23% of the long-term mean (CT DEP 2005). The catch per unit effort (CPUE) from the beach seine survey in western Long Island bays shows a slightly different trend. While these bays also exhibited an increase in winter flounder densities from the mid-1980s to early 1990s, since then CPUE seems to vary without clear trend (DEC 2005). Beach seine catches are largely comprised of young-of-the-year and one year old fish (DEC data) while trawl surveys (such as CT DEP) are dominated by fish above 3.94 inches (10 cm) total length.

New York and Connecticut trends are somewhat different from the pattern seen in the entire SNE/MA stock which exhibits a decline from the mid-1980s to a record low in the mid-1990s and a subsequent increase (NEFSC 2003). Local variations in population trends are not surprising since the SNE/MA stock of winter flounder is really a complex of populations experiencing different suites of stressors and environmental conditions. In addition, these increases in the larger stock are now being called into question as fisheries scientists recognize that fishing mortality was underestimated in that analysis (NEFSC 2005).

During the mid-1980s and early 1990s, winter flounder stocks in the Western Atlantic underwent steep declines. By 1994, the SNE/MA stock declined to 8.9% of the target biomass or 4.5% of its “unfished” state (NEFSC 2003). While this stock has increased from these low levels, it remains “overfished,” and “overfishing” continues to occur (NEFSC 2003; NOAA 2006). The recent downward trend in recruitment has raised additional concerns.

Although there are no population assessments of winter flounder for New York State or Great South Bay, declines in New York indices are evident and reflect basic trends in the larger stock. Most striking are trends in total commercial and recreational landings in New York State, which have declined since the mid-1980s by approximately 50% and 90%, respectively (NMFS catch database). While these statistics are not scaled by measures of effort, the sharpest declines occurred in the 1980s prior to more stringent regulations, indicating that this reduced catch does reflect dramatic declines in population size. The latest assessment, conducted by the Northeast Fisheries Science Center’s Groundfish Assessment Review Meeting (GARM III) in 2008 estimated SNE/MA biomass to be 9% of its target. Management efforts are now focused on regulations that will achieve the lowest possible fishing mortality rate while minimizing economic and social impacts as well as dead discards. Although a large percentage of winter flounder landings are presently taken from federal waters, consideration of additional state specific harvest restrictions should be made upon evaluation of whether the recently implemented federal and interstate regulations are resulting in the desired effects. The overall winter flounder stock is composed of smaller, localized spawning populations that return to inshore waters each year. Increased fishing mortality on localized spawning populations in state waters will have a direct effect on the status of these local populations and on the entire SNE/MA stock (ASMFC 2005).

Priority Threats

Harvest
Sedimentation on eggs
Predation
Reduction of habitat
Global climate change

Objective and Recommended Actions

Objective 6: Rebuild the Mid-Atlantic Southern New England winter flounder stock as specified in Amendment 1 to the Atlantic States Marine Fisheries Commission Winter Flounder Fishery Management Plan, while expanding knowledge of the species and local populations, and reducing human use impacts on flounder reproduction in GSB

Strategic Action 6.1: **Reduce fishing mortality rates regionally, state-wide, and in Great South Bay**

Action Step 6.1.1: Institute a moratorium on the winter flounder harvest until population size returns to allow sustainable harvest.

Responsible Entity: DEC

Strategic Action 6.2: Improve fishery data on winter flounder, statewide and in GSB

Action Step 6.2.1: Follow Action Steps outlined in Predatory Fish- Strategic Action 5.1 page 22, targeting winter flounder.

Responsible Entities: DEC, NMFS

Action Step 6.2.2: Fund and conduct a study to identify nesting and juvenile habitat of winter flounder in Great South Bay.

Responsible Entity: DEC

Action Step 6.2.3: Fund and conduct an evaluation of stage-specific mortality rates of winter flounder in Great South Bay. Correlate with work on key variables including temperature, precipitation, and predator density.

Responsible Entity: DEC

Action Step 6.2.4: Fund and conduct research to identify predators of winter flounder in Great South Bay (i.e., by studying gut contents).

Responsible Entity: DEC

Action Step 6.2.5: Fund and conduct research to identify primary diet of winter flounder in Great South Bay.

Responsible Entity: DEC

Action Step 6.2.6: Develop and implement a comprehensive fishery-independent monitoring plan for GSB, which incorporates multiple gear types and multiple trophic levels. A trawl survey should be conducted on a quarterly basis (at minimum), accompanied by a seasonal beach seine survey to provide young of year, recruitment, and population indices.

Responsible Entities: DEC, Stony Brook University

Strategic Action 6.3: Reduce potentially detrimental human-induced disturbance to key winter flounder spawning habitat in GSB

Action Step 6.3.1: Identify key winter flounder spawning habitat areas and to the extent possible avoid dredging (navigation, crab and scallop dredging) in known spawning habitat during the time that flounder are spawning and eggs are on the bottom.

Responsible Entities: DEC, Suffolk County, USACE

Surrogate: Alewives

Introduction

Two species are commonly referred to collectively as “river herring”: alewives (*Alosa pseudoharengus*) and blueback herring (*A. aestivalis*). Although there are anecdotal reports of blueback herring in Great South Bay, most river herring in the system are alewives. Anadromous (living in salt water and spawning in fresh water) members of the herring family (*Clupeidae*), they range from the Carolinas to the Canadian maritime provinces. Alewives spend most of their lives in marine and estuarine ecosystems, making annual spawning runs up coastal rivers and streams typically between the ages of three and five years. At southern latitudes, many alewives display a semelparous life history, meaning they spawn once and then die, like the Pacific salmonids. Moving north through the species’ range, fish display greater iteroparity, meaning they make repeat spawning runs over the course of their lives. On Long Island, spawning runs typically begin between mid-March and early April. Juveniles remain in freshwater systems for several months after hatching, and then migrate in late summer or early fall to nearby coastal waters where they will spend the remainder of their first year.

While until recently a small-scale recreational fishing for alewives as bait occurs in Great South Bay, they are most important as prey fish. They support populations of harbor seals, ospreys, bluefish, striped bass, and other predators, all of which provide opportunities for passive recreation and fishing. On eastern Long Island, the reproductive rate of ospreys in the late 1990s and early 2000s was much lower than in nearby southern New England (approximately 0.8 young fledged per nest; NYS DEC unpublished data). Although there are no good data on dietary differences, New England birds may fare better due to stronger herring runs. Similarly, in St. John Harbor, New Brunswick the density of harbor seals during the alewife run is five times the yearly average (Brown and Terhune 2003), suggesting that alewives are important prey for harbor seals there. In the absence of abundant alewives, harbor seals may exert greater predation pressure on other species, causing those species excess ecological stress.

Sport fish especially rely on river herring as a seasonally important prey item during the time of their spawning runs. River herring can make up as much as 20% of the diet of juvenile bluefish (Juanes *et al*. 1994) and 40% of the diet of larger bluefish (Buckel *et al*. 1999) in the Hudson River estuary. All along the Atlantic coast, river herring are also important for striped bass, comprising up to 33% of the diet in the northeast, 50% of the diet off North Carolina, and nearly 80% of the diet in the Chesapeake Bay (Walter and Austin 2003; Walter *et al*. 2003). River herring are also important prey for sport fish in freshwater systems. For example, the diet of white perch in two coastal lakes in Maine was 15% river herring at the start of the spawning run in the spring, and climbed to 100% by the time juveniles were migrating downriver in the fall (Moring and Mink 2002).

Because they move among different ecosystems, alewives are also important as transporters of energy and carbon. Although there are no data on inputs of carbon from the ocean into the estuary, there are estimates of the contribution of marine carbon in freshwater ecosystems. These studies show that 36 - 42% of the carbon in the tissues of freshwater predators is of marine origin, and therefore presumably derived from anadromous herring (Garman and Macko 1998; MacAvoy *et al*. 2000).

Historic Distribution and Current Status

Within the Great South Bay project area, alewife runs were reported in 10 different tributaries during the State’s 1938 survey of biological resources on Long Island (Table 1; DOS 1999). This is likely an underestimate of the number of tributaries that have ever supported runs. For example, although a spawning run was not reported in Mud Creek in the 1938 survey, its similarity to neighboring creeks suggests that Mud Creek likely supported alewives prior to habitat degradation and poor water quality induced by a duck farm built near its headwaters in the 1920s.

