U. S. Army Corps of Engineers
New York District

Atlantic Coast of Long Island, Fire Island Inlet to Montauk Point, New York: Reformulation Study

Submerged Aquatic Vegetation (SAV) Bed Characterization

Final Report
October 2004

EXECUTIVE SUMMARY

The Atlantic Coast of Long Island, Fire Island Inlet to Montauk Point (FIMP), New York, Storm Damage Reduction Reformulation Study seeks to evaluate long-term solutions for storm damage reduction along the south shore of Suffolk County, Long Island. As part of this major Reformulation Study, a multitude of studies is being conducted in order to understand ecosystem function in the study area.

The overall project study area extends 83 miles from Fire Island Inlet to Montauk Point and includes three major bay systems. Great South Bay extends a coastal distance of 33.8 miles with connections to the ocean through Hempstead Bay to the west, Fire Island Inlet and Moriches Bay (at Narrow Bay) to the east (USFWS 1983). Moriches Bay extends 14.4 miles along the coast with oceanic connections at Great South Bay (Narrow Bay) to the west, Moriches Inlet and Shinnecock Bay to the east via Quantuck Canal, Quantuck Bay and Quogue Canal (USFWS 1983). Shinnecock Bay extends 11.2 miles coastally with connections to the ocean through Moriches Bay to the west via Quogue Canal and Shinnecock Inlet, and to the east through Great Peconic Bay via the Shinnecock Canal (USFWS 1983).

This report provides a summary of available historic and current biological and physiological data relevant to submerged aquatic vegetation (SAV) within the study area and an analysis of possible relationships to SAV bed distribution. Existing information on community structure of the south shore estuary intertidal wetland habitat of these bays is limited. The historical site assessment provides an overview of historic and current mapping of the SAV beds, as well as qualitative information on local land use, physical, hydraulic and surface water quality data.

This report also summarizes the more recent findings of a seasonal field survey conducted in the study area from June through October 2003. The field survey was designed as an ecological inventory of six SAV beds, two in each of the three bays located in the FIMP study area: the East Fire Island and Bellport beds in Great South Bay, Great Gun and Cupsogue beds in Moriches Bay, and Tiana and Ponquogue East beds in Shinnecock Bay. (See Figures I-1 through I-4, Table I-1). Observations made during previous United States Army Corps of Engineers (USACE) field investigations indicated that this time period coincided with peak eelgrass productivity. Major components of the field survey included the collection of finfish and invertebrates in the eelgrass beds using a seine net, snorkeling to observe flora and fauna, eelgrass quadrat analysis and collection of water quality data. This study will be used to provide baseline data on finfish, invertebrates and flora associated with these eelgrass habitats within the FIMP study area.

The following general conclusions are based on this review of existing information and collection and analysis of more current data for Great South Bay, Moriches Bay and Shinnecock Bay:

1. There has been an apparent loss of SAV beds fringing the mainland south shore in Great South Bay over the past 25 years.

2. SAV distribution and abundance in the south shore embayments appears to be strongly correlated with both depth and a combination of other environmental factors (e.g., tidal flushing, water clarity, etc.).

3. Distributions of eelgrass were patchy throughout each of the study sites. Density of eelgrass was greatest during August, which corresponded with highest water temperatures.

4. The tallest stands of eelgrass were observed in Moriches and Shinnecock Bays, which were the locations with greater water clarity.

5. Finfish species richness and abundance was generally found to increase from west to east.

6. Invertebrate species richness and crab abundance remained similar across all bays, with slightly higher values observed to the east.

7. Overwashes, breaches and new inlets may have positive or negative effects on SAV growth and distribution by creating new habitat or destroying existing SAV beds. A lack of historic SAV mapping that could be correlated to historic breach locations prevents a more conclusive assessment concerning the net effects of breaching on SAVs.

8. Stabilized inlets have led to significant increases in bay flushing, water quality and possibly SAV growth relative to pre-stabilization conditions at Moriches and Shinnecock Bays. There is insufficient historic bathymetric and SAV coverage data to speculate what the net effect of inlet stabilization has been on overall sediment accumulation in the bays and concomitant creation of shallow areas supporting SAV growth.

ACRONYMS

CMP	Comprehensive Management Plan
DEIS	Draft Environmental Impact Statement
EPA	Environmental Protection Agency
FIMP	Fire Island Inlet to Montauk Point
GIS	Geographic Information System
GPS	Global Positioning System
GSB	Great South Bay
ICW	Intracoastal Waterway
MOR	Moriches Bay
MSL	Mean Sea Level
MSRC	Marine Sciences Research Center (State University of New York)
NOAA	National Oceanic and Atmospheric Association
NTU	Nephelometric Turbidity Units
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
NYSGEP	New York Sea Grant Extension Program
SAV	Submerged Aquatic Vegetation
SCDHS	Suffolk County Department of Health Services
SH	Shinnecock Bay
SPM	Shore Protection Manual
SSER	South Shore Estuary Reserve
STP	Sewage Treatment Plant
USACE	United States Army Corps of Engineers

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I. INTRODUCTION

The USACE, New York District is conducting a comprehensive feasibility-level Reformulation Study to identify, evaluate, and recommend long-term measures for hurricane storm damage reduction for the south shore of Long Island, New York, from Fire Island Inlet to Montauk Point (FIMP). The Reformulation Study is a multi-year and multi-task effort, involving project planning and engineering, economic analyses and environmental studies. Numerous study tasks are involved in the planning of storm damage reduction projects for the approximately 83-mile study area length. The study area also includes 26 miles of the Fire Island National Seashore (FIIS), which is under the jurisdiction of the National Park Service (NPS).

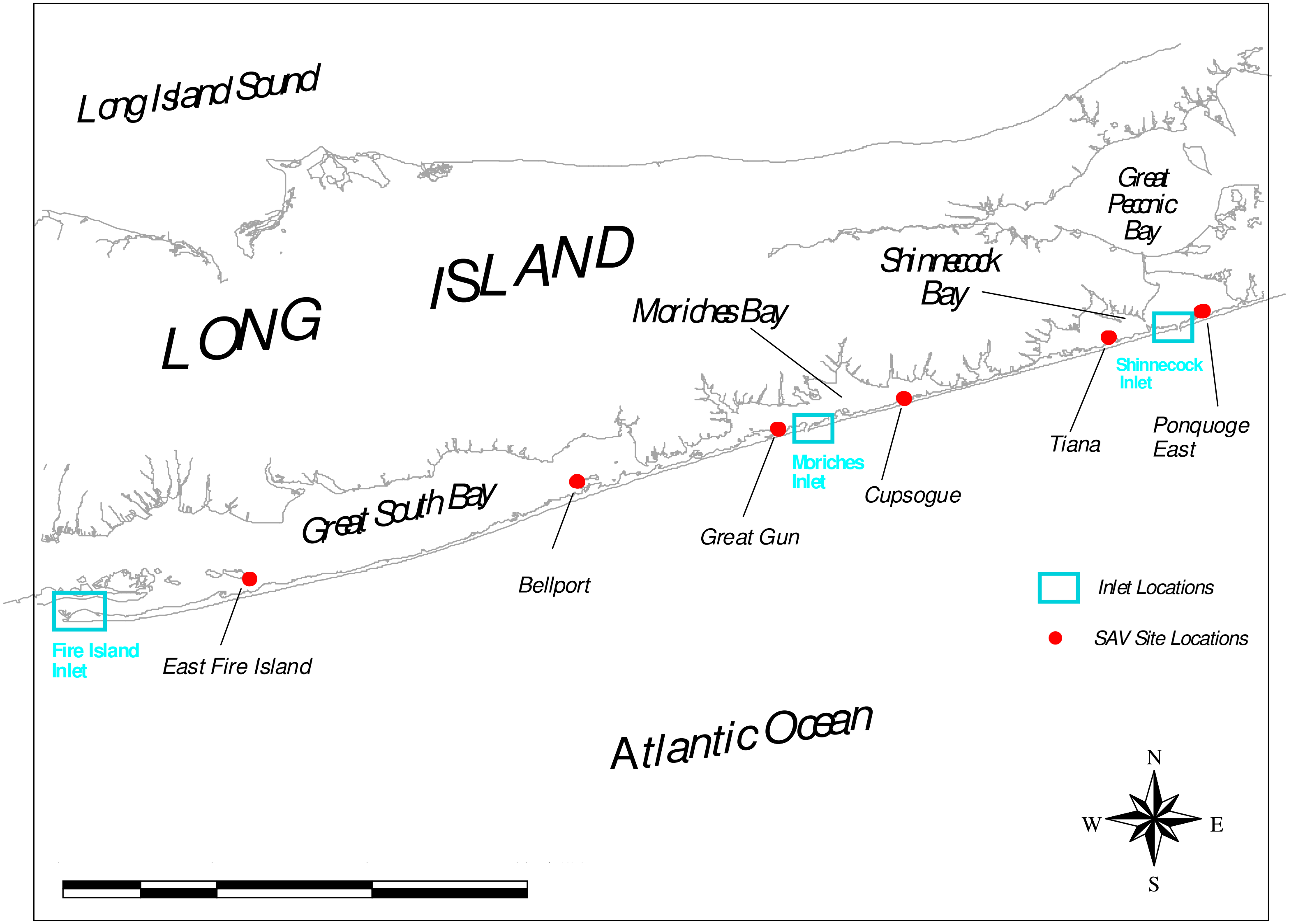
The project area is located entirely in Suffolk County, Long Island, New York, along the Atlantic and bay shores of the towns of Babylon, Islip, Brookhaven, Southampton, and East Hampton (Figure I-1). The study area includes three estuarial bays, which are in order from west to east: Great South Bay, Moriches Bay, and Shinnecock Bay. These bays are connected to the Atlantic Ocean through Fire Island, Moriches, and Shinnecock Inlets, all of which are federally-maintained navigation channels. The project area includes the ocean and bay shorelines, the aforementioned inlets, barrier island beaches, the mainland, as well as suitable offshore sand borrow areas for beach construction and replenishment. The study encompasses approximately 70 percent of the total Atlantic Ocean frontage of Long Island, as well as hundreds of miles of bay shoreline.

The potential exists for breaching and/or flooding of the barrier islands that may significantly impact mainland communities bordering Great South Bay, Moriches Bay, and Shinnecock Bay. Coastal communities of the study area are subject to economic losses during severe storms. Principal damages to these coastal areas are the result of flooding and erosion associated with extreme tides and wave action. These storms, as well as alternatives that provide for storm damage reduction, also have the potential to affect backbay environments and the species associated with them.

A review of the Data Gap Analysis performed as part of the Reformulation Study indicated a lack of background information for the backbay environment along the south shore of Long Island (USACE, 1999a). This project is designed to provide information that will assist the USACE in evaluating project alternatives as part of the Reformulation Study. This report presents information on SAV beds located in the study area. The physiological perspective uses currently available SAV maps to relate beds with physical, hydraulic and water quality parameters. Special emphasis is placed on historical breaching and overwash. The historical site assessment provides an overview of SAV coverage in the South Shore embayments, focusing on both historical and current mapping efforts. This discussion includes a qualitative assessment of local land use changes, which focuses on known pollutant sources (point and non-point).

A current study of SAV beds was conducted by the USACE in 2003. This report presents the study design, methodologies and results from this one-year survey of SAV in each of the bays of the FIMP study area (Figures I-2 through I-4, Table I-1). The primary objective of the field study was to survey the eelgrass (*Zostera marina*) habitats of the barrier island's backbay environment and provide information on community structure of this estuarine ecosystem. Specifically, this component of the program defines the physical characteristics, faunal and floral use of six SAV beds that occur in the backbay area within the FIMP study area. Information will be provided in the Draft Environmental Impact Statement (DEIS) on potential impacts to the SAV beds based on the alternatives presented in the recommended plan as inputs to defining the spatial and temporal trends in community structure of the SAV habitats.