Table 1: Focal tributaries within the Great South Bay project area

Name	Total length (miles)	Inaccessible length (miles)	Percent inaccessible	Alewife run present in 1938 survey [a]	Trout run present in 1938 survey [a]
Carmans River	14.0	9.7	69%	Y	Y
Connetquot River	8.7	5.4	62%	Y	Y
Carlls River	6.1	5.0	82%	Y	Y
Sampawams Creek	5.2	1.8	35%	Y	
Patchogue River	4.9	3.4	69%		Y
Browns Creek	4.8	2.8	58%	Y	
Swan River	3.9	2.4	62%	Y	Y
Champlin Creek	3.8	2.8	74%		Y
Orowoc Creek	3.1	2.4	77%		Y
Mud Creek	3.1	1.9	65%		Y
Tuthills Creek	3.0	1.8	60%		
Penataquit Creek	2.8	0	0%		
Willets Creek	2.6	2.1	81%		
Beaverdam Creek	2.5	0	0%	Y	Y
West Brookb	1.5	1.2	80%		
Little Neck Run[c]	1.4	0	0%	Y	Y
Yaphank Creek[c]	1.3	0	0%	Y	Y
Rattlesnake Brook[b]	1.3	0	0%	Y	Y

Summary statistics:

Total length of focal tributaries: *74 miles*
Total inaccessible length: *44 miles*
Percent of total accessible: *59%*
Total accessible length: *30 miles*
Percent of total accessible: *41%*

Notes:
a Refers to the 1938 State biological survey of freshwater resources on Long Island, summarized and mapped in New York State Department of State (DOS) 1999.
b Tributary of Connetquot River.
c Tributary of Carmans River.

Inadequate monitoring makes it difficult to determine the current state of alewife runs on Long Island. A volunteer-based visual survey has been conducted each spring since 2006 (EDF and SSER 2007; Kritzer *et al.* 2007; Hughes and O'Reilly 2008; Kelder 2009; Kelder 2010). The survey has confirmed the presence of a persistent population in the Carmans River each year. Since the installation of a fish ladder at the Hards Lake dam before the spawning run in 2008, the survey has documented fish spawning in both tidal and freshwater reaches of the river. Smaller numbers of fish were confirmed in the nearby Howells Creek in 2006 and 2007, in the Swan River in 2006, 2007, and 2009, and in the Connetquot River in 2009. Whether these apparent spawning runs in Howells Creek, Swan River, and Connetquot River are simply missed by the survey in some years, or whether they only appear in substantial numbers intermittently cannot be discerned. However, these confirmed sightings suggest that alewives are still returning to other South Shore tributaries, and that additional strong runs could be established by aggressive restoration. It should be noted that monitoring effort in all years of the survey is not optimally distributed either in space or time, and the results are therefore likely to be an underestimate of the current situation. But it is clear that substantial increases in alewife populations are both needed and possible.

Priority Threats

Dams
Insufficient culverts
By-catch
Altered phytoplankton including harmful algal blooms
Riparian de-vegetation
Road runoff
Invasive aquatic plants

Objective and Recommended Actions

Objective 7: Increase the size of the Great South Bay alewife population from less than 10,000 individuals to greater than 100,000, distributed over at least four tributaries, by 2022

Strategic Action 7.1: Appropriately manage harvest of alewives in Great South Bay and its tributaries and nearby waters

Action Step 7.1.1: Based on emerging science and the most recent ASMFC river herring plan, prohibit harvest of alewives in Long Island waters, including GSB and its tributaries to facilitate alewife restoration until a fishery management plan (FMP) has been developed and rebuilding targets are met.

Responsible Entities: DEC, NY State Legislature

Action Step 7.1.2: Reduce unintentional by-catch of river herring in recreational and commercial Atlantic Herring fisheries by providing access to a simple waterproof herring identification tool that includes locally common similar species such as Atlantic Herring, Alewife, Blueback Herring, and Hickory Shad.

Responsible Entity: DEC
Potential Partners: ASMFC LI Diadromous fish workgroup, Estuary Programs

Action Step 7.1.3: Set minimum coast-wide river herring management measures, recognizing that local populations interact with other areas through straying within the larger coastal metapopulation.

Responsible Entities: DEC, NY voting representatives on ASMFC, ASMFC

Strategic Action 7.2: Allow access to 30 new miles (48 km) of suitable freshwater alewife habitat by 2017

Action Step 7.2.1: Identify the dams that cause the most severe problems in terms of fish passage, thermal pollution, and promoting invasive aquatic plant populations, and work with dam owners and appropriate municipalities and stakeholders to modify or remove those dams.

Responsible Entity: DEC
Potential Partners: GSB Townships, dam owners, OPRHP, Diadromous fish working group, SSER

Action Step 7.2.2: Create or charge an existing staff position within DEC with the purpose of achieving an effective and efficient process for modifying or removing barriers to fish passage in New York State. Through coordination among DEC's Freshwater Fisheries Unit, Anadromous Fisheries Unit, and Dam Safety Unit, and Division of Water, develop and adopt policies and or regulations to facilitate dam modification or removal. Establish a financial assistance scheme to support dam modification or removal projects.

Responsible Entity: NY State Legislature

Action Step 7.2.3: Mitigate barriers (culverts and dams) to fish passage by implementing recommendations of the recent inventory and assessment of barriers six tributaries of the SSER. Work with dam owners to install fish passage structures at priority dams where removal is not feasible.

Responsible Entities: DOS, DEC
Potential Partners: Suffolk County, GSB Townships, LI Diadromous Fish Working Group

Action Step 7.2.4: Action steps under the Water Quality objective should be implemented by relevant entities to maintain necessary temperature and dissolved oxygen conditions.

Action Step 7.2.5: Document existing occurrences of aquatic invasive plants, and work with local municipalities to prevent further spread where possible.

Responsible Entity: DEC
Potential Partners: LIISMA

Action Step 7.2.6: Prioritize parcels for land acquisition, easements, and vegetated buffers along the shores of tributaries where significant acres of undeveloped waterfront land remain, e.g., Swan River, Mud Creek and Carmans River.

Responsible Entity: DEC, Town of Brookhaven, Suffolk CountyPotential Partners: Land Trusts

Strategic Action 7.3: Establish recurrent spawning runs in four or more GSB tributaries

Action Step 7.3.1: Once the Carmans River population has reached 10,000 fish, transplant spawners from the Carmans to the Connetquot River and Carlls River to establish eastern, western and central stronghold populations in the three longest rivers in the watershed.

Responsible Entities: DEC, Suffolk County DPW, SCPD, Brookhaven Department of Environmental Protection
Potential Partners: GSB Townships, Babylon Village, NY State Parks

Action Step 7.3.2: Monitor other tributaries for natural straying and re-establishment of spawning runs from the stronghold populations.

Responsible Entities: DEC, members of the Diadromous Fish Workgroup

Action Step 7.3.3: Transplant spawners to additional tributaries where natural straying does not occur.

Responsible Entities: DEC, members of the Diadromous Fish Workgroup

Strategic Action 7.4: Investigate and mitigate oceanic by-catch of alewives

Action Step 7.4.1: Support, expand and refine river herring by-catch efforts soon to be initiated by NEFMC through Amendment 5 to its Atlantic Herring FMP, and by MAFMC through Amendment 14 to its Squid, Mackerel and Butterfish FMP. Advance refinements in management of sea herring or other fisheries where as new understanding of oceanic bycatch emerges.

Responsible Entities: NY voting representatives on ASMFC and MAFMC, ASMFC, MAFMC, NEFMC

Action Step 7.4.2: Support and participate in the large-scale, multi-state, multidisciplinary research effort underway to understand oceanic migrations of individual river runs and to match fish caught as by-catch with their natal streams.

Responsible Entities: DEC, Research institutions

Strategic Action 7.5: Monitor and fill gaps in information by conducting appropriate research and monitoring

Action Step 7.5.1: Continue and expand the visual survey of Great South Bay tributaries to document the presence, timing, and number of tributaries used as spawning runs.

Responsible Entities: SSERC, Members of the Diadromous Fish Workgroup

Action Step 7.5.2: **Supplement the visual survey with more quantitative methods such as fish counters and trap or weir program to provide indices of population size and growth, and amount of tributaries used.**

Responsible Entities: SSERC, Members of the Diadromous Fish Workgroup, DEC

Action Step 7.5.3: **Continuously measure water temperature and dissolved oxygen in the Carlls, Connetquot, and Carmans Rivers as part of a general water quality monitoring program in order to aid in understanding the ability of these rivers to support aquatic life.**

Responsible Entities: Suffolk County, DEC, OPRHP

Surrogate: Piping Plovers

Introduction

A suite of species depends on the dynamic nature of the barrier island beach, including beach-nesting species such as the piping plover. The piping plover, *Charadrius melodus*, is a small Nearctic (i.e. North American) shorebird approximately 7 inches (17 cm) long with a wingspan of about 15 inches (38 cm) (Palmer 1967). The Atlantic coast population breeds on coastal beaches from Newfoundland to North Carolina, wintering along the Atlantic coast from North Carolina south, along the Gulf coast, and in the Caribbean. Piping plovers arrive on Long Island as early as March 11th (Goldin 1990), and feed on a variety of invertebrates, including marine worms, fly larvae, beetles, crustaceans and mollusks (Forbush 1925; Bent 1929; Cairns 1977; Nicholls 1989; Gibbs 1986; Shaffer and Laporte 1994).

Piping plovers utilize early successional habitat for nesting, defined as sparsely vegetated, wide sandy beach. Natural processes, including beach overwash, barrier island breaching, and storm events resulting in dune blowouts or vegetation clearing, are essential for the creation and maintenance of this habitat type. The term overwash is used to describe events, typically associated with storm tides, during which waves wash over the barrier island, carrying sand to the back side of the island where it creates an "overwash fan." Storm tides often clear a vegetation-free path from ocean-side to bay side. This is a natural process, necessary for the health of the barrier island, and is often referred to as barrier island "rollover," or migration. As the ocean side of the island erodes, the bay side grows, maintaining the overall shape of the island as it migrates towards the mainland. In extreme storm events, or if the barrier island is narrow, the island may be breached by storm tides, allowing subsequent high tides to carry even more sand to the bay side, resulting in flood tide deltas. Breaches may naturally close, or may result in the formation of new inlets. Lesser storm events may result in dune blowouts or a clearing of dense vegetation, thereby creating optimal piping plover nesting habitat. Overwash also creates and maintains points of access to preferred foraging habitats, such as bay side flats (Elias-Gerken 1994; Elias *et al.* 2000; Loegering and Fraser 1995). Often such access is restricted by development landward of the oceanfront. Development behind the high-energy ocean beach also increases the likelihood of other human impacts, including beach nourishment and dune building, activities undertaken to protect human-made structures. Beach stabilization projects increase vegetation encroachment, which often creates a barrier to chick bayside access (Loegering and Fraser 1995).

The importance of allowing natural processes to occur is most evident in the work of Wilcox (1959), who was able to study the reaction of piping plovers on Long Island to the natural formation of Moriches and Shinnecock Inlets, in 1931 and 1938, respectively. In 1929, only three to four pairs of piping plovers nested on 17 miles (27.4 km) of barrier beach along Moriches and Shinnecock Bays. Following the opening of Moriches Inlet in 1931, plover numbers jumped to 20 pairs along a 2 mile (3.2 km) stretch by 1938. The 1938 hurricane opened Shinnecock Inlet, and flattened dunes. This same 17 mile (27.4 km) stretch of beach had 64 pairs of nesting piping plovers. Wilcox attributed the subsequent decline in plover numbers to dredged material deposition, reconstruction of dunes, and coastal development of roads and houses. The Barrier Island Complex section of this report, starting on page 18, addresses the importance of these processes and outlines strategic actions for their protection.

Historic Distribution and Current Status

The Atlantic coast piping plover population is designated as threatened under the federal Endangered Species Act, and is considered endangered under New York State Environmental Conservation Law. Piping plovers also receive protected status under the Migratory Bird Treaty Act, as well as several local ordinances.

Although historic numbers of piping plovers on Fire Island are difficult to determine from existing literature, there are numerous sources that estimate the species' population on Long Island as a whole. Giraud (1844) considered the species common on Long Island before the 1840s. In subsequent years, heavy hunting pressure greatly reduced its numbers, and by 1910, piping plover breeding activity was limited to Gardiner's Island and the eastern end of Long Island (Eaton 1910). The species began recovering following protection granted in 1913, and Nichols (1921) estimated 300 piping plover individuals existed on Long Island by 1920. The species reached a population peak during the 1930s, when approximately 500 pairs were nesting on Long Island again (Wilcox 1939). Another rapid population decline occurred post-World War II due to increased development along the coast and greatly increased recreational and vehicular traffic on the species' nesting beaches. Wilcox (1959) also attributes these losses to the proliferation in beach nourishment projects that prevented habitat revitalization.

During the 1970s there were only an estimated 80 to 100 pairs on Long Island (Cairns and McLaren 1980). Prompted by DEC's listing of the piping plover as endangered, official population counts began in 1983 through the efforts of the Seatuck Research Program and DEC. Eighty-eight adults were counted during this initial survey. In 1986, management and monitoring intensified with the listing of the species under the federal Endangered Species Act as a threatened species. This listing was the catalyst for the establishment of The Nature Conservancy's piping plover protection program. At the time of federal listing, 106 pairs were known to exist on Long Island, of which 8 adults were recorded on Fire Island (4 each at Democrat Point and Smith Point County Park).

In the early 1990s, the DEC became the lead agency for piping plover protection in the state, coordinating monitoring efforts through its Long Island Colonial Waterbird and Piping Plover Survey (LICWS). At this time, The Nature Conservancy began transferring management responsibility of many sites to other agencies and organizations, resulting in increased island-wide effort. In 1994, breeding pairs became the official survey metric for piping plovers, replacing adult counts. This same year, eight piping plover pairs nested on Fire Island; two pairs at Democrat Point, three pairs at Fire Island East (Smith Point County Park), two pairs at Sunken Forest, and one pair in the Wilderness Area. In 2004, 54 pairs nested on Fire Island. This dramatic increase in nesting activity occurred primarily at three sites on Fire Island: Democrat Point, Fire Island East (Smith Point County Park), and the Wilderness area, which supported 17 pairs, 17 pairs, and 13 pairs, respectively. This increase in nesting activity may have resulted from the fact that as the Atlantic coast and Long Island populations increased, birds began to utilize available habitat on Fire Island. In addition, recent years have seen an increase in management effort of suitable nesting habitat on Fire Island. This increasing trend continued on Fire Island and across Long Island. During the four-year period 2006-2009, the Long Island population averaged 440 breeding pairs, with a peak of 457 pairs in 2007, as reported through the LICWS. During this same time period, Fire Island averaged 59 nesting pairs with a high count of 62 pairs in 2007. The 2010 season saw a decline across Long Island (390 breeding pairs) with Fire Island contributing significantly to this decline where only 37 nesting pairs were tracked for productivity. From the 2009 to 2010 nesting season, Democrat Point alone experienced a twelve pair drop, with the main causes attributed to high predation rates (fox) and habitat suitability/availability.

Priority Threats

Shoreline armoring
Predation
Off-road vehicles
Development
Sea level rise

Objective and Recommended Actions

Objective 8: By 2015, increase the number and productivity of piping plovers to 65 pairs and a five-year average of 2.0 chicks fledged per pair for the Fire Island reach of their New York range

Strategic Action 8.1: **Undertake a cooperative effort by the National Park Service, Suffolk County, New York State, appropriate towns, and private organizations to manage and monitor all plover sites by April 1st every year**

Action Step 8.1.1: Hire and train seasonal stewards to monitor and manage piping plover nesting areas, including installing plover fencing by the start of the nesting season.

Responsible Entities: OPRHP, FINS, SC Parks Department

Strategic Action 8.2: **Close nesting beaches to off-road vehicles (ORVs), at a minimum during periods when unfledged chicks are present**

Action Step 8.2.1: As per USFWS guidelines, enforce existing closure guidelines and off-road vehicle regulations.

Responsible Entities: FINS, OPRHP, SC Parks Department

Action Step 8.2.2: Increase penalties and fines for off-road vehicle use violations.

Responsible Entities: GSB Townships, Suffolk County, DEC, NYS Park Police, FINS

Action Step 8.2.3: Conduct annual training for enforcement officers to enable officers to identify endangered and threatened species on the beach and understand endangered species laws and their responsibilities under these laws.