FIGURE I-1
Fire Island to Montauk Point Reformulation Study Area



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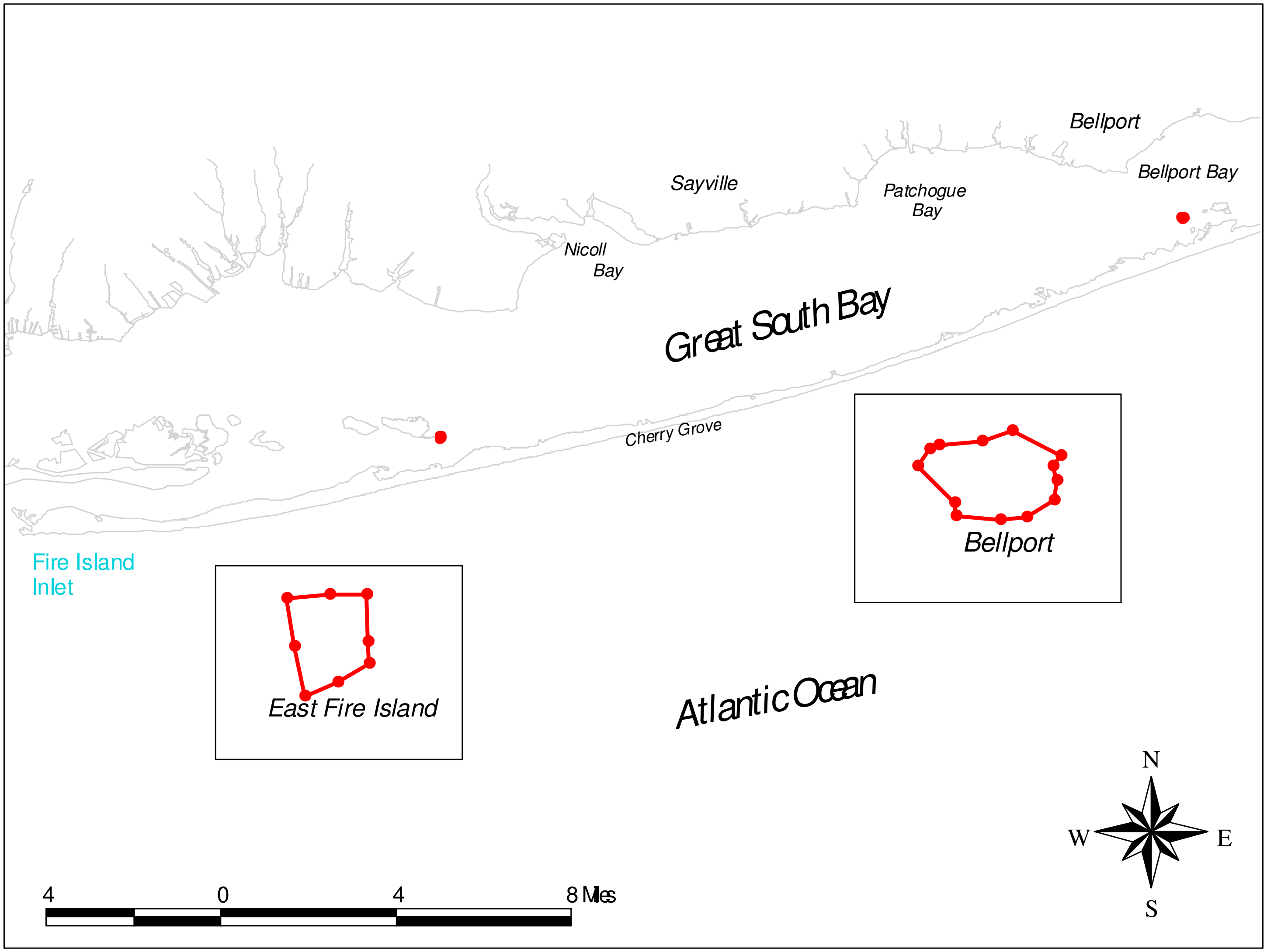
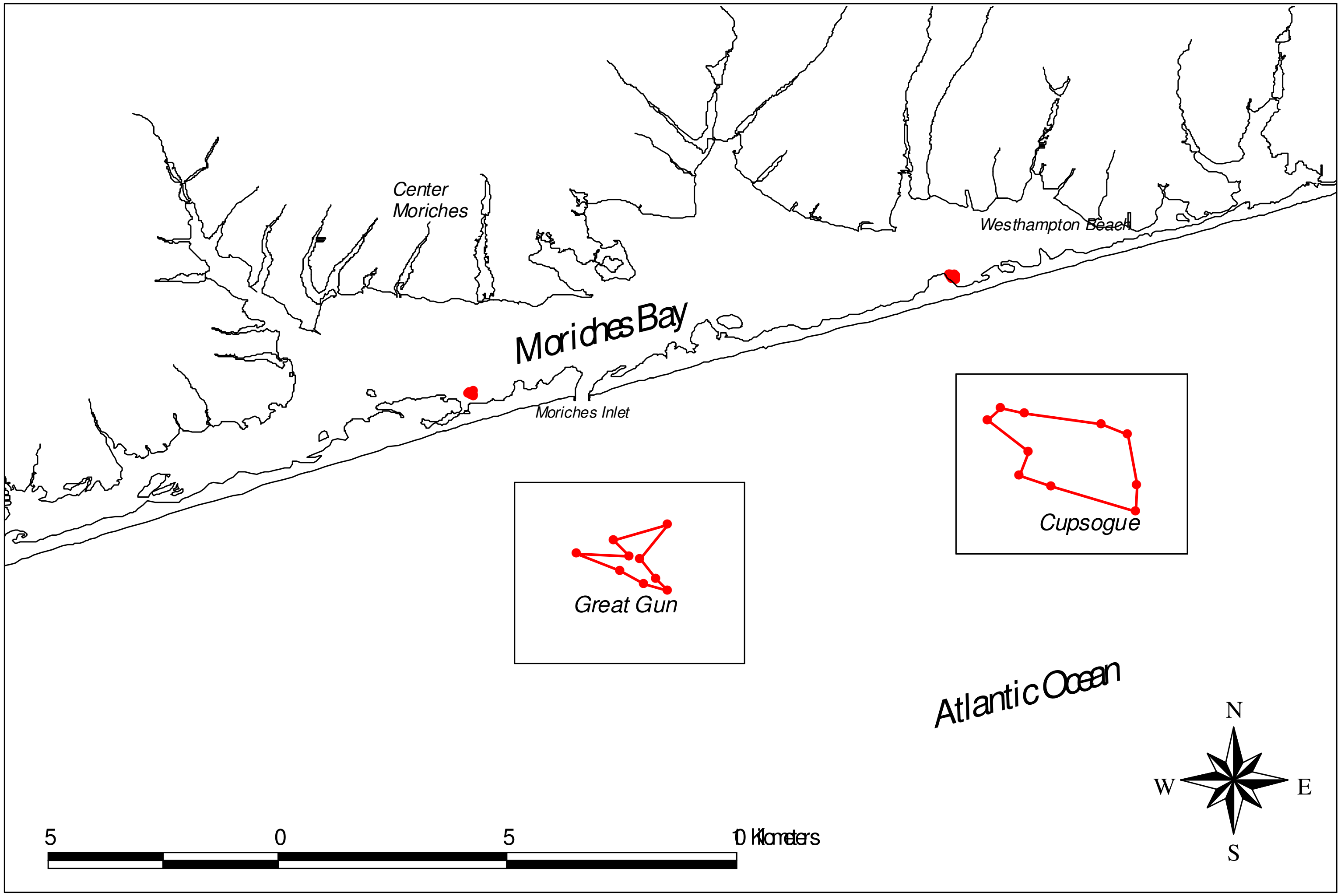
See text for distances between inlets and station locations.

FIGURE I-2
Great South Bay Site Locations



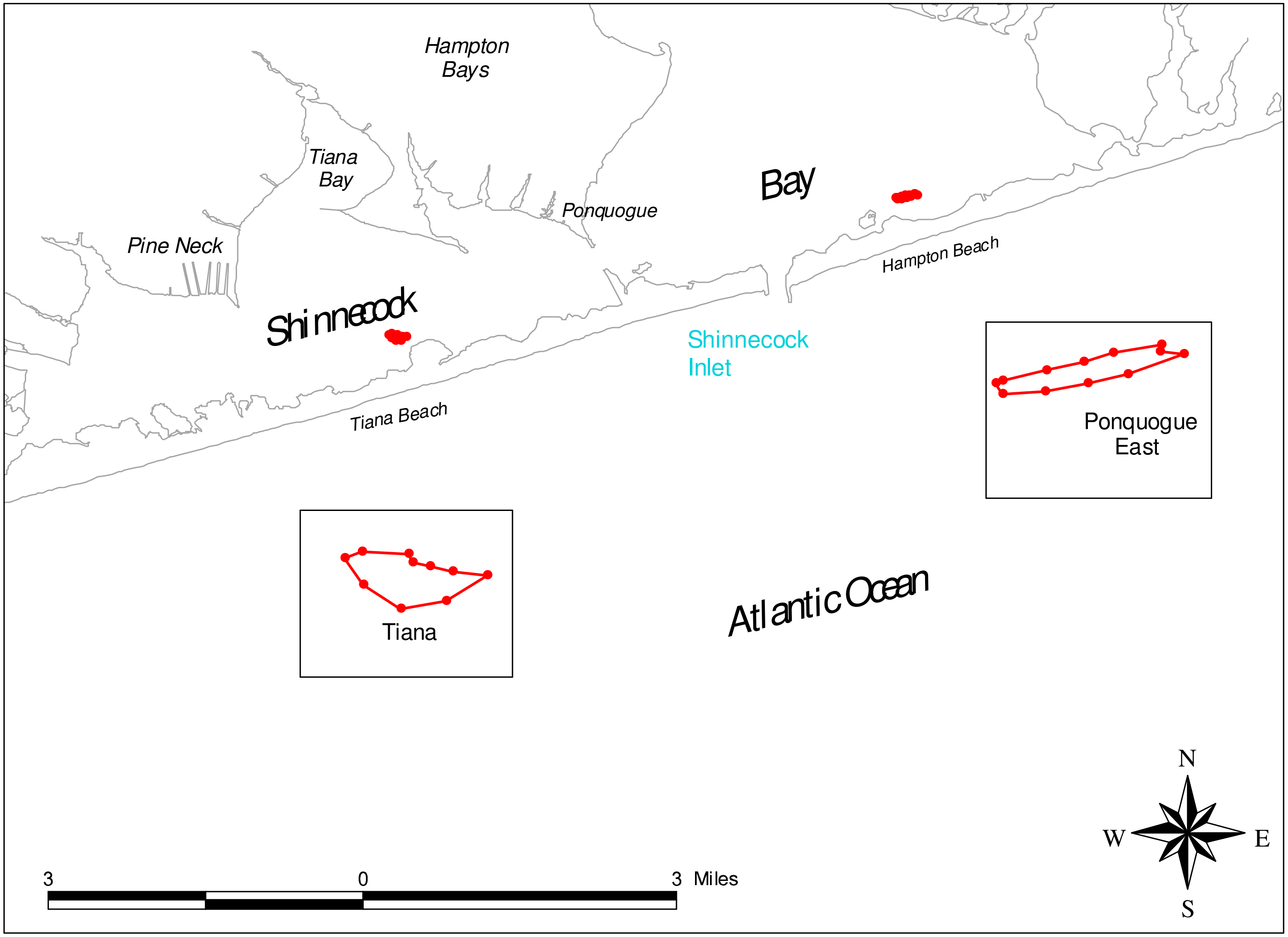
See text for distances between inlets and station locations.

FIGURE I-3
Moriches Bay Site Locations



See text for distances between inlets and station locations.

FIGURE I-4
Shinnecock Bay Site Locations



See text for distances between inlets and station locations.

TABLE I-1

GPS Locations of SAV Beds Surveyed

GSB = Great South Bay MOR = Moriches SH = Shinnecock

Bay	Station	Date	Location	Latitude	Longitude
GSB	East Fire Island	6/5/2003	NW Corner	40'39.186	73'10.374
GSB	East Fire Island	6/5/2003	West	40'39.148	73'10.368
GSB	East Fire Island	6/5/2003	SW Corner	40'39.109	73'10.359
GSB	East Fire Island	6/5/2003	South	40'39.120	73'10.334
GSB	East Fire Island	6/5/2003	SE Corner	40'39.135	73'10.309
GSB	East Fire Island	6/5/2003	East	40'39.152	73'10.310
GSB	East Fire Island	6/5/2003	NE Corner	40'39.189	73'10.311
GSB	East Fire Island	6/5/2003	North	40'39.189	73'10.340
GSB	Bellport	6/5/2003	NNW	40'43.533	72'55.631
GSB	Bellport	6/5/2003	WNW	40'43.510	72'55.609
GSB	Bellport	6/5/2003	NW	40'43.502	72'55.608
GSB	Bellport	6/5/2003	West	40'43.500	72'55.580
GSB	Bellport	6/5/2003	West Central	40'43.501	72'55.564
GSB	Bellport	6/5/2003	SW Corner	40'43.512	72'55.547
GSB	Bellport	6/5/2003	SSW	40'43.524	72'55.546
GSB	Bellport	6/5/2003	SW	40'43.539	72'55.543
GSB	Bellport	6/5/2003	South	40'43.533	72'55.548
GSB	Bellport	6/5/2003	SE	40'43.555	72'55.573
GSB	Bellport	6/5/2003	East	40'43.548	72'55.592
GSB	Bellport	6/5/2003	NE	40'43.546	72'55.618
GSB	Bellport	6/5/2003	North	40'43.543	72'55.624
MOR	Great Gun	6/2/2003	SE	40'45.898	72'46.572
MOR	Great Gun	6/2/2003	SSE	40'45.880	72'46.550
MOR	Great Gun	6/2/2003	South-cut to West	40'45.871	72'46.541
MOR	Great Gun	6/2/2003	SW	40'45.876	72'46.560
MOR	Great Gun	6/2/2003	Central West	40'45.887	72'46.579
MOR	Great Gun	6/2/2003	NW	40'45.901	72'46.615
MOR	Great Gun	6/2/2003	North Central	40'45.911	72'46.585
MOR	Great Gun	6/2/2003	NE	40'45.924	72'46.541
MOR	Great Gun	6/2/2003	East Central	40'45.896	72'46.563
MOR	Cupsogue	6/3/2003	South	40'47.255	72'40.919
MOR	Cupsogue	6/3/2003	SE Corner	40'47.241	72'40.870
MOR	Cupsogue	6/3/2003	East	40'47.256	72'40.869
MOR	Cupsogue	6/3/2003	NE Corner	40'47.285	72'40.875
MOR	Cupsogue	6/3/2003	North Central	40'47.291	72'40.890
MOR	Cupsogue	6/3/2003	NW Corner	40'47.297	72'40.934
MOR	Cupsogue	6/3/2003	WNW Corner	40'47.300	72'40.948
MOR	Cupsogue	6/3/2003	West Central	40'47.293	72'40.955
MOR	Cupsogue	6/3/2003	SSW	40'47.275	72'40.932
MOR	Cupsogue	6/3/2003	SW Corner	40'47.261	72'40.937
SH	Tiana	6/4/2003	East	40'50.028	72'31.675
SH	Tiana	6/4/2003	North	40'50.044	72'31.718
SH	Tiana	6/4/2003	NE	40'50.032	72'31.697
SH	Tiana	6/4/2003	NNW	40'50.046	72'31.762
SH	Tiana	6/4/2003	NW	40'50.040	72'31.779
SH	Tiana	6/4/2003	South	40'49.999	72'31.682
SH	Tiana	6/4/2003	SE	40'50.024	72'31.642
SH	Tiana	6/4/2003	SW	40'49.991	72'31.725
SH	Tiana	6/4/2003	West	40'50.015	72'31.761
SH	Tiana	6/4/2003	NNE	40'50.036	72'31.714
SH	Ponquogue East	6/4/2003	East	40'51.207	72'27.427
SH	Ponquogue East	6/4/2003	North	40'51.197	72'27.496
SH	Ponquogue East	6/4/2003	NE	40'51.213	72'27.425
SH	Ponquogue East	6/4/2003	NNE	40'51.206	72'27.469
SH	Ponquogue East	6/4/2003	NNW	40'51.190	72'27.529
SH	Ponquogue East	6/4/2003	NW	40'51.181	72'27.569
SH	Ponquogue East	6/4/2003	South	40'51.178	72'27.492
SH	Ponquogue East	6/4/2003	SE	40'51.205	72'27.405
SH	Ponquogue East	6/4/2003	SSE	40'51.186	72'27.456
SH	Ponquogue East	6/4/2003	SSW	40'51.171	72'27.531
SH	Ponquogue East	6/4/2003	SW	40'51.169	72'27.570
SH	Ponquogue East	6/4/2003	West	40'51.178	72'27.575

II. HISTORIC AND PHYSIOLOGICAL SITE PERSPECTIVE

Two species of seagrasses predominate in the coastal waters of Long Island, eelgrass and widgeon grass (*Ruppia maritima*). Eelgrass generally occupies the deeper, more saline waters of the bays and estuaries, while widgeon grass is characteristically found in the shallower, quiescent coves, sluggish tidal creeks, brackish pools, and often near a freshwater source. Light intensity has been reported as a principal factor controlling plant distribution, vigor, and depths to which both of these species are found (Thayer, *et al*., 1984, Batiuk, *et. al*. 1992; Kantrud 1991). Light penetration through the water column is controlled by dissolved and suspended materials in the water and by water depth. Studies suggest that as much as 22% of incident sunlight is required for SAV survival in mesohaline and polyhaline environments (Chesapeake Bay Program, 2000).

Several other physiological parameters, however, may significantly constrain SAV survival and distribution, working in conjunction with or independent of light levels. These include salinity levels, temperature, waves, currents, sediment grain size, and sediment organic content. For example, bottom shear induced by waves or high currents may exceed the threshold of motion for bottom sediments and thus prevent SAV growth even if the light intensity requirement is met. Table II-1 provides a summary of the general habitat requirements for eelgrass and widgeon grass.

The following sections include a summary of available SAV mapping and physiological data within Great South, Moriches, and Shinnecock Bays as well as a discussion of possible relationships with SAV coverage in the bays. Relevant parameters were grouped into three principal categories:

- Physical (bathymetry and surficial sediments)
- Hydraulic (tide range, tidal currents, and waves)
- Water Quality (turbidity, dissolved oxygen, salinity, and temperature)

In addition, a discussion of historic overwash and breaching is presented, as well as preliminary findings regarding possible relationship to SAV coverage. Later in the report, this information will be used as a basis of comparison for the findings of the current USACE investigation.

A. Available SAV Mapping

1. <u>Historical Documentation</u>

While commercial and recreational fishing and clamming of Long Island's south shore bays has spanned over a century, with the exception of Great South Bay, historical documentation and mapping of SAV is lacking. Two historical studies have been conducted by the Marine Sciences Research Center (MSRC) in Great South Bay, entitled "*Surficial Sediment and Seagrasses of Eastern Great South Bay, NY*" (Greene, et. al., 1978) and "*Distributions of Surficial Sediment and Eelgrass in Great South Bay, NY from Smith Point to Wantagh State Parkway*" (Jones and Schubel, 1980). The findings of these studies are summarized below.

The New York State Department of Environmental Conservation (NYSDEC), the New York State Department of State (NYSDOS), and the New York Sea Grant Extension Program (NYSGEP) were contacted for information on historic SAV mapping. Based on discussions with the NYSDEC and USACE during early Environmental Technical Meeting Group (ETMG) meetings and a data gap analysis effort conducted as part of the Reformulation Study, there is no SAV data for the south shore of sufficient quality to satisfy the needs of the Reformulation Study (USACE-NAN, 1999a). The NYSDOS indicated that while they had compiled vintage wetlands mapping and land cover data for land surrounding the south shore embayments, SAV were not previously mapped. The NYSGEP responded that the National Park Service (NPS) had conducted a limited field survey of the Fire Island National Seashore, which included documentation of eelgrass beds along the northerly shoreline of the barrier island. The findings of this recent study by Raposa and Oviatt (1997) *"A Field Evaluation of the Fire Island National Seashore Estuarine Resources with an Emphasis on Nekton Communities,"* in relation to eelgrass coverage is also summarized.

a. Greene, et. al. (1978)

During 1977, Greene *et. al*. conducted a study of the sediments in Great South Bay, primarily focused on the distribution of hard clams (*Mercenaria mercenaria*). However, the presence of eelgrass beds in Great South Bay was also documented as supporting habitat for the hard clams. Data were collected at one hundred and eighty-six stations along the eastern portion of Great South Bay from Fire Island Pines/Homans Creek in Sayville to the west, eastward to Carmans River/Smith Point. Data on eelgrass distribution and vegetative density were recorded along the south shore of the mainland, as well as the north shore of the Fire Island barrier. The Greene study indicated that eelgrass distribution was fairly limited to fringes along the mainland shoreline. Bed widths were typically less than 0.02 km (0.01 mi) with the exception of areas adjacent to tidal creeks and canal outlets, where beds reached a maximum width of approximately 0.4 km (0.2 mi). Greene also noted at the time that eelgrass along the mainland shoreline seldom grew at surface water depths greater than 0.5 m (1.6 ft) (although this is no longer the case), and these northern beds were fairly thin. No eelgrass was reported along the mainland to the west of the NYSDEC conservation area in Blue Point.

In the 1977 study, the largest eelgrass beds with the greatest density were recorded along the north shore of the Fire Island barrier, between Davis Park and Smith Point. Eelgrass distribution on the north shore typically extended 0.9 to 1.3 km (0.6 to 0.8 mi) from the shoreline, compared to the northern side of the bay, where eelgrass extended to depths of approximately 1.8 m. Greene noted that due to the prevailing southwesterly winds in the summer, waters on the north shore of the bay were generally rougher and remained turbid. Since light penetration has been shown to be one of many limiting factors controlling eelgrass growth and survival, the study hypothesized that this might be a cause for the differences in distribution and density of eelgrass in Great South Bay.

b. Jones and Schubel (1980)

The study area of the Jones and Schubel report includes the study area of the 1978 report by Greene *et. al*., with the addition of 396 sampling stations that cover the westerly portion of

Great South Bay to Wantagh State Parkway. One significant finding of this study is the relative lack of eelgrass coverage along the mainland south shore from near the NYSDEC conservation area in Blue Point, all the way west to Howell Creek in Amityville. Relatively small, isolated patches of eelgrass near the outlets of several tidal creeks (e.g.; Champlin Creek, Quintuck Creek, the boat basin at Heckscher State Park, Connetquot River) were recorded along this approximate 37 km (23 mi) stretch. Within the study area along the mainland shoreline, extensive eelgrass beds were found only in the western portion of Great South Bay, from Howell Creek west to Massapequa Creek.

In contrast, there are several expansive eelgrass beds as large as 2.8 km (1.7 mi) wide, located along the south side of the bay, bordering the barrier shoreline. A few major expanses of eelgrass were identified: one to the northeast of Cedar Island Beach east to Captree Island, another bordering the northeasterly side of West and East Fire Island, and a third at the easterly end of the bay from Davis Park to Old Inlet.

The Jones and Schubel report noted that the densest eelgrass beds in Great South Bay were found at the following locations:

- north of Captree Island and West Fire Island;
- east of East Fire Island and Saltaire; and
- Ocean Beach, Fire Island Pines, Davis Park, Bellport Beach and Old Inlet.

Jones and Schubel mapped both the depth and composition of the bay bottom sediments in the study area of the Great South Bay. The relatively coarse-grained substrate present on the southerly portion of the bay, coupled with optimal water depths (< 2 m or 6.5 ft) and sufficient protection from wind and wave energy, may be key factors in supporting the healthiest eelgrass beds on the north side of the Fire Island barrier. This is discussed further in the Physical Parameters sub-section that follows.

c. Raposa and Oviatt (1997)

The Raposa and Oviatt study examined the various estuarine habitats in Great South Bay that occupy the northern shoreline of the Fire Island National Seashore Wilderness Area reaching from the Watch Hill Visitor's Center in the west to Smith Point County Park in the east. While the primary focus of this study was the distribution and abundance of finfish and macrobenthic species among various habitat types, the study also mapped eelgrass distribution and density fringing the northerly shoreline. Extensive eelgrass beds were identified in close proximity to the barrier shoreline throughout most of the study area. However, SAV beds to the east were identified further offshore bordering Ridge Island near Old Inlet.

2. Recent SAV Mapping Efforts

As part of the FIMP Reformulation Study, the USACE conducted a delineation of SAV in Great South Bay, Moriches Bay and Shinnecock Bay. This study entailed photographic interpretations of potential SAV signatures using 9" by 9" hard copy 1997 color aerial photographs (scale 1:13,000) obtained from the New York State Police Aviation Unit. All potential SAV beds were hand-delineated and the data was later transferred into a digital baseline map in GIS format. This USACE Phase 1 SAV mapping effort has been compiled into a report dated January 2002 entitled "*Draft Determination of Potential Sub-Aquatic Vegetation (SAV) in Great South Bay, Moriches Bay, and Shinnecock Bay.*"

Subsequently, in 2001 the USACE conducted a field reconnaissance effort to "ground-truth" a select number of previously mapped SAV beds (USACE-NAN, 2001). Phase 2 mapping included new and updated SAV bed delineations based on field notes and data gathered using a hand-held Global Positioning System (GPS) unit. While the results of this Phase 2 effort have been entered into a GIS database system, no summary reports have been prepared to date. Figure II-1 presents the results of the SAV Phase 1 and Phase 2 USACE mapping efforts.