Responsible Entities: USFWS, DEC, SC Parks Department, OPRHP, TNC

Strategic Action 8.3: **Selectively control documented predators at sites with high predation rates**

Action Step 8.3.1: Eliminate access to human food waste by using closed non-mesh trash containers and frequently removing trash and positioning trash receptacles away from nesting areas.

Responsible Entities: OPRHP, FINS, SC Parks Department, GSB Townships

Action Step 8.3.2: Erect predator exclosures in areas of high predator pressure where deemed appropriate.

Responsible Entities: FINS, OPRHP, SC Parks Department

Action Step 8.3.3: Establish and maintain predation monitoring protocols in order to determine sites with high predation rates.

Responsible Entities: USFWS, DEC

Surrogate: Horseshoe Crabs

Introduction

Horseshoe crabs, *Limulus polyphemus*, look like swimming fossils for good reason: they are an ancient life form that dates back some 500 million years. Actually more closely related to spiders than crabs, they spawn on beaches from the Yucatan Peninsula to Maine, but are most abundant between Virginia and New Jersey (Shuster 1982). Just north of the center of their range, horseshoe crabs are common throughout New York's estuaries, including Great South Bay. While they have adapted to and survived several large scale changes in climate and sea level, the loss of nesting beaches due to shoreline armoring, coastal development and human harvest have the potential to take an irreversible toll on this species.

Horseshoe crabs are an important component of Long Island's south shore estuarine ecosystem. The crabs spawn on estuarine beaches in the high intertidal zone, where their eggs are consumed by several marine species that are of commercial, recreational, or ecological importance such as juvenile striped bass, American eels, killifish, weakfish, northern kingfish, Atlantic silversides, summer flounder and winter flounder (Botton *et al.* 2003). It is likely that larval stages of the horseshoe crab are foraged on by several species of fish and crustaceans (Botton *et al.* 2003). Recently the ecological importance of horseshoe crab eggs for migratory shorebirds has received much attention and has led to concern about over-harvest (ASFMC 1998) and the closure of large areas to harvest in Delaware Bay (ASMFC 2006). Large juvenile and adult horseshoe crabs are a preferred diet item of loggerhead sea turtles, a New York State and federally listed threatened species.

Historic Distribution and Current Status

There is little documentation of the historic abundance and distribution of horseshoe crabs in Great South Bay. In parts of their range, horseshoe crabs were historically harvested for fertilizer, eel bait, and occasionally as food for poultry and hogs. Today horseshoe crabs are harvested commercially and recreationally for use as bait in the eel and whelk fisheries. Harvest of horseshoe crabs for Limulus Amoebocyte Lysate (LAL), a human pathogen detector, is occurring in many parts of the species' range, but not currently in New York waters (K. McKown, DEC, personal communication). In 1998 the ASMFC approved its first horseshoe crab fishery management plan. The fishery is currently managed through state-by-state fishing quotas as outlined under Addendum VI which has been extended and enhanced through Addendum V and VI, the later approved in August of 2010. Some states, including New York, have adopted harvest quotas that are more restrictive than required by the ASMFC plan for fear that fishing efforts would be redirected from states restricting their harvest quotas. As neighboring states tightened restrictions on horseshoe crab harvest, the price of crabs in New York had escalated. In the fall of 2006, New York fishermen reported receiving close to $2.00 per crab. In 2005, New York had the second largest harvest level (number of crabs) of all states on the east coast with approximately 58% (97,600 crabs) coming from the south shore bays (DEC unpublished data). It is unclear how much of the south shore harvest typically came from Great South Bay although there are some popular harvesting locations along the bay side of Fire Island.

There is no information on horseshoe crab population trends in Great South Bay. However, elevated harvest rates, prior to the passage of the ASMFC Addendum I, have apparently led to localized population declines in Delaware Bay through the 1990s to the 2000s (ASMFC 2006). A trawl survey in Long Island's Peconic Bay indicates a similar decline through that same time period (DEC unpublished data). The ASMFC recognizes the New York population status as declining and suggests that the fishery may not be sustainable (ASMFC 2011). Conversely, preliminary analyses of beach seine survey data suggest that the nesting population in Jamaica Bay, Little Neck Bay, and Manhasset Bay have varied without trend since the late 1980s (DEC unpublished data).

Unlike most other fisheries, which focus on sustainability as the main management objective, an objective of the coast-wide management of horseshoe crabs is the production of excess eggs as a food source for migratory shore birds. Although horseshoe crab eggs are clearly utilized by migratory shorebirds in Great South Bay the interaction with the red knot is not as clearly defined as it is in Delaware Bay (M. Sclafani, CCE, personal communication). This potentially important connection to other wildlife combined with evidence of a declining local horseshoe crab population has led the NPS to take advantage of a recent court ruling and restrict harvest from the waters within their jurisdiction.

New York State has been working with CCE to develop a nesting beach monitoring program; currently, the program has one monitoring location near Captree State Park. Although New York State has a harvest reporting system to manage a recently adopted state-wide harvest quota, the current reporting system does not have sufficient precision to evaluate removal rates from particular beaches or estuaries along the south shore of Long Island (K. McKown, DEC, personal communication).

Priority Threats

Shoreline armoring
Harvest

Objective and Recommended Actions

Objective 9: Determine and maintain a nesting population of horseshoe crabs in Great South Bay at a level that is self-sustaining and provides adequate availability of eggs as forage for fish and shorebirds

Strategic Action 9.1: Protect and restore horseshoe crab nesting and staging habitat by eliminating the threat of new structural development on or adjacent to natural shorelines and areas immediately landward of the higher high water line within the estuary

Action Step 9.1.1: Where possible, remove shoreline armoring and other structures that restrict or will restrict access of horseshoe crabs to the high water mark along estuarine beaches.

Action Step 9.1.2: See natural shoreline protection strategies in barrier island complex surrogate starting on page 18.

Strategic Action 9.2: Initiate and advance research and monitoring needed to properly manage horseshoe crabs in Great South Bay

Action Step 9.2.1: Continue and expand the horseshoe crab spawning population survey currently being conducted by Cornell Cooperative Extension through the State Wildlife Grant Program, ensuring that methods are standardized with other studies along the coast.

Responsible Entities: DEC, CCE, Dowling College

Action Step 9.2.2: Establish and map horseshoe crab population baseline in GSB, identify key spawning areas, estimate emigration rates and site fidelity, determine target bay-wide spawning stock required to meet the appropriate management and restoration objectives.

Responsible Entity: DEC
Potential Partners: CCE, Dowling College, Research institutions

Action Step 9.2.3: Conduct appropriate research and monitoring to assess the current condition of benthic communities and put the current condition in a historic perspective. Use these data to assess whether the current condition of benthic communities is a limiting factor for benthic predators such as horseshoe crab and winter flounder.

Responsible Entity: Research institutions

Action Step 9.2.4: Assess future impacts of sea level rise on horseshoe crab nesting beaches and incorporate the results into future land use decisions concerning erosion and shoreline armoring.

Responsible Entities: Research institutions, DEC, DOS, OPRHP, Suffolk County, GSB Townships

Strategic Action 9.3: Ensure that the harvest management and enforcement efforts are consistent with long-term sustainability of a functioning horseshoe crab population

Action Step 9.3.1: Using economic incentives, develop and promote alternative bait for the eel and whelk fisheries with the ultimate goal of phasing out the use of horseshoe crabs for bait altogether. In the interim, the use of bait bags and bait recycling should be encouraged.

Responsible Entities: DEC, ASMFC
Potential Partners: National Sea Grant, CCE, baymen, economic development agencies, Research institutions

Action Step 9.3.2: Upon identifying important horseshoe crab spawning areas in GSB, work collaboratively to control harvest at these sites to locally sustainable levels.

Responsible Entities: DEC, FINS, USFWS, GSB Townships, SC Parks Department, National Audubon Society, baymen, law enforcement

Action Step 9.3.3: Where they already exist, clarify and enforce existing harvest restrictions on nesting horseshoe crabs (such as within FINS).

Responsible Entities: FINS, DEC

CROSS-CUTTING OBJECTIVES

In addition to the objectives, strategic actions, and action steps aimed at preserving and restoring specific surrogates, recommendations were developed for addressing cross-cutting problems that impact the ecosystem as a whole. These issues include water quality and global climate change as well as outreach and education.