During the latter stages of the SAV Phase 1 mapping effort, the USACE discovered that the NYSDOS also had interest in mapping the SAV of the South Shore Estuary Reserve. NYSDOS in association with the National Oceanic and Atmospheric Administration (NOAA), obtained 2002 photographic coverage of the south shore embayments, and recently completed their SAV mapping effort. The NYSDOS/NOAA work is currently not available to the public, however it is under peer review with an anticipated release date in 2004.

3. Comparison of Recent SAV Mapping with Historical Mapping

The SAV mapping in Great South Bay conducted by the MSRC in the late 1970's corresponds generally well to the recent mapping conducted by the USACE. While the USACE's Phase 2 field reconnaissance effort did not confirm all of the beds identified by the Phase 1 photo interpretation effort, characteristic SAV signatures were found covering many of the bed locations formerly mapped by Jones and Schubel (1980). The western portion of Great South Bay continues to support extensive eelgrass beds to the north and west of Captree Island. Additionally, extensive beds were identified by USACE to the northeast of East Fire Island. The eastern portion of Great South Bay also continues to support expansive eelgrass beds, particularly from Davis Park eastward to Smith Point.

The major difference in SAV coverage comparing the historical mapping to current USACE efforts is the relative lack of SAV beds fringing the south shore of the mainland from Howell's Point in Bellport west to the Robert Moses Causeway. SAV coverage occurred in isolated patches, restricted to tidal creek and canal outlets along the northern side of Great South Bay in the late 70's. Recent USACE mapping indicates that even these narrow fringes have either shrunk or disappeared, with the possible exception of some remnant beds at the outlets of Hedges and Mud Creeks in Bellport, and the Heckscher State Park Boat Basin.

B. Physical Parameters

The FIMP study area is comprised of two distinct physiographic regions: (1) a barrier island portion extending from Fire Island Inlet to Southampton and (2) a headland segment from Southampton to Montauk Point. The 80-km (50-mi) long barrier island segment is characterized by low-lying islands fronting Great South, Moriches and Shinnecock Bays. The bays are connected through narrow tidal waterways of the Long Island Intracoastal Waterway (ICW). In addition, Great South, Moriches and Shinnecock Bays are connected to the Atlantic Ocean through Fire Island, Moriches and Shinnecock Inlets, respectively (see Figure I-1). A physical description of each bay is presented in the following paragraphs:

1. Bathymetry

Bathymetry and surface water depth are important environmental features, since seagrasses are highly dependent upon light penetration through the water column. Therefore water depth is one of many limiting factor in the distribution and size of SAV beds. Eelgrass can survive at depths up to 3 meters but typically occurs in water between 0.6 to 2 meters deep. Widgeon grass has also been reported in coastal waters up to 4.5 meters deep, but commonly occupies the upper 0.5 to 1.5 meters (Kantrud, 1991). Depth of occurrence is typically decreased in more turbid waters. The minimum depth of occurrence is determined by the lowest annual tidal level, due to intolerance to air exposure and desiccation.

Great South Bay. Great South Bay is the largest of the project area estuaries extending about 55 kilometers from Massapequa in South Oyster Bay to Smith Point in the east near Bellport Bay (Figure II-1). Numerous tidal rivers and creeks, as well as several significant embayments, including Patchogue and Nicoll Bays and Great Cove, characterize the northern shore of Great South Bay. The larger tidal rivers include the Connetquot River and Champlin Creek. Great South Bay consists of two distinct basins, east and west, relative to the location of Fire Island Inlet. East of the inlet, bay widths vary from between 3.2 to 8 km with water depths averaging roughly 2.5 m (Figure II-1). Maximum bay water depths reach about 5 m. The basin west of Fire Island Inlet is not a part of the study area, but includes South Oyster Bay and portions of Great South Bay; the west basin is characterized by widths that are generally less than 2.5 km. Water depths to the west of the inlet are shallow, averaging approximately less than 1 m. Total water surface area of Great South Bay (from the Nassau County/Suffolk County border east to Smith Point) is about 285 square kilometers. (Note: the FIMP study area does not include the portions of Great South Bay west of the Nassau/Suffolk border.)

Available bathymetric data for Great South Bay, Moriches Bay, and Shinnecock Bay is generally outdated, dating back to the 1930's for some locations. Bathymetry is only regularly updated in the vicinity of inlets and navigation channels. In addition, the Marine Sciences Research Center at Stony Brook University recently collected bathymetry data in Great South Bay under contract with the State of New York, Department of State (Flood, 2003). The Stony Brook data, however, has not been reviewed or incorporated into this effort yet. Therefore, the relationship between SAV coverage and bathymetry should be assessed with caution, particularly if SAV growth appears to extend beyond the normally accepted depth range.

Figure II-1 also shows the distribution of SAV beds in the three bays according to Phase 1 (USACE-NAN, 2002) and Phase 2 (USACE-NAN, 2003) mapping efforts. The figure suggests a clear relationship between water depths and SAV beds in Great South Bay. In general, SAV beds are not present in areas deeper than 2 m below Mean Sea Level (MSL). The three largest SAV beds in Great South Bay are located over the shallowest areas: South Oyster

Bay, north of East and West Fire Islands, and along the southeastern shore of Great South Bay (from Watch Hill to Smith Point). The average bottom depth of these SAV beds is less than 1 m. As discussed above, this distribution pattern is related to light penetration and surface water turbidity levels (see water quality discussion below). These findings are consistent with previous studies published by others (Jones and Schubel, 1980 and New York Sea Grant, 2001).

Other shallow areas such as the relatively narrow strip along the northern shoreline, and along the southern shoreline from Kismet to Watch Hill appear to have very limited SAV coverage, probably due to other limiting factors such as bottom soil characteristics and exposure to waves (see discussion below).

Moriches Bay. Moriches Bay is a comparatively small estuary comprised of an ocean entrance, eastern and western connections to Shinnecock Bay and Great South Bay, respectively, and a number of tidal rivers and creeks (Figure II-1). The bay extends to Smith Point (inclusive of Narrow Bay) at its western end where it adjoins Great South Bay and to Potunk Point on its eastern end where it meets Shinnecock Bay through the Quantuck and Quogue Canals. Moriches Bay is about 22.5 kilometers long and has widths in the main body ranging from 1.2 to 4 kilometers. Widths in Narrow Bay range from approximately 300 to 1200 m. Moriches Bay has a surface area of roughly 41 square kilometers and consists of an eastern and western basin, both of which are approximately 4 kilometers wide with average water depths of approximately 2 m (Figure II-1). The mainland side of the bay features numerous streams and tidal creeks, the largest of which are the Forge River and Seatuck Creek.

SAV abundance also correlates strongly with bottom depth in Moriches Bay, with SAV extending to depths of approximately 2 m. While the data suggest that the average bottom elevation of SAV beds is deeper at Moriches (approx. 1.5 m) compared to Great South Bay (less than 1 m), this increase is likely related to increased tidal range, flushing, and water clarity (see discussion on hydraulic and water quality parameters below). Although also limited, SAV beds along the mainland shoreline appear to be more extensive than in Great South Bay, possibly due to reduced exposure to waves and improved water clarity in Moriches Bay.

Shinnecock Bay. Shinnecock Bay, like Moriches Bay to the west, is a relatively small estuary comprised of an ocean entrance, a western connection to Moriches Bay, and several tidal rivers and creeks (Figure II-1). The bay extends from the Village of Southampton to the east to the Village of Quogue to the west where it connects with Moriches Bay through the Quantuck and Quogue Canals. These canals, which are about 70 m in width and include a surface area of about 5 square kilometers in Quantuck Bay, permit water exchange between Moriches and Shinnecock Bays. The Shinnecock Canal provides navigation access between Shinnecock and Peconic Bays. Flow between the bays is limited by the presence of a lock and gates. Shinnecock Bay is about 15 kilometers in length and has widths that range from about 0.7 to 4.5 kilometers. Average water depths in the bay are about 2 m with maximum depths of approximately 4 m outside the main inlet channels (Figure II-1). The total water surface area of Shinnecock Bay is approximately 39 square kilometers.

SAV coverage appears to be less limited by water depth in Shinnecock Bay than in Moriches Bay or Great South Bay. Large beds are found along the northern edge of the inlet flood shoal, in depths ranging from 2 to 4 m. Coverage is also thick along the barrier island shoreline west of the inlet, in depths of up to 2.5 m. Note, however, that a large SAV bed mapped during Phase 1 in eastern Shinnecock Bay in depths greater than 3 m is not included in Phase 2, possibly suggesting that this area was not in fact SAV. Nonetheless, an increase in SAV depth is reasonable given that tidal range, flushing, and water clarity are greater in Shinnecock than in Great South or even Moriches Bays (see discussion on hydraulic and water quality parameters below).

2. Surficial Sediments

Sediment characteristics may also be an important environmental feature influencing SAV distribution. Available literature (Chesapeake Bay Program, 2000) suggests that maximum percent fines (i.e., silty and clay particles with a diameter of less than 0.063 mm) and organic content in surficial sediment for suitable eelgrass habitat is on the order 15% and 8.0%, respectively. On the order hand, SAV tends to accumulate fine particles due to a reduction in current velocity and wave energy within the SAV beds. Based on the work of other authors, Thayer et al. (1985) concluded that substrate type does not limit eelgrass distribution, although growth rates and plant morphology may be influenced by the physicochemical characteristics of the sediment.

Jones and Schubel (1980) mapped the texture of surficial sediments, their organic content, and the distribution of eelgrass in Great South Bay. The authors collected a total of 582 samples from April 1977 to October 1978. Information recorded at each station included depth, SAV coverage and sediment characteristics. Penetration of each sample into the sediment was 4 to 8 cm (1.5 to 3 in). The top pane in Figure II-2 shows the texture of surficial sediments in Great South Bay according to these data. The figure shows that a large percentage of the bay bottom consists of sand, particularly over the southern two thirds of the bay. Areas with high concentrations of fines are near the northern shoreline and the deeper bay areas south of Bayport, where tidal currents are slower. Other areas with high fine sediment concentrations are located in Great Cove and near the mouth of the Connetquot, Patchogue, and Carmans rivers.

Sediments along the southern portion of the bay are mostly sand, which has been transported to this area by barrier island sediment transport processes (e.g.; overwash and breaching/inlet formation).

A detailed characterization of bottom sediments throughout Moriches or Shinnecock Bays is not available outside the immediate vicinity of the inlets. However, an overall distribution pattern similar to that of Great South Bay, with finer material along the northern shoreline and sand along the southern barrier shoreline, is very likely given that the sediment transport processes that govern this distribution are similar in all three bays. Nonetheless, the relative importance of barrier island processes (particularly inlet related), has been more significant within Moriches and Shinnecock Bay in recent history, so the percentage of sandy bottom is expected to be even higher in these two bays than in Great South Bay.

The bottom pane in Figure II-2 (also from Jones and Schubel, 1980) shows the percent of combustible organic content in the surficial sediments estimated from loss on ignition (expressed as a percent of dry mass) in Great South Bay. As would be expected, high organic content generally corresponds with high percent fines.

SAV distribution in Great South Bay appears to be consistent with the fines and organic content limits stated above. Specifically, the data Jones and Schubel (1980) data indicate that the percent of fines along the southern portion of the bay is less than 5 and the percent organic is less than 1 with a few isolated exceptions. For example, the percent of fines is higher within South Oyster Bay, but still less than 15% percent, on average, particularly along the southern edge of the bay (north of Captree Island), where SAV coverage is concentrated. Conversely, a relatively high percentage of fines and organics may have contributed to the lack of SAV beds in Bellport Bay

C. Hydraulic Parameters

Tides, currents, and waves can significantly affect the suitability of a specific area to SAV growth either directly (e.g., bottom shear stresses caused by currents and waves) or indirectly through their attendant effects on turbidity and light availability (Chesapeake Bay Program, 2000). The following summarizes conditions within the three bays in the FIMP project area concerning these hydraulic parameters.

1. Tides

It has been suggested that the vertical range (distance between minimum and maximum SAV depths) that SAV beds will occur can be reduced with increased tidal range (Chesapeake Bay Program, 2000). The minimum depth (i.e., maximum elevation) of SAV beds is limited by the low tide, while the maximum depth (i.e., minimum elevation) is mostly limited by light. Presumably, light will be further attenuated as tidal range increases.

Water levels in Great South, Moriches, and Shinnecock Bays are dominated by semi-diurnal astronomical tides under normal conditions and by storm tides during northeasters and hurricanes. Astronomical tides along Long Island, New York are semi-diurnal. Bay water levels are controlled by tidal elevations at Fire Island, Moriches, and Shinnecock Inlets.

Bay tides are generally less than and lag the ocean tides. The difference between ocean and bay tides is particularly significant within eastern Great South Bay (Figure II-3). The tidal range at the ocean end of Fire Island Inlet is approximately 1.3 m. However, the ocean tidal signal is significantly muted along the long inlet throat. Recent monitoring at the Fire Island Coast Guard Station suggests a tidal range of 0.5 m at this location (i.e., a 50% reduction in approximately 5 Km) compared to bay waters in most of Great South Bay away from the inlet that have an average tidal range on the order of 0.3 m, i.e., a 70% reduction. Tidal prism discharge through Fire Island Inlet is the order of 65 million cubic meters. The average tidal prism in the bay is approximately 0.3 m.

The tidal range at the ocean side of Moriches Inlet is approximately 1.1 m; the range is decreased to 0.75 m across the inlet near the Coast Guard Station (Figure II-3). In areas removed from the inlet, such as Potunk Point and Mastic Beach at the eastern and western limits of

Moriches Bay, respectively, the range is decreased to 0.5-0.6 m. The estimated average tidal range in Moriches Bay obtained using recent available tidal records is approximately 0.6 m. Tidal prism is estimated to be approximately 37 million cubic meters.

The reduction in tidal range within Shinnecock Bay is much less pronounced due to the configuration of the inlet and flood shoals. The range goes from approximately 1 m at the ocean side of the inlet, to 0.8 m in the vicinity of the Ponquogue Point (Figure II-3). The tide range in the bay averages approximately 0.9 m. The estimated tidal prism is approximately 37 million cubic meters.

SAV distribution, also shown in Figure II-3, does not appear to correlate with a specific tidal range as SAV beds are found in areas with tidal ranges from the minimum (0.3 m in Great South Bay) to the maximum (0.9 m in Shinnecock Bay) observed in the FIMP area. Nonetheless, it appears that SAV beds extend into deeper water in areas where the tidal range is greater. This relationship may be due to increased light penetration and increased flushing in the bay as a result of increased tidal prism (see water quality discussion below). SAV beds are precluded from intertidal areas where breaking waves and other physical stresses (e.g., ice and desiccation) are significant. This effect is clearly observed in the SAV coverage data for the FIMP study area. In Great South Bay, where the tidal range is relatively small (0.3 m), SAV beds are located closer to the shoreline than in Moriches or Shinnecock Bays, where the tidal range, and thus the intertidal fringe, is larger.

2. Currents

Peak tidal currents in Great South, Moriches, and Shinnecock Bays are shown in Figure II-4. Values shown in this figure are based on model results from a Delft3D hydrodynamic model of the three bays built in support of storm surge modeling efforts for the FIMP Reformulation Study. Maximum velocities are always at the inlet mouth, where values exceed 1.5 m/sec. Peak velocities in the bays away from the inlets are typically less than 0.2 m/sec, which is significantly lower than maximum velocity constraints for SAV survival found in the literature, that ranges from 0.5 to 1.8 m/s (Chesapeake Bay Program, 2000).

Within the FIMP study area, SAV beds are generally located in areas of reduced flow velocities away from the tidal channels, although some coverage is observed along the relatively shallow channel located northeast of Moriches Inlet, where the peak tidal velocities are on the order of 0.7 m/s. Another example of SAV beds situated in relatively high currents is the area immediately west of Ponquogue Bridge in Shinnecock Bay, where peak tidal velocities are close to 0.7 m/s. These data suggest that the maximum velocity threshold might be close to 1 m/s, which also happens to be a typical threshold of motion for sandy sediments.

3. Wind Generated Waves

Waves can increase turbidity in the water column, scour bottom sediments, or uproot SAV beds. Waves within Great South, Moriches, and Shinnecock Bays are generated by local winds. Ocean waves only affect areas in the immediate vicinity of the inlets. Typically, these areas are also deep and exposed to relatively high currents, which also constrain SAV growth

(Chesapeake Bay Program, 2000). Therefore, the following discussion focuses on wind-generated waves within the bays.

On an annual basis the prevailing winds along the south shore of Long Island are from the southwest (Table II-2). On a seasonal basis, the prevailing winds are from the southwest from April through October, from the west in November and December and from northwest in January, February, and March. Over 50 percent of winds exceeding 32 knots were from the west and northwest, with similar winds from the east, southeast and south totaling about 20 percent.

Representative areas susceptible to storm wave activity in Great South, Moriches and Shinnecock Bays were identified in a previous report prepared for the FIMP Reformulation Study (USACE-NAN, 1998a). The areas selected for examination in that report are listed in Table II-3. Note that these locations were selected based on susceptibility to storm damage and not presence of SAV beds. Nonetheless, the wave hindcast captured a range of wave exposure conditions, including different wave exposure directions, estuary positions and fetch lengths. As a result, wave hindcast results are available for numerous estuary locations, including both mainland and barrier island shorelines. These data may be used to provide some insight into expected wave conditions and its effects on SAV beds.

Maximum fetch distances were determined for each hindcast location, based on procedures in the Shore Protection Manual (SPM) (USACE, 1984). Maximum fetch distances corresponding to principal wave exposure directions per site were radially averaged based on eight increments of 3 degrees centered about the maximum wave exposure direction. Radially averaged fetch lengths are listed in Table II-3, along with a representative average water depth within the wave generation area. Wave hindcasts were performed using design wind speeds developed using extreme value analysis of available wind records.

Computations were conducted by combining wind-frequency relationships with estimated fetch lengths and storm-induced water depths. Results of wave hindcast are summarized in Table II-4. This table represents the existing condition mean wave height and period for each site and three selected return periods, 2, 25 and 100 years. The 2-yr wave heights can be considered representative of normal storm conditions in the area, and thus are probably a good estimate of the wave climate that controls SAV growth for a specific area of the bay.

Wave hindcast results suggest that 2-yr return period wave heights vary between 1.1 and 2.5 feet, depending on fetch and direction of exposure to winds. Relatively protected areas such as Bellport, Orchard Neck Creek, and Weeks Creek in Great South Bay, Moriches Bay, and Shinnecock Bay, respectively, have 2-year waves at the lower end of this range. On the other hand, Great South Bay locations such as Nicoll Point (at Heckscher State Park), Cherry Grove, and Shirley are more exposed and 2-yr waves are over 2 feet. Therefore, wave conditions in existing SAV areas are also likely to be on the lower end of this range. For example, the fetch over SAV beds in South Oyster Bay is comparable to that at Brightwaters or Berry Point, so waves are likely to be on the order of 1.8 ft or less.

SAV areas north of East and West Fire Islands appear to be slightly more exposed to wind-generated waves, but not to an extent sufficient to preclude SAV growth. SAV areas in eastern

Great South Bay, although somewhat exposed to prevailing southwest winds, are relatively well protected from strong northwest and southeast winds, allowing for increased SAV coverage in this area relative to other, more exposed, areas along Fire Island's bay shoreline."

In general, fetch distances are significantly smaller within Moriches and Shinnecock Bays (Table II-3). Therefore SAV coverage is not constrained as much by waves. As a result, SAV coverage appears to be more spatially uniform in these two bays than in Great South Bay, particularly along the barrier shoreline (Figure II-1).

D. Water Quality

1. Land Use and Known Pollutant Sources

Land use and associated pollution sources affect regional water quality, establishment of SAV beds and the potential for impaired water quality and planktonic blooms. The Long Island South Shore Estuary Reserve (SSER) Comprehensive Management Plan (CMP) project area encompasses the FIMP Reformulation Study area and serves as an excellent source of information regarding historic land use, and both point and non-point pollution sources within the study area (South Shore Estuary Reserve Council, April 2001). NYSDOS conducted a land cover study utilizing satellite imagery to characterize the SSER, to measure the extent of land cover changes between 1984 and 1994, and to estimate the potential for non-point pollution (NYSDOS, 1997). This data was compiled by NYSDOS onto a map of "Non-Point Pollution Potential" for the SSER. On an additional set of maps, NYSDOS compiled data on bay water depths, impaired waterbodies, and point source discharges. Two point source discharges are indicated on these maps: the outfalls from the Ocean Beach and Patchogue Sewage Treatment Plants (STPs).

Land Use. The NYSDOS land cover study indicated that the extent of woodland and grassland cover throughout the SSER project area decreased significantly during the late 80's to early 90's. This was largely due to increased development in the eastern towns of Brookhaven, Southampton and East Hampton. However, land uses within the Town of Islip did not change significantly, since the area was primarily built out previous to 1984 (Roy Fedelem, Pers. Comm. Dec. 2003). Increased concentrations of high-density housing, commercial and industrial uses often indicate where water quality problems exist. This is evident in the NYSDOS Non-Point Pollution Potential map that indicates a reduction in potential non-point pollution as one proceeds from the highly developed areas in the west to the more open areas in the east. The NYSDOS map also identifies many stream and river outlets (i.e., Watchogue and Pentaquit Creeks in Bay Shore, Green Creek, Brown Creek, Tuthill's Creek, Patchogue and Swan Rivers, etc.) as sources of high pollution potential. The NYSDOS map indicates that this trend often continues from the outlet upstream into the developed portions of the watershed. Overall, however, the number of outlets and upstream areas labeled as high pollution potential also decreases from west to east along the south shore of the mainland.

The NYSDOS Non-Point Pollution Potential map also exhibited several areas of non-point source pollution potential on the north side of Fire Island, which closely correlates to the developed portions of the barrier (i.e., Robert Moses Sate Park, Ocean Beach, Ocean Bay Park, and Davis Park). Further east to William Floyd Parkway, the pollution potential declines due to the presence of the Fire Island National Seashore (FINS) Wilderness Area immediately west of the Parkway. However, pollution potential increases along the northern side of the barrier island from William Floyd Parkway to the easterly side of Shinnecock Bay.

SAV. A comparison of the 2001 USACE SAV maps to the NYSDOS maps did not reveal any general trends or relationship between land cover and pollution potential with SAV bed distribution. This suggests that there may not be a direct link between non-point source pollution potential, STP outfalls, and SAV beds. While it was anticipated that few to no SAV beds would be present near the STP outfalls and areas of high non-point pollution or areas earmarked for priority stormwater remediation, this was not the case throughout the project area. For example, a relatively large SAV bed is present directly north of the Ocean Beach STP outfall. Spotty SAV vegetation is present directly south of the Patchogue STP outfall with little to no beds to the west, yet increasing SAV coverage to the east. Areas of high (85-100%) non-point pollution potential near Smith Park County Marina maintain SAV beds. Terrell River (located between Davids and Radio Points off of Moriches Bay), which was identified by NYDOS as a priority area for stormwater remediation, maintains SAV coverage at its mouth and upstream while areas elsewhere on the south shore of the mainland support little to no SAV beds. This suggests that other factors are overriding the effects of land development and pollution sources in determining SAV bed distribution in the FIMP study area.

As stated in previous sections, SAV beds may have historically fringed the south shore of the mainland from Howell's Point in Bellport west to the Robert Moses Causeway, with isolated SAV patches fringing the northern side of Great South Bay at tidal creek and canal outlets. Presently, these SAV patches have either shrunk or disappeared. Non-point source pollution potential is generally high along the south shore of the mainland (60-70%) and highest (85-100%) at many creek and river outlets, possibly stressing the SAV beds over time. However, the absence of any trends in SAV occurrence and non-point source potential due to land use changes, suggests that the loss of SAV is more likely due to other physiological factors and/or their synergistic effect.

Algal Blooms. Over 155 species of phytoplankton have been reported as occurring in the New York Bight and provide an important function as primary producers in the estuarine food chain. The nutrients limiting phytoplankton growth include nitrogen (NO_3, NH_4), Phosphorous (PO_4) and Silica (Si).