Water Quality

Introduction

Like other estuaries along the eastern seaboard of the US, the Great South Bay watershed has been extensively developed during the past century. In a landmark paper published more than 50 years ago, Ryther (1954) documented water quality problems in South Shore bays, demonstrating linkages between land use (e.g., duck farms) and persistent phytoplankton blooms. Despite that duck farm waste discharge has decreased and the western portion of the watershed has been sewered with an ocean outfall, loadings of land-based sources of nutrients (e.g., nitrogen) have increased to Great South Bay from development. Sources of nitrogen loading have intensified as a result of increased residential development leading to the proliferation of septic systems and use of fertilizers, an increase in the percent of impervious surface, changes in atmospheric deposition, and loss of forested areas, salt marsh and vegetated buffers (Bowen and Valiela 2004; SCCWRMP 2010; Kinney and Valiela 2011). Kinney and Valiela (2011) found septic systems are the dominant (55%) source of nitrogen to Great South Bay with lesser amounts coming from atmospheric deposition (31%) and fertilizer use (15%).

Koppelman (1978) and more recently the Suffolk County Health Department (2010) demonstrated the significance of ground water transport of nitrogen and other chemicals into coastal waters of Long Island. According to the draft Suffolk County Comprehensive Water Resources Management Plan (2010), prior to extensive development, nitrate levels in the Upper Glacial aquifer were less than 1 mg per liter and in some areas less than 0.05 mg per liter, which is comparable to levels found in non-eutrophied estuaries. Suffolk County reports that from 1987 to 2005, nitrate concentrations in the Upper Glacier aquifer increased 40 percent from 3.12 mg per liter to 4.34 mg per liter. Levels in the Magothy aquifer rose 200 percent from 1.14 mg per liter to 3.43 mg per liter. Today, in the densely developed, unsewered areas, nitrate concentrations can exceed the 10 mg per liter Maximum Contaminant Level (MCL) drinking water standard, levels considered toxic to human health. The deepest aquifer (Lloyd) is also experiencing similar trends with nitrate tripling since 1987 to about 2.88 mg per liter. The nitrate concentrations in the ground water are dramatically high for bays and estuaries (C. Gobler, SoMAS, personal communication). For example, Suffolk County surface water monitoring indicates nitrate concentrations in the bay are typically 0.01 mg per liter, approximately 500 times lower than the average nitrate concentrations in the Upper Glacial aquifer (Gobler 2011a). Therefore, the levels of nitrogen found in ground water in Suffolk County can have a large, negative effect on Great South Bay.

There have been ecological changes to Great South Bay that are linked to changes in nutrient and other contaminant loading (Gobler 2011a). Of particular concern are changes in food web dynamics including recurring brown tide and other harmful algal blooms. The scientific synthesis of 20 years of brown tide research highlights that brown tide algae have a tactical advantage over other algae under high nitrogen concentrations when the amount of dissolved organic nitrogen (DON) is greater than the amount of dissolved inorganic nitrogen (DIN) (Gobler et al. 2005). This same synthesis concludes that reductions in nitrogen loading would facilitate reductions in DON, which could lessen the likelihood of brown tides and foster more efficient food webs (Gobler et al. 2005).

Also troubling, the fish-killing red tide harmful algal bloom consisting of *Cochlodinium polykrikoides*, was observed for the first time in Great South Bay during the Summer of 2011. Experimental investigations by Gobler *et al.* (2005, 2007, 2011b) link nitrogen loading with the occurrence of the red tide as well as other harmful algal blooms in harbors in Long Island Sound, Peconic Estuary, and Eastern Shinnecock Bay. The scientific consensus paper, "Eutrophication and Harmful Algae Blooms" concludes that "nutrient pollution promotes the development and persistence of many harmful algae blooms," and that management and reduction of nutrient inputs could lead to significant reduction in harmful algae blooms (Heisler *et at*. 2008). Nitrogen and other nutrients are produced, used, and regenerated within the bay through relatively complex cycles and feedback loops. This cycling impacts the seasonal availability and chemical composition of dissolved and particulate nutrients. However, management tools to mitigate the tendency for these blooms to occur are often limited to addressing proximate sources of nitrogen rather than altering biological nutrient cycles within the bay.

In their 2008 report, "Nitrogen Loading to Great South Bay: Land Use, Sources, and Transport from Land to Bay" Valiela and Kinney noted that "Great South Bay's nitrogen load falls in the middle-lower range of estuaries in the US, but it is likely making the bay more susceptible to algae blooms, contributing to the loss of ecologically important eelgrass, and impacting other plants and animals that are susceptible to eutrophication." As nitrogen loading continues to increase, it is likely that harmful algal blooms will expand, intensify and persist.

Increased nutrient loading has also been shown to negatively affect salt marsh by changing the allocation of biomass from belowground to aboveground (N. Maher, TNC, personal communication). This change in biomass is found to reduce salt marshes' ability to grow vertically in response to sea level rise (Turner 2009). Additionally, nutrient increases have also shown to reduce the soil strength in salt marsh peat, making marshes more vulnerable to erosion and slumping (Turner 2011).

In 2008, NYS DEC declared the entire South Shore Estuary, including Great South Bay, as an 'impaired waterbody' thereby adding it to the EPA 303(d) list, citing nitrogen loading and algal blooms as the cause of the impairment. In 2010, Dr. Valiela and Dr. Kinney led an effort to assess water quality improvement scenarios for Great South Bay provided by County, Town, and Village officials and community stakeholders to evaluate potential nitrogen removal effectiveness. Results of this work can be found in the Appendices (IV and V) of this document.

Estuarine water quality can also be degraded by persistent organic compounds such as pesticides and oil and gas, heavy metals and other contaminants from industrial waste, and drugs and other chemicals from personal use products leaching from septic systems and sewage effluent discharged to the bay. Atmospheric deposition of contaminants, sediment runoff and pathogens conveyed by storm water and from a lack of vegetative buffers, can also reduce water quality resulting in closed shellfish beds and bathing beaches.

Objective and Recommended Actions

Objective 10: Reduce pollution in GSB to ensure that water quality is sufficient to support the viability and sustainability of the habitats, species and human uses of GSB by 2020

Strategic Action 10.1: Improve management and coordination of water delivery, ground water quality and quantity, surface water quality and wastewater treatment

Action Step 10.1.1: Develop and adopt an updated ground water protection plan for Long Island that guides land use decisions for long-term protection of ground water.

Responsible Entity: NYS Legislature

Action Step 10.1.2: Establish a ground water quality standard for nitrogen that is protective of estuarine and aquatic ecological health.

Responsible Entity: NYS Legislature

Action Step10.1.3: Require Suffolk County Water Authority to create conservation pricing to generate funds for pollution reduction activities.

Responsible Entity: Suffolk County Water Authority

Action Step 10.1.4: Upgrade sewage treatment plants to the highest level of treatment available (e.g., tertiary) and expand areas served.

Responsible Entities: DEC, Suffolk County, GSB Townships

Action Step 10.1.5 Provide incentives to connect remaining (unconnected) residents living within the Southwest Sewer District to the sewage treatment plant.

Responsible Entity: Suffolk County Department of Public Works

Strategic Action 10.2: Reduce nitrogen loading to ground water from wastewater on-site discharge systems (e.g., septic, cesspools, package plants)

Action Step 10.2.1: Establish nitrogen limits on wastewater effluent of all on-site discharge systems.

Responsible Entities: DEC, Suffolk County

Action Step 10.2.2: Develop a new management and financing approach to provide financial incentives for phasing in advanced wastewater treatment systems to reduce nitrogen.

Responsible Entities: Suffolk County, DEC, GSB Townships

Strategic Action 10.3: Promote demonstrations of new nitrogen reduction technology and on-the-ground "clean up"

Action Step 10.3.1: Create opportunities for pilot projects that demonstrate new, innovative advanced on-site and clustered wastewater treatment systems that significantly reduce nitrogen beyond current available technology.

Responsible Entities: Suffolk County, DEC, GSB Townships

Strategic Action 10.4: Reduce nitrogen loading from atmospheric deposition

Action Step 10.4.1: Adopt critical loads as the approach to setting air pollution standards in NY. Establish a scientific advisory panel to help develop the critical loads and create a monitoring program that links ecological response to chemical responses and deposition levels.