In shallow and nutrient rich waters such as Great South Bay, algal blooms often become problematic in midsummer to late fall each year. Dense algal blooms can significantly affect the growth of shellfish, lead to oxygen depletion and affect the growth of SAVs by limiting light penetration. In the early 1950's, dense blooms of "green tide" caused by the algae *Nannochloris* sp. and *Strichlococcus* sp. were noted in Great South Bay, primarily triggered by nitrogenous effluents from duck farms. These green tide events diminished after 1953, when such effluent streams were restricted and Moriches Inlet opened allowing increased tidal flushing. Great South Bay was again affected in 1985 by a "brown tide" bloom caused principally by the species *Aureococcus anophagefferens*. Although the exact cause of these brown tide events has not been ascertained, it has been shown in laboratory experiments that this species responds favorably to increases in salinity, organic nutrients and inorganic micronutrients. The scientific community presently believes that "brown tide" blooms occur when a significantly dry year follows a significantly wet year (USACE-NAN, 1999d). New York Sea Grant reports that "brown tide" events have occurred primarily in Great South Bay, but have also recently appeared in Moriches and Shinnecock Bays, as follows (New York Sea Grant, March, 1998 & November 2000):

- 1985 – GSB
- 1986 – GSB
- 1988 – GSB, MOR, SH
- 1991 – GSB, MOR, SH
- 1992 – GSB, MOR, SH
- 1993 – GSB
- 1994 – GSB
- 1995 – GSB, MOR, SH
- 1997 – GSB, MOR, SH
- 1999 - GSB, MOR, SH
- 2000 – GSB

2. Water Quality Parameters

Long-term water quality data has been obtained from the Suffolk County Department of Health Services (SCDHS), Office of Ecology, Hauppauge, New York. The data consist of salinity, temperature, secchi depth (water clarity), dissolved oxygen (DO), and various other water quality and nutrient parameters collected between 1977 and 2000. Measurements were taken on a monthly to annual basis. The following paragraphs focus on the spatial distribution of the average value of salinity, temperature, secchi depth, and DO, and its relationship to existing SAV bed distribution. Seasonal trends, however, were not specifically assessed.

Data collected from 21 stations in Great South Bay, 12 stations in Moriches Bay, and 10 stations in Shinnecock Bay were analyzed. Stations are shown on Figure II-5. Average and standard deviation values of salinity, temperature, DO, and secchi depth at each station were computed as part of this study and are summarized in Tables II-5 through II-7. The spatial variability of average salinity, temperature, DO, and secchi depth is shown in Figures II-6 through II-9.

a. Salinity

Eelgrass shows a salinity preference from the mid to high range of 20-30 ppt (i.e., polyhaline conditions), and exhibits reduced vigor at lower salinity levels. This decreased tolerance to low salinity levels limits eelgrass distribution to only salt and brackish water environments and excludes it from freshwaters (USACE-NAN, 2002).

SCDHS data indicates that average salinity conditions within the three bays fall within the 20-30 ppt range. However, spatial and temporal salinity values in Great South Bay may vary significantly as a result of freshwater inflows (Figure II-6). The effects of Carmans River in eastern Great South Bay near station 110 and the Connetquot River in the middle of the bay near station 160 are particularly noticeable. As a result of river discharge and reduced tidal exchange, average salinity values in eastern Great South Bay are lowest for the study area (~24 ppt). Standard deviations (representative of the temporal variability) are also higher at these two locations. Average salinity levels are higher closer to the inlet and within South Oyster Bay, which is flushed by both Fire Island Inlet and Jones Inlet to the west. Salinities within Moriches and Shinnecock Bays are closer to ocean levels due to increased tidal mixing with ocean water penetrating through the inlet, and reduced average freshwater discharge into these two bays (Figure II-6).

Although SAV light and nutrient requirements might be influenced by salinity levels (Chesapeake Bay Program, 2000), the relationship is poorly defined within the relatively narrow range of average salinities in the FIMP study area. Therefore it is difficult to draw any conclusions regarding a direct correlation between salinity and SAV distribution. Note, however, that higher salinities are typically indicative of increased ocean and bay water exchange, which typically results in improved water clarity. Correlation between water clarity (secchi depth) and SAV distribution is addressed below.

b. Temperature

Surface water temperature is an important factor influencing eelgrass distribution for several reasons including reproduction (USACE-NAN, 2002). Within its Atlantic coastal range, eelgrass prefers water that has an average temperature ranging between 10°-20°C. Bay surface water temperature is dictated by a balance between ocean water, freshwater, and solar radiation. Spatial and temporal distributions of temperature in the bays are dependent upon: (1) season, and (2) exchange rate of ocean and bay waters through tidal inlets.

SCDHS data indicate that average ocean temperature increases from east to west (from 12 to 15°C), and the average temperature within the bays also follows this trend (Figure II-7). The data presented in Figure II-7 also suggest that average temperatures tend to increase with distance from the inlet, particularly within Great South Bay (from 15°C at the inlet to 17°C at Smith Point). This gradient can be partly attributed to the majority of the temperature measurements occurring during the late spring, summer, and early fall months at which point the bay is warmed slightly more than the ocean due to solar radiation.

Average temperatures in Moriches and Shinnecock Bays are at the lower end or below the average temperature requirement, particularly near the inlets. Temperatures in Great South Bay are slightly higher. Nonetheless, there does not appear to be a strong direct correlation between spatial temperature distribution and SAV coverage in the study area.

Note, however, that temporal variability, and particularly extreme temperatures held over a relatively long period of time, can lead to SAV demise. The abnormally high temperatures of the summer of 1977 and the documented decline in SAV abundance are an example of this effect.

c. Water Clarity (Secchi Depth)

In general, there is a strong positive correlation between water clarity and the maximum depth to which SAV beds grow (Thayer *et al.,* 1984). Secchi depth measurements are typically used to gauge water clarity by measuring the depth at which a white disk is no longer visible from the surface. Figure II-8 shows average secchi depth values based on measurements collected by SCDHS for the three bays. As expected, average secchi depth is greatest, that is, the water is clearest, in the vicinity of the inlet (8-10 ft, 2.5-3 m). Away from the inlets secchi depth is reduced considerably (2-4 ft, 0.6-1.2 m), particularly within Great South Bay, where the tidal exchange is relatively limited compared to Moriches and Shinnecock Bays. Shinnecock Bay has the greatest average secchi depths ranging from 6-8 ft, or 1.8-2.5 m, for over 50% of the bay as a result of increased ocean and bay water exchange.

The relationship between water clarity and maximum depth of SAV is also evident in the study area, as the maximum depth of SAV growth increases from Great South to Moriches and Shinnecock Bays (see bathymetry discussion above). In Shinnecock Bay, large SAV beds are found along the northern edge of the inlet flood shoal, in depths ranging from 2 to 4 m (note uncertainty regarding the SAV bed northeast of the inlet). As shown in Figure II-8, this area has the highest secchi depth values (i.e. water clarity) in any of the three bays.

Available SAV mapping (see above) suggests that coverage, as a percentage of total bay area, is also greater within Moriches and Shinnecock Bay than within Great South Bay. This may be at least partly due to increased water clarity.

d. Dissolved Oxygen (DO)

Average dissolved oxygen values based on SCDHS measurements are presented in Figure II-9. Values are around 8.5 mg/L, well above the EPA-specified criterion of 4.8 mg/L for chronic and acute effects (USEPA 1999). Standard deviations are also relatively small (typically less than 2 mg/L). More importantly, as opposed to salinity, temperature, or water clarity, there does not seem to be a relationship between tidal exchange and DO levels. Conditions are very similar in the three bays and in areas close and away from the inlets. Therefore, DO probably has very little effect on spatial SAV distribution.

E. Historic Overwash and Breaching

The severity of economic storm damages in the areas surrounding Great South, Moriches and Shinnecock Bays is strongly dependent on the integrity of the barrier islands from Fire Island Inlet to Southampton. In this regard, overwashing and/or breaching of the barrier islands can exacerbate storm damages as bay storm tide elevations are increased. Reduction of overwashing/breaching frequency and severity are, consequently, principal goals of the Reformulation Study. On the other hand, barrier island overwashing and breaching also contribute to natural barrier island changes. Alteration of the beach may change these natural processes, affecting the integrity of the barrier island system and environmental resources in the study area, including SAV beds.

1. Historic Overwash

Estimates of overwash quantities for historic storms indicate annual overwashed sediment volumes between 139,000 and 385,000 cubic yards per year (cy/yr) between 1938 and 1962 (USACE-NAN, 1999c). The total land area subject to overwash averages about 115 acres/yr or approximately two percent of the barrier island land area between Fire Island Inlet and Southampton. Areas most subject to overwash between 1938 and 1962 were Tiana Beach, Westhampton (East) and Robert Moses State Park (Kana, 1985).

Overwash volume estimates indicate approximately 39,500 cy/yr covering 10.3 acres/yr for the period between 1980 and 1995. The sites most subject to overwash were Shinnecock Inlet (West); Tiana Beach; Smith Point Park; and Westhampton (West), the site of the 1992 breach. This is markedly lower than the 1962-1980 period, which is dominated by the Hurricane of 1938. Estimates between 1962 and 1980 are not presented due to a lack of available data, but it is noted that major storms were generally absent during this period.

Overwash has been identified as a source of sediments to the barrier island that can contribute to elevation changes (Leatherman and Allen, 1985). Depending on the storm magnitude and island width, overwash areas of newly transported sand may penetrate no further than the dunes, or may be spread onto the marshes or into the bay. In general, however, major overwashes extending into the bay occur only during exceptionally severe storms. Therefore, overwash has a more significant impact on subaerial and intertidal barrier island resources (e.g., backbay marshes) than on SAV beds, which are typically located farther away from the barrier island shoreline. Depending on the pre- and post-storm backbay depths and presence or absence of SAV beds prior to the storm, large overwashes that penetrate far into the backbay may bury these existing SAV beds or may generate sandy substrate at depths suitable for SAV growth.

2. Historic Breaching

According to records dating to the 16th century, numerous breaches and inlets areas have existed along the study area. The recent stability of the three existing inlets is largely due to Federal maintenance and stabilization efforts that have included dredging of navigation channels and jetty construction (USACE-NAN, 1998b).

Figure II-10 summarizes the inlet and breach history for the study area in terms of location and approximate periods during which the inlets existed. It is evident that inlets and breaches are ephemeral in the absence of inlet maintenance and/or stabilization efforts, and that long periods of multiple inlets to any single estuary are rare. On the other hand, long periods characterized by no inlets have been experienced, although only at Moriches and Shinnecock Bays. This history suggests that the estuaries in the study area are generally incapable of supporting multiple inlet openings. However, it must be stated that breaches since the Hurricane of 1938 have typically been closed artificially rather than by natural processes. Nonetheless, historic observations suggest the existence of a ceiling on sustainable inlet areas and, therefore, on maximum tidal exchange (USACE-NAN, 1998b).

During a breaching event, the fate of sediments displaced from the barrier island depends largely on how the barrier island breached (i.e.; oceanward or bayward). When a breach opens via ebb flows (bayward), the displaced sediments are moved offshore. When a breach opens due to overwash and storm flows from the ocean side, displaced sediments are moved into the adjoining backbay. Breaches that remain open, however, have the greatest influence on sediment transport dynamics by redirecting/trapping longshore sediment transport into ebb and flood shoals during the period that the breach remains open (USACE-NAN, 1999c). Flood shoals serve as platforms for new marsh development. Most of the marshes in Great South, Moriches, and Shinnecock Bays are associated with former flood shoals (Leatherman and Allen, 1985).

Depending on elevation, these shoals might also support SAV growth. In fact, relatively shallow bay areas and SAV beds in the three bays generally correlate with relict inlet flood shoals. Specific examples include SAV beds north of Captree, Sexton, East and West Fire Islands, all in the vicinity of historic Fire Island Inlet locations. SAV beds are also located along the southern shoreline of Great South Bay, near two former inlets: Old Inlet (1763-1825), and Smith's Inlet (1773-1834). SAV beds appear to be clustered between West Inlet Island and East Inlet Island, an area that is part of the historical flood shoal complex at Moriches Inlet. Substantial SAV coverage was noted to the west of Moriches Inlet, between two former inlets: one south of Pattersquash Island referred to as the Mastic Gut (1773-1829) and one referred to as the Hallets Inlet (1788-1833). Finally, substantial SAV coverage appears to occupy the northern half of the existing flood shoal north of Shinnecock Inlet as well as areas near the historic inlet locations to the west.

Differences in the habitat requirements of eelgrass and widgeon grass will affect the distribution of each following a breaching event. Widgeon grass is adapted to withstand a wide range of salinities, which would be typical of the gradual water fluctuations in a tidal pool that result from evaporation and periodic flooding. However, widgeon grass does not tolerate rapid changes in salinity and turbulent water conditions that would result from a breach. It is likely, therefore, that this species would disappear from the backbay area immediately surrounding the breach location. Conversely, eelgrass is more tolerant of rapid salinity changes, has a more extensive rhizome system, and is likely to be less affected by a breach than widgeon grass. In a concurrent study of vegetative patterns associated with breach and overwash events, widgeon grass appears to have established itself in the quiescent bay area of Old Inlet, which was impacted by historic overwash (USACE-NAN, 2004, in development)

Notwithstanding the above positive effects, the short-term impacts of breaches and new inlets, such as the scouring or smothering of SAV beds by the formation and evolution of new channels and flood tidal shoals, can also result in negative effects (Cashin Associates, 1993 and USACE-NAN, 1999c). If a breach occurred through the barrier at a point where extensive SAV beds currently exist, it could theoretically destroy a significant area of SAV. However, SAV beds may re-establish on the bayside deposits over time, once the breach is closed. If the breach remains open and forms a new inlet, the new inlet flood shoal could potentially support new SAV beds that could presumably compensate for those destroyed by the breach. Tidal current velocities and depths, however, would be too great to support an SAV environment in the immediate vicinity of the new inlet (i.e., inlet throat and adjacent flood/ebb channels).

More importantly, it is very unlikely that two inlets would remain open in any one bay. If both inlets did remain open, the area of the existing inlet will most likely decrease to maintain a total inlet area comparable to pre-breach conditions. Tidal flows to the estuary may, however, be reduced due to increased frictional effects through smaller inlets (USACE-NAN, 1998b). Therefore, initial increases in tidal flushing and water clarity that are likely to benefit eelgrass growth would not continue in the long-term. This effect is currently under examination by USACE near the Pikes Breach at Westhampton. In 1998, new eelgrass shoots appeared in the vicinity of the 1992 breach. However, based on subsequent investigations, the substrates appeared to have shifted, thus promoting development of macro-algae blooms and loss of these eelgrass patches.

Inlet stabilization and shoreline protection, which have arguably reduced breaching, have not necessarily precluded bay deposition. Total bay deposition quantities may have actually been greater due to inlet stabilization and the concentration of flood shoals near the inlets. In other words, stabilized inlets may lead to limited bay deposition elsewhere while quantities adjacent to the inlets exceed those that would otherwise occur in the absence of stabilized inlets. It is not possible to predict what the net effect of inlet stabilization would be on total SAV coverage in the study area bays.

Finally, it should be noted that jetty construction and dredging have resulted in the relative stability of the inlets. This stability has led to an increase of bay flushing relative to pre-stabilization conditions because the maintained inlets permit the continual exchange of bay and ocean waters. In contrast, unstabilized inlets are vulnerable to closure as evident from inlet records. For instance, no inlets to Moriches Bay existed for a period of nearly 100 years from 1839 to 1931. It is safe to assume that eelgrass was absent from the bay during this period due to low salinity and water clarity conditions. Furthermore, estuary records available for the majority of the 20th century indicate that tidal ranges for Moriches and Shinnecock Bays have constantly increased, presumably improving water quality in the bays. However, the hydraulic efficiency of Fire Island Inlet has probably diminished over the last few decades as a result of continued shoaling at the inlet throat and only limited maintenance (USACE-NAN, 1999b), which has resulted in reduced bay flushing and most likely reduced water clarity. The latter might be one of the factors that have contributed to the loss of SAV beds fringing the mainland south shore.

F. Summary and Conclusions

A summary of available SAV mapping and physiological data within Great South, Moriches, and Shinnecock Bays, including a discussion of historic overwash and breaching, has been presented. These data were used to describe the habitat requirements for SAV, and to identify potential relationships between habitat requirements and historic and/or existing SAV coverage. As noted above, however, historical documentation and mapping of SAVs in the South Shore embayments is lacking, with the exception of Great South Bay where two historical studies have been conducted by the Marine Sciences Research Center (MSRC) (Greene, et. al., 1978 and Jones and Schubel, 1980). These historical data were supplemented by a recent SAV delineation in Great South Bay, Moriches Bay and Shinnecock Bay conducted by the USACE as part of the FIMP Reformulation Study and based on photographic interpretation and subsequent field reconnaissance. Conclusions are as follows:

Previous Mapping. The SAV mapping in Great South Bay conducted by the MSRC in the late 1970's corresponds generally well to the recent mapping conducted by the USACE. Specifically, the western portion of Great South Bay appears to continue to support extensive eelgrass beds to the north and west of Captree Island and northeast of East Fire Island. The eastern portion of Great South Bay also continues to support expansive eelgrass beds, particularly from Davis Park eastward to Smith Point. However, it appears that over the past 25 years, there has been a loss of SAV beds fringing the mainland south shore or northerly side of Great South Bay from Howell's Point in Bellport west to the Robert Moses Causeway. The exact causes are unknown, but it is likely tied to increased environmental stresses on SAV beds that were formerly occupying less than optimal substrate conditions.

Physical Parameters. Eelgrass distribution in the south shore embayments appears to be strongly correlated with depth (generally less than 2 meters) and a combination of environmental factors. The SAV beds appear to be confined to shallower depths (1-meter average depth in Great South Bay for the largest beds) in areas of reduced light penetration as a result of poor tidal flushing or presence of fine sediments in the bottom substrate. The SAV beds are found at greater depths (1.5 meters in Moriches Bay, and 2-4 meters in Shinnecock Bay) subject to more flushed bay conditions and clearer water.

Hydraulic Parameters. The SAV beds are generally located further bayward in areas subject to a greater tidal fluctuation (e.g.; Moriches and Shinnecock Bays). Additionally, there may be a threshold of current velocity that limits the distribution of SAV beds. Although not specifically tested, from the available data it appears this threshold may be approximately 1 m/sec.

The SAV beds in the FIMP study area are typically located away from the inlet throat and ebb/flood channels. This may be due to excessively deep waters coupled with swift currents and possible exposure to ocean waves. The SAV distribution also appears to be more constrained in waters with a greater fetch distance (e.g., Great South Bay) and more spatially uniform in waters with a reduced fetch distance (e.g., Moriches and Shinnecock Bays). A similar pattern emerges when studying the distribution of intertidal and emergent wetlands.

Water Quality Parameters. Point and non-point pollution sources do not appear to directly affect SAV distribution. However, the effects of increased urbanization in adjacent land areas may induce secondary impacts on SAV beds, associated with decreases in water quality.

Salinity gradients alone do not appear to directly affect SAV distribution in the FIMP study area. However, a shift in representative SAV species may occur, with a greater representation of widgeon grass in more brackish waters. Furthermore, higher average salinities are typically indicative of increased tidal flushing and improved water clarity, which may lead to SAV growth extending to lower depths (e.g., Moriches and Shinnecock Bays).

There is a positive relationship between water clarity and the maximum depth to which SAV beds grow in the study area. Data also suggests that SAV coverage is greater within

Moriches and Shinnecock Bay than within Great South Bay. This may be at least partly due to increased water clarity.

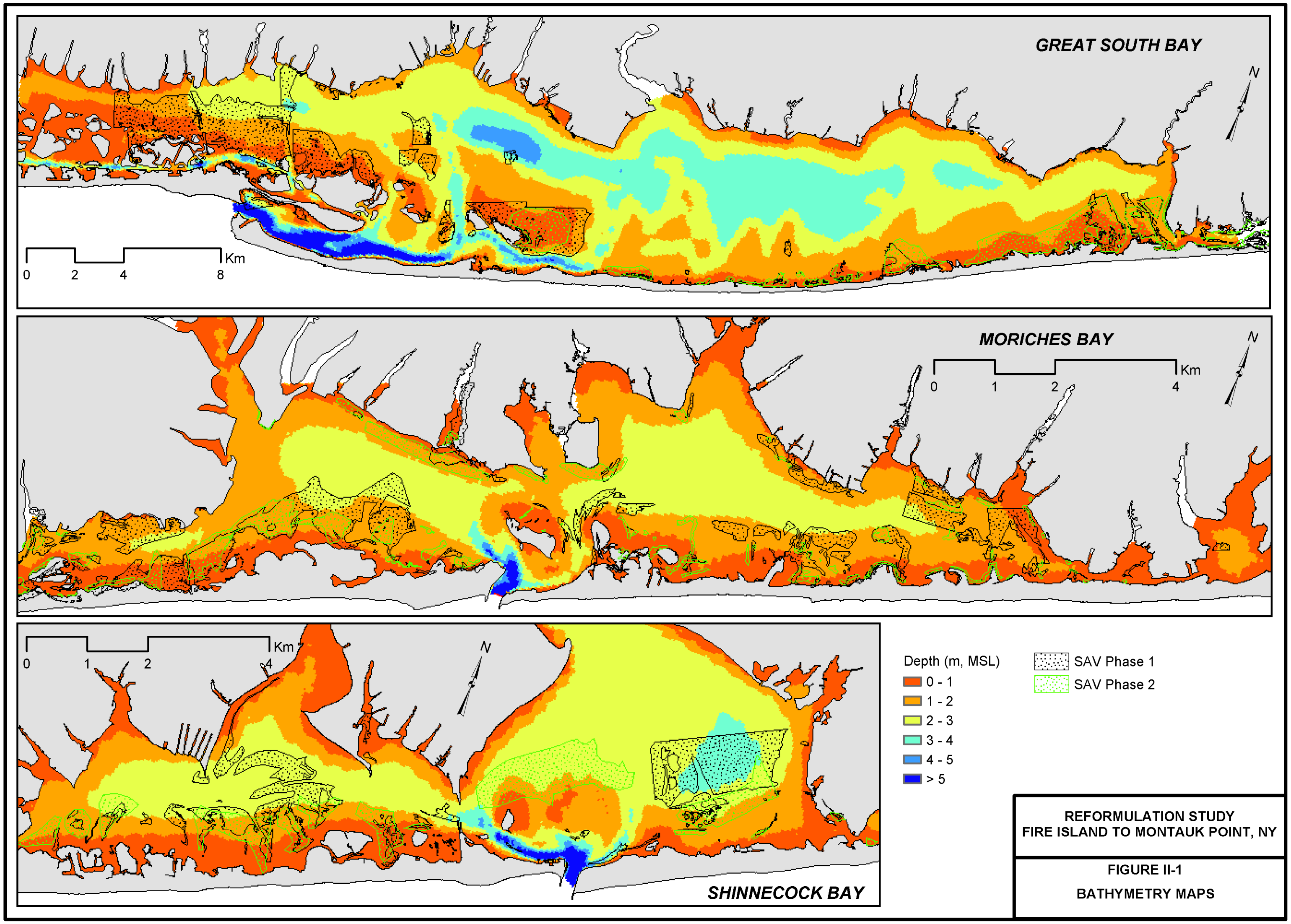
DO conditions are very similar in the three bays and in areas close and away from the inlets; therefore there is very little correlation between average DO levels and SAV coverage.