Responsible Entity: DEC
Potential Partner: NYSERDA

Strategic Action 10.5: Reduce nitrogen loading from fertilizer

Action Step 10.5.1: Reduce fertilizer application by increasing education about impacts of over use and providing financial incentives to homeowners for not fertilizing property.

Responsible Entity: Suffolk County
Potential Partners: Research institutions, CCE

Strategic Action 10.6: Reduce pathogens to Great South Bay

Action Step 10.6.1: Provide homeowners and businesses incentives to reduce impermeable surfaces and increase vegetated buffers.

Responsible Entities: Suffolk County, DEC

Action Step 10.6.2: Update and utilize maps of storm water drainage to identify and implement high priority storm water mitigation projects.

Responsible Entities: GSB Townships, DEC, SSERC, Suffolk County

Strategic Action 10.7: Reduce pesticide/herbicide application throughout the watershed and minimize and remediate sources of other toxic contaminants in GSB watershed

Action Step 10.7.1: Provide incentives to landscape industry and homeowners to reduce chemical applications.

Responsible Entities: GSB Townships, Suffolk County, DEC

Strategic Action 10.8: **Protect remaining open space and under-developed land**

Action Step 10.8.1: Protect remaining undeveloped land in the Carman's River watershed by expanding the Pine Barren's Core area.

Responsible Entities: Brookhaven Township, NY State Legislature

Action Step 10.8.2: Use land protection tools including acquisition, easements, clearing restrictions, buffers, and set-backs, etc.

Responsible Entities: DEC, Suffolk County, GSB Townships

Strategic Action 10.9: **Investigate and mitigate suspected and known hot spots for ground water and surface water contamination**

Responsible Entities: DEC, SCDHS

Recent Actions

Since the original draft of this document was finalized many of the action steps originally outlined in the plan have been taken. These include:

- ✓ Identified major sources of nitrogen loading to Great South Bay
- ✓ Designation of vessel "no discharge zone" in Great South Bay
- ✓ Improved understanding of the linkage between degraded ground and surface water quality and habitat

Global Climate Change

Introduction

According to the International Panel on Climate Change (IPCC), global atmospheric concentrations of greenhouse gases – including carbon dioxide, methane, and nitrous oxide, among others – have increased markedly as a result of human activities over the past 200 years and now far exceed pre-industrial levels. These increases are contributing to warming of the Earth's climate. The IPCC reports that 11 of the 12 years between 1995 and 2006 rank among the 12 warmest years since 1850 (the first year that global temperatures were recorded) and are indicative of a strong upward warming trend over the last 50 years. Significantly, the IPCC reports that global ocean temperature rose by 0.10°C from the surface to 2,300 feet (700 m) depth from 1961–2003. Observations of sea-surface temperatures, based on a reconstruction of the long-term variability and change in global mean sea-surface temperature for the period 1880 to 2005, show that they have reached their highest levels during the past three decades over all latitudes. Warming has occurred through most of the 20th century and appears to be independent of measured inter-decadal and short-term variability.

As with terrestrial warming trends, warming of ocean temperatures will result in the shifting of species' ranges, trophic relationships, and other interspecies interactions, as well as changes in the timing of natural events such as spawning, germination, and even growth rates of certain organisms. Increased global atmospheric carbon dioxide's impact on the pH of oceanic waters is anticipated to negatively impact marine organisms with calcium carbonate shells (Royal Society 2005; Doney 2006; Kleypas *et al.* 2006). However recent analyses on the pH of highly productive estuaries suggest that high primary production in spring and summer can actually strip estuarine waters of CO_2 resulting in seasonal fluctuations in the pH of estuaries that approaches an order of magnitude more pH variability than has been estimated to have occurred in oceanic surface waters from 1750 – 1994 (IPCC 2007; Nixon 2011).

The most obvious impacts of climate change in Great South Bay are increased temperature and the squeezing of coastal habitats between sea level rise and coastal development. Conservative models are now projecting that sea level will rise in the Great South Bay area by more than 2 feet (0.61 meters) by the end of the century. Rising seas impact people as well as nature through increased flooding in coastal communities, submergence of below ground septic systems, loss of storm buffers in low-lying areas, and heightened storm surges. Currently the policies and procedures used to manage and permit projects in low lying and coastal areas are not required or equipped to incorporate the short-or long-term impacts of sea level rise into the decision making process. Climate change will have – and in many cases is already having – significant effects on the surrogates used in this plan. A few examples of climate change impacts include:

- Sea level rise has the potential to significantly reduce available nesting habitat for the piping plover and horseshoe crabs between the high tide line and the vegetated dune and result in higher than normal incidents of nests being submerged (Strange *et al*. 2008);
- Elevated water temperatures and altered seasonal temperature patterns may create a mismatch between the spawning cycle of winter flounder and the migratory patterns of their primary predators, potentially elevating already high predation rates on young-of-the-year fish; and
- As sea levels rise, salt marshes, beaches, and intertidal flats cannot migrate landward unless there is suitable buffer between the high water line and adjacent development (Strange *et al*. 2008).

In addition to some of the impacts on natural communities mentioned above, climate change is likely to affect economic and social goods and services supported by natural resources, including recreation, tourism, water supplies, fishing, and other resource uses. There are a number of recommendations from New York State and local Great South Bay initiatives that address and prepare for the potential impacts of climate change. Three efforts in particular are worth noting here:

The New York State Sea Level Rise Task Force

Called together by the New York State legislature in 2007, the Sea Level Rise Task Force was charged with preparing a report that addresses ways of protecting New York's remaining coastal ecosystems and natural habitats, and increasing coastal community resilience in the face of sea level rise, including recommendations for an action plan to protect coastal communities and natural resources from rising sea levels. The report, including analyses on the impacts of climate change and recommendations on how to address them, can be found at: http://www.dec.ny.gov/docs/administration_pdf/slrtffinalrep.pdf

The New York State Climate Action Council

Created by Executive Order 24, the New York State Climate Action Council was tasked with preparing a Climate Action Plan to help the state meet its goal of reducing emissions 80% below levels emitted in 1990 by the year 2050. The Council was responsible for considering all economic sectors of New York State to develop strategies to reduce emissions and adapt to the impacts of climate change. An interim report has been released and can be found at http://nyclimatechange.us/InterimReport.cfm.

The Nature Conservancy's Coastal Resilience Project

In an effort to provide communities with easy access to information for their planning, zoning, acquisition and permitting decisions, the Nature Conservancy developed an online mapping tool, the Future Scenarios Mapper, to visualize the potential impacts of sea level rise on human and natural communities, as well as a review of possible regulatory options available to municipalities to address these impacts. This may be a useful tool and resource base to assist local governments in identifying areas of potential impacts for more detailed investigation within the Great South Bay watershed. For more information, the tool can be accessed by visiting http://coastalresilience.org/geographies/new-york-and-connecticut.

The recommendations below focus solely on strategies to adapt to the eventual impacts of climate change. The challenges in addressing the globally increasing rate of emissions of carbon dioxide or equivalent greenhouse gasses are beyond the scope of these recommendations; however, reducing, and potentially reversing the rate of human induced global warming is essential for the long-term protection of both the human and natural communities in Great South Bay and its watershed.

Objective and Recommended Actions

Objective 11: By 2020, establish a well-coordinated, multi-layered protocol to protecting coastal habitat in the face of sea level rise

Strategic Action 11.1: **Implement the relevant recommendations of the Sea Level Rise Task Force and the New York State Climate Action Plan – Adapting to Climate Change chapter**

Action Step 11.1.1: Establish and adopt sea-level rise projections, task all state agencies to consider projections in planning, implementation, and permitting of coastal projects, and request that local governments also utilize these official projections when making land use decisions. In addition, establish and adopt statewide projections of other potential impacts of climate change (i.e. shifts in temperature regimes; changes in the frequency and duration of precipitation events).