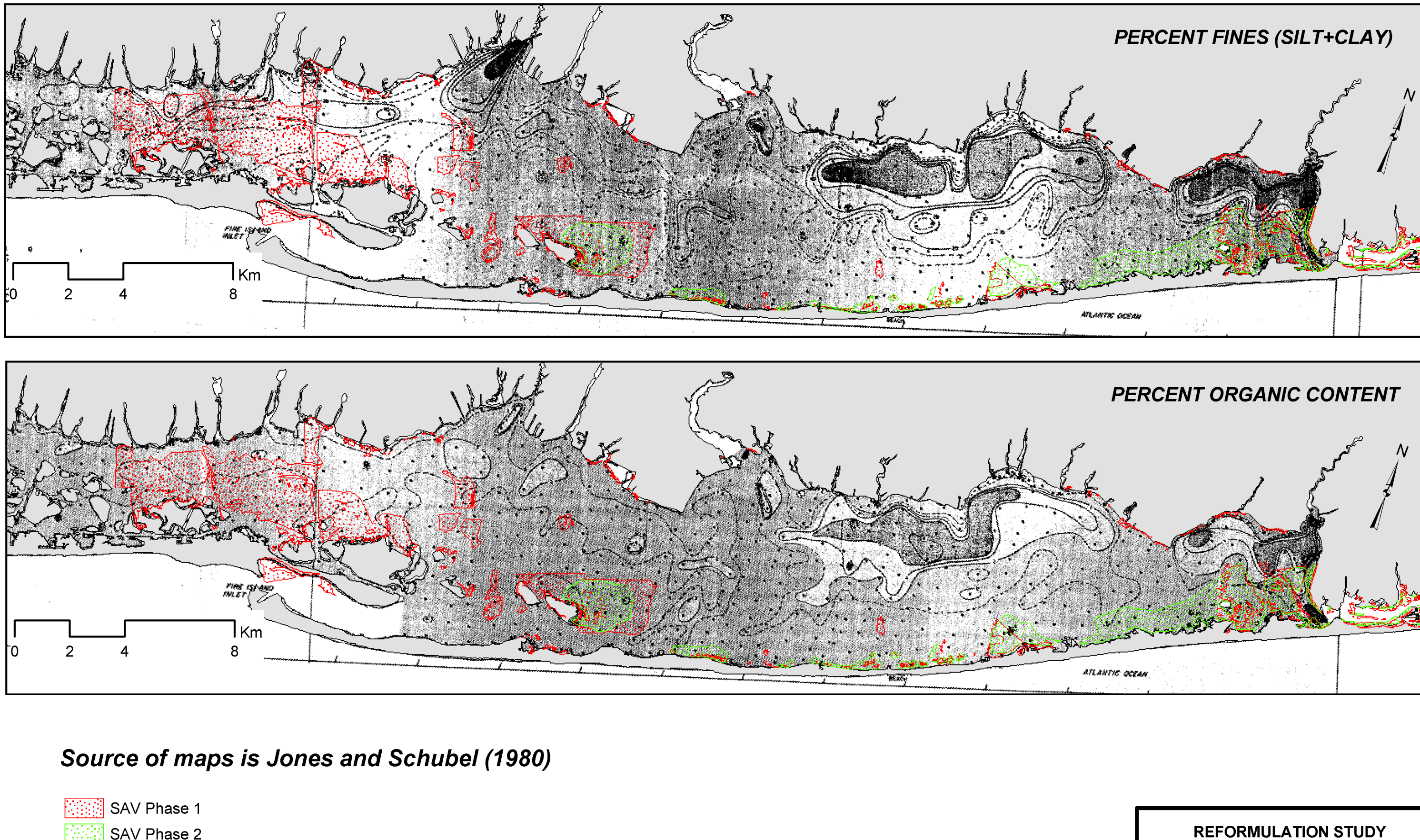
Historic Overwash and Breaching. Overwash has been identified as a source of sediments to the subaerial and intertidal sections of the barrier island (e.g., backbay marshes). In general, however, overwashes extending into subtidal backbay areas occur only during exceptionally severe storms. In addition, these large overwashes are more likely to negatively impact existing SAV beds than to generate a net increment in areas suitable for SAV growth.

Flood shoals created by breaches during storms and new inlets serve as platforms for new marsh development. Depending on elevation, these shoals might also support SAV growth. Existing SAV beds occupying relatively shallow areas in Great South, Moriches and Shinnecock Bays generally correlate with relict inlet flood shoals. However, storm breaches and new inlets may lead to the scouring or smothering of these SAV beds. In other words, depending upon the location of the breach, SAV beds will either be created or destroyed by such an episodic event. If the breach occurs at a point where major SAV beds previously existed, then the breach is likely to destroy the SAV beds immediately in its path. However, if the breach creates a flood shoal at an adequate depth to support SAVs, a new SAV bed may establish over time. The lack of historic SAV mapping that could be correlated to historic breaching prevents a more conclusive assessment regarding the net effects of breaching on SAV distribution.

It is very unlikely that two inlets would remain open in one single bay. If they do, however, tidal flows would be noticeably reduced due to increased frictional effects through smaller inlets. Therefore, the initial increases in tidal flushing and water clarity that are likely to benefit SAV growth would not continue in the long-term. These beneficial effects might actually be reversed unless at least one of the inlets is maintained through regular dredging.

There is insufficient historic bathymetric data to speculate what the net effect of inlet stabilization has been on overall sediment accumulation in the bays. Although stabilized inlets might have reduced the potential for breaching and related bayward sediment transport at other barrier island locations, they might have also increased the amount of transport to the adjacent inlet flood shoals relative to a hypothetical natural inlet. More importantly, stable inlets have led to significant increases in bay flushing and water quality relative to pre-stabilization conditions at Moriches and Shinnecock Bays.

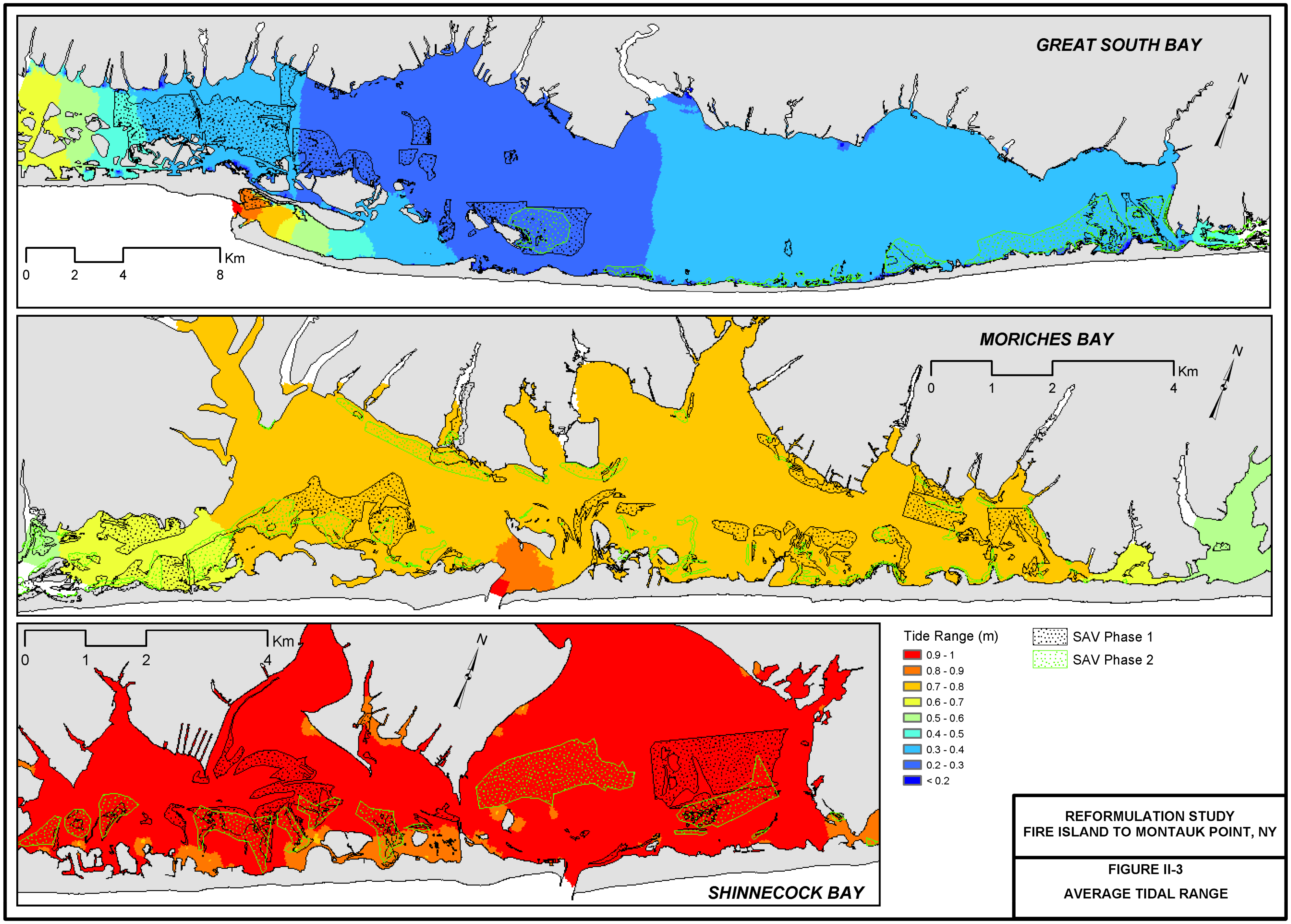

GREAT SOUTH BAY
Km
0 2 4 8
N
MORICHES BAY
Km
0 1 2 4
N
SHINNECOCK BAY
Km
0 1 2 4
N
Depth (m, MSL)
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
SAV Phase 1
SAV Phase 2
REFORMULATION STUDY
FIRE ISLAND TO MONTAUK POINT, NY
FIGURE II-1
BATHYMETRY MAPS

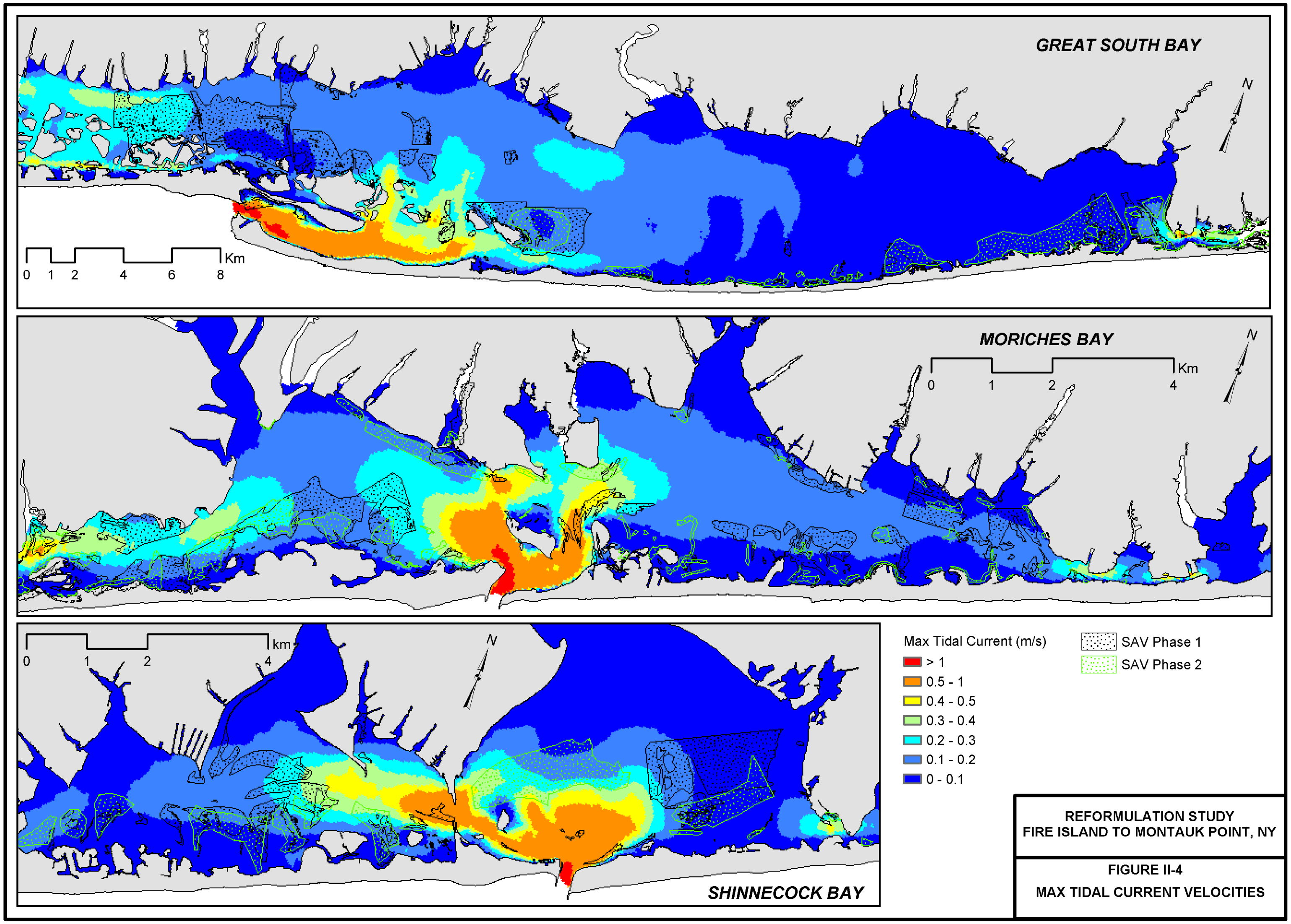