Responsible Entity: NY State Legislature

Action Step 11.1.2: **Update natural resource laws and regulations to account for the projected impacts of climate change.**

Responsible Entities: DEC, DOS, NY State Legislature

Action Step 11.1.3: **Institute stronger wetland protection codes at the state and local levels that integrate "rolling" buffer and setback requirements.**

Responsible Entities: DEC, GSB Townships

Action Step 11.1.4: **Create a dedicated, consistent funding stream to support the acquisition of coastal property.**

Responsible Entity: NY State Legislature

Action Step 11.1.5: **Where practical, and in particular on public lands, direct development and infrastructure away from shorelines and sensitive coastal habitats.**

Responsible Entities: DEC, Suffolk County, OPRHP, GSB Townships, FINS

Action Step 11.1.6: **Engage in pre-storm planning that guides development away from vulnerable ecosystems and develop post-storm redevelopment plans that reduce community vulnerability in the wake of major storm events.**

Responsible Entities: DEC, DOS, SEMO, GSB Townships

Outreach and Education

"In the end we will conserve only what we love. We will love only what we understand. We will understand only what we are taught."

Baba Dioum 1968

Introduction

Education and outreach are important for the long-term stewardship and sustainability of the natural resources of Great South Bay. Having well-informed users of the bay's resources will help ensure their persistence through time. Maintaining a healthy connection between the resources of the bay and the local community provides motivation for protection of these resources. Understanding the delicate and intricate nature of this ecosystem can allow for the development of a balanced plan to maximize the health of the bay. Sharing both the value of the bay resource and the means to protect those resources start and end with education and outreach. As envisioned here, education and outreach is not a one-way transition of knowledge and information, but rather an informed dialog among citizens, stakeholders, experts, and the leaders and agencies charged with protection of public trust resources for the benefit of current and future generations. Ideally this dialog elevates the collective understanding of the management goals necessary for the community to maintain healthy resources. These goals are then pursued through modifications of policy, social and/or cultural change or simply investing in further study. It is these decisions that will ultimately impact public natural resources and quality of life around GSB. Due to the importance of these decisions, stakeholders should be universally informed by the most current and accurate understanding of the ecosystem as well as the short and long-term desires and needs of the community. President Lincoln once said, "*I like to see a man proud of the place in which he lives. I like to see a man live so that his place will be proud of him*." As is true throughout Long Island, the citizens who live in GSB communities highly value the bay as it relates to their quality of life (Rauch Foundation 2003), and there is a strong desire to leave a positive legacy in terms of the condition of the bay that is passed down to future generations (Appendix VI). As the saying goes, if you want to save it; you must share it.

According to a recent poll (Appendix VI), 62% of respondents living in the GSB watershed go to the shore or spend time on the water regularly, with responses higher from people who live in areas that border the shore. Focus group participants who live in waterfront communities expressed a great sense of nostalgia for the way they remember the bay from their youth, and were very supportive of various policies aimed at restoring the bay. However this poll, and several other outreach and communication efforts with GSB stakeholders, revealed there is not a universal understanding of serious underlying causes of problems facing the long-term health of Great South Bay.

It is important for residents, stakeholders, user groups, and leaders to generally agree on a long-term vision for the future of GSB. This is particularly important when it comes to making difficult decisions, funding expensive mitigation projects, or negotiating trade-offs between competing human uses or between short and long-term costs and benefits in order to reach a shared vision.

Making key information about the estuary available to everybody in the general public, including school-aged children has much long-term value. Increased efforts for education and outreach is important for building the case for actions that need to be taken by the public agencies whose responsibility is to safeguard the natural environment, human health, and quality of life in Great South Bay communities. Communication should be inclusive of the short and long-term needs and values of the community, as well as the most up to date scientific understanding of the causes and potential solutions to the issues. It should also maintain a two-way communication stream to encourage feedback from the community to decision makers.

All the priority threats and strategic actions discussed in this report would benefit from ongoing education and outreach efforts. Some immediate needs identified include education, outreach, and further dialog on: 1) a quantification of water quality impacts from activities on land -- specifically, how land-based activities contribute towards harmful algae blooms, declines in shellfish, seagrass, saltmarsh, and human health and subsequent impacts on cultural, recreational and economic values of the community; 2) issues resulting from the combined effect of rising seas and extensive coastal development on critical shoreline habitats and natural and human coastal communities and the short and long-term costs and benefits of alternative solutions; and 3) the future effects of inlet management and barrier island breach and overwash policies on bay heath, long-term barrier island integrity, natural shoreline ecosystems, and human coastal communities on the barrier islands and the mainland. Having an engaged community of stakeholders is essential to achieve this goal.

Actions to achieve the education and outreach objective are presented here along with a select group of participatory stakeholders acting within the GSB study site. The main goal is to clearly articulate the problems facing the GSB, communicate the severity of these issues, and motivate the stakeholders to pursue solutions to these problems. A secondary goal is to enhance and expand the public appreciation of the GSB's cultural and ecological values. This in turn will lead to increased public stewardship of the bay.

A number of mechanisms exist for achieving a meaningful and effective education and outreach communication strategy. To date there have been a number of very successful programs active within the GSB. There are also a number of programs that have been effective in other regions that can, and should, be expanded to the GSB. Similarly, there is potential to create new programs specific to the issues identified within this EBM document.

Although this plan provides a pathway for achieving ecosystem-based management, the actual implementation of these recommendations will fall largely on preexisting programs whose authority lie beyond the purview of this plan. The purpose of this plan is to recommend how these programs can be supported and best utilized in working towards the objective of creating a healthy, productive, sustainable, and resilient ecosystem that provides a complete set of ecosystem services for the benefit of current and future generations of residents and visitors.

Objective and Recommended Actions

Objective 12: By 2020 increase the stewardship ethic as measured by a 15% increase in the participation in programs operating within the GSB

Strategic Action 12.1: Develop and implement a public education campaign to increase educated awareness on the primary threats to GSB including degraded water quality, rising sea level, and management of natural barrier island processes

Action Step 12.1.1: Quantify and publicize the economic loss from degraded water quality and the benefit of investing in clean water.

Responsible Entities: SSERC, Suffolk County, USEPA
Potential Partners: NY Sea Grant, TNC

Action Step 12.1.2 Create an educational insert to local newspapers, which outlines threats to GSB and strategies to abate threats, and provides a list of educational resources.

Potential Partners: SSERC, USEPA, TNC

Action Step 12.1.3: Create a well distributed newsletter which presents active scientific research relevant to the GSB ecosystem and/or threats.

Responsible Entity: SSERC

Action step 12.1.4: Organize and/or create a series of lectures, conferences and educational opportunities that specifically target the local community as the primary audience.

Potential Partners: SUNY, SSERC, CCE, TNC

Action Step 12.1.5: Increase strategically placed interpretive signage around the GSB demonstration site which specifically addresses primary threats.

Potential Partners: New York State Coastal Resources Interpretive Program (NYSCRIP), SSERC, Town and County Parks

Action Step 12.1.6: Continue the use of polling to determine efficacy of efforts and stakeholder appreciation and understanding of issues.

Potential Partner: SSERC

Strategic Action 12.2: Develop and maintain an effective venue to allow and encourage participation in ecosystem-based management decisions to all stakeholders

Action Step 12.2.1: Develop, enhance, and maintain web-based communications, with a specific focus on:

- Maintaining a central events calendar which will provide relevant meeting times and information along with past meeting minutes
- Creation of an online discussion forum to allow users a chance to discuss current issues
- Creation of an online news feed (such as an RSS feed or email list) which community members can subscribe to receive current events
- Creating regular web content, blogs and interesting feature stories to keep audiences up-to-date on news and latest developments

Potential partners: SSER CAC, SUNY, GSB Townships, Suffolk County

Action Step 12.2.2: Encourage "open house" meetings held by agencies or partners surrounding ecosystem-based management decisions.

Potential Partners: SSERC, DEC, GSB Townships

Strategic Action 12.3: Increase the participation of community members in programs and projects that function within GSB

Action Step 12.3.1: Maintain an up-to-date list of on-going programs, projects, and volunteer opportunities on the SSER website, through other web-based and social media channels, and through media. Programs should include:

- Horseshoe Crab Volunteer Monitoring Network
- Piping plover monitoring programs
- Seatuck Environmental Association
- Theodore Roosevelt Nature Center
- Long Island Beach Buggy Association
- Clam seeding programs

Responsible Entity: SSERC
Potential Partners: SUNY, CCE, TNC, DEC

Action Step 12.3.2: Encourage the expansion or adoption of existing successful programs into the GSB demonstration site to increase and diversify opportunities for community member involvement.

Potential Partners: Spat Program, Water Logging by CCE, SPLASH- Stop Polluting Littering and Save Harbors

Action Step 12.3.3: Encourage program representatives to participate in community events such as the LI Maritime Museum's Annual Seafood Festival and Craft Fair as a means to recruit participants.

Potential Partners: SSERC, DEC, CCE, TNC, SPLASH, Event Coordinators

Action Step 12.3.4: Publicize and encourage teacher training opportunities through organizations such as New York State Marine Educators Association, Seatuck Environmental Association, Project WILD and Project WET, LINCK

Responsible Entity: SSERC

Education Outreach Volunteer Program Summaries

The following summaries are provided to give an introduction to programs and projects that were referenced in the recommendation section above. This is not meant to be an exhaustive list of programs active in the GSB but rather provide a brief background to allow readers the opportunity to learn more about these programs.

SOUTH SHORE ESTUARY RESERVE COUNCIL (SSERC)

The SSERC has several outreach and stewardship opportunities available. One of the most valuable resources is the SSERC website, managed by the SSER Office and the NYS DOS, which acts as a repository for information on the south shore estuary, grant opportunities, project updates, stewardship opportunities, current news and events. The SSERC encourages stewardship of the south shore estuary through members and partners.

HORSESHOE CRAB VOLUNTEER MONITORING NETWORK

Administered by CCE, the Long Island Horseshoe crab volunteer monitoring network goal is to develop a better understanding of Horseshoe crab abundance and distribution in the New York Marine District. Involving the public in these volunteer surveys provides an opportunity to raise awareness of the importance of the horseshoe crab and can lead to a vested interest and stewardship for the horseshoe crabs. CCE's Marine Program is helping to develop this network through funding provided by the New York State Department of Environmental Conservation (DEC). For more information: http://ccesuffolk.org/long-island-horseshoe-crab-volunteer-monitoring-network/ and; http://www.nyhorseshoecrab.org/

PIPING PLOVER FENCING AND VOLUNTEER PROGRAMS

Volunteers are recruited through federal, state and local municipalities, as well as through groups like the Audubon Society and The Nature Conservancy. These volunteers can assist in bird monitoring, maintenance of protective fencing and signage and can act as advocates for the protection and stewardship of both the birds and the beaches they occupy.

SEATUCK ENVIRONMENTAL ASSOCIATION

Seatuck Environmental Association currently offers many education and outreach programs. The objective of this organization is to conserve wildlife through education, research and advocacy. For more information: http://seatuck.org/index.php

THEODORE ROOSEVELT NATURE CENTER

The Nature Center is on a barrier island beach within Jones Beach State Park. An exhibit area depicts a variety of marine habitats including the South Shore Estuary Reserve, the seashore and the dune environment. Inside the center, children can touch live marine animals, look through a children's microscope or play in the kid's activity area. Outside the center, children can dig up whale bones in the Discovery Bone Cove, walk through the butterfly garden or view a shipwreck. An environmental boardwalk takes you out into the dune environment to see plants and animals that live there. Interpretive programs are available for schools, youth organizations, clubs and the general public.

LONG ISLAND BEACH BUGGY ASSOCIATION

LIBBA (Long Island Beach Buggy Association) is a volunteer based organization committed to the conservation of Long Island beaches while protecting the right to access these same Long Island beaches for past, present and future generations. LIBBA is a great example of an effort meant to conserve natural resources while maintaining historical human recreational uses of the land. One of their major conservation efforts is beach grass and dune restoration.

CLAM SEEDING

Clam seeding programs exist across Long Island. They are supported by local governments, schools, teachers, non-profits and other groups. For example, the combined efforts of Mount Sinai and Comsewogue High School, Town of Brookhaven, and Sayville Maritime Museum, students were able to seed about 50,000 clams in structures they built themselves in Mount Sinai Harbor. For more information: http://www.northshoreoflongisland.com/Articles-i-2009-10-29-81950.112114-sub18235.112114_Students_seed_50000_clams_in_Mt_Sinai_Harbor_waters.html

SPAT (SOUTHOLD PROJECT IN AQUACULTURE TRAINING)

Run by Cornell Cooperative Extension, the SPAT program was created to encourage community members and groups to become stewards of their environment and to restore shellfish to the bays. SPAT volunteers learn how to rear shellfish to when they are released into local creeks and bays. Volunteers are offered monthly workshops and provided with shellfish seed and necessary tools and supplies to grow their shellfish gardens either at their own waterfront or in the SPAT community garden. http://ccesuffolk.org/spat

Most of the current SPAT program takes place in on the east end of Long Island. It would greatly benefit the GSB to use this program within the ecosystem. An expansion of the shellfish gardening program, or “adoption” of a community shellfish garden can promote a sense of pride in the local ecosystem and provide a first-hand experience with science and nature. This program is a very creative way to make stewardship of the GSB very educational and profitable in a variety of ways.

WATER LOGGING BY CCE

CCE currently has an outreach and stewardship program called Water Logging. Water Logging is a water quality monitoring program with the goals of using field monitoring as an educational tool and an outreach experience. The program is foremost concerned with developing a stewardship of local bays and waters. Water logging further serves to screen for water quality impairments, determine long-term water quality trends, and provide useful water quality data to interested parties. The name, "Water Logging", is derived from a ship’s log which is used to keep a record of the ship's occurrences at sea. In this program, participants are “logging” water quality parameters.

SPLASH (STOP POLLUTING LITTERING AND SAVE HARBORS)

SPLASH is a volunteer run non-profit organization which organizes beach cleanups along the South shore of LI. Through cleanup activities they also provide a unique opportunity to educate participants to the impacts that storm water runoff can have. For more information: http://operationsplash.net/

NEW YORK STATE MARINE EDUCATION ASSOCIATION (NYSMEA)

NYSMEA promotes marine awareness and encourages the growth and exchange of instructional resources within the scientific, commercial, and educational communities and is an important partner for teacher training, first-hand nature experiences and a source for conferences and lectures. NYSMEA maintains a website with current educational resources, volunteer opportunities, an events calendar and a list of web links. For more information: http://www.seagrant.sunysb.edu/nysmea/index.php

PROJECT WILD/ PROJECT WET

Project WILD and Project WET's missions are to provide wildlife-based conservation and environmental education that fosters responsible actions toward wildlife and related natural resources. The goal of Project WILD is to assist learners of any age in developing awareness, knowledge, skills and commitment to result in informed decisions, responsible behavior and constructive actions concerning wildlife and the environment upon which all life depends. They also provide educators with materials that support national, state, and district standards in science, mathematics, language arts, social studies, and expressive arts.

THE LONG ISLAND NATURE COLLABORATIVE FOR KIDS (LINCK)

The Long Island Nature Collaborative for Kids (LINCK), a national demonstration site, is a network of environmentalists, nature educators, early childhood educators, and health professionals working together to bring children outdoors and reconnect them with nature. LINCK can be used as a teacher training tool and as a way to provide first-hand experiences with nature for kids. This organization should be a partner in establishing an educational campaign to connect people with their actions and their effects on the environment.

CONCLUSION

The recommendations made in this EBM plan are intended to be used as a tool for all stakeholders with vested interest in the GSB ecosystem. It is not the sole responsibility for any one agency or any one user group to execute this plan. Although the authority for implementing many of these recommendations may rest with a limited group of agencies, the process of developing and motivating a movement towards adopting these recommendations requires a coordinated effort among all stakeholders.

Although the GSB ecosystem is vastly more complex than the representative surrogates focused on in this plan, tackling the management of this invaluable resource using a methodological approach allows for a simpler and systematic review and re-prioritization of those actions and objectives. As more is learned about the GSB new threats may emerge and current threats may be abated. Objectives may be achieved and strategic actions may fail. One must bear in mind that this is all part of the process of Ecosystem-based Management and that pursuing a healthy functioning ecosystem for both people and nature must remain the focus of the plan through any and all iterations.

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Great South Bay Ecosystem-based Management Plan

APPENDICES

Appendix I: Development of the Great South Bay Ecosystem-based Management Plan

Appendix II: Great South Bay Ecology

Appendix III: Restoring Hard Clams to Great South Bay

Appendix IV: Nitrogen Loading to Great South Bay; Land Use, Sources, and Transport from Land to Bay

Appendix V: Nitrogen Loading to Great South Bay; Management Scenarios

Appendix VI: Kitchen Group: Issue Analysis Poll and Focus Group Report

Appendix VII: Acronym Reference and Glossary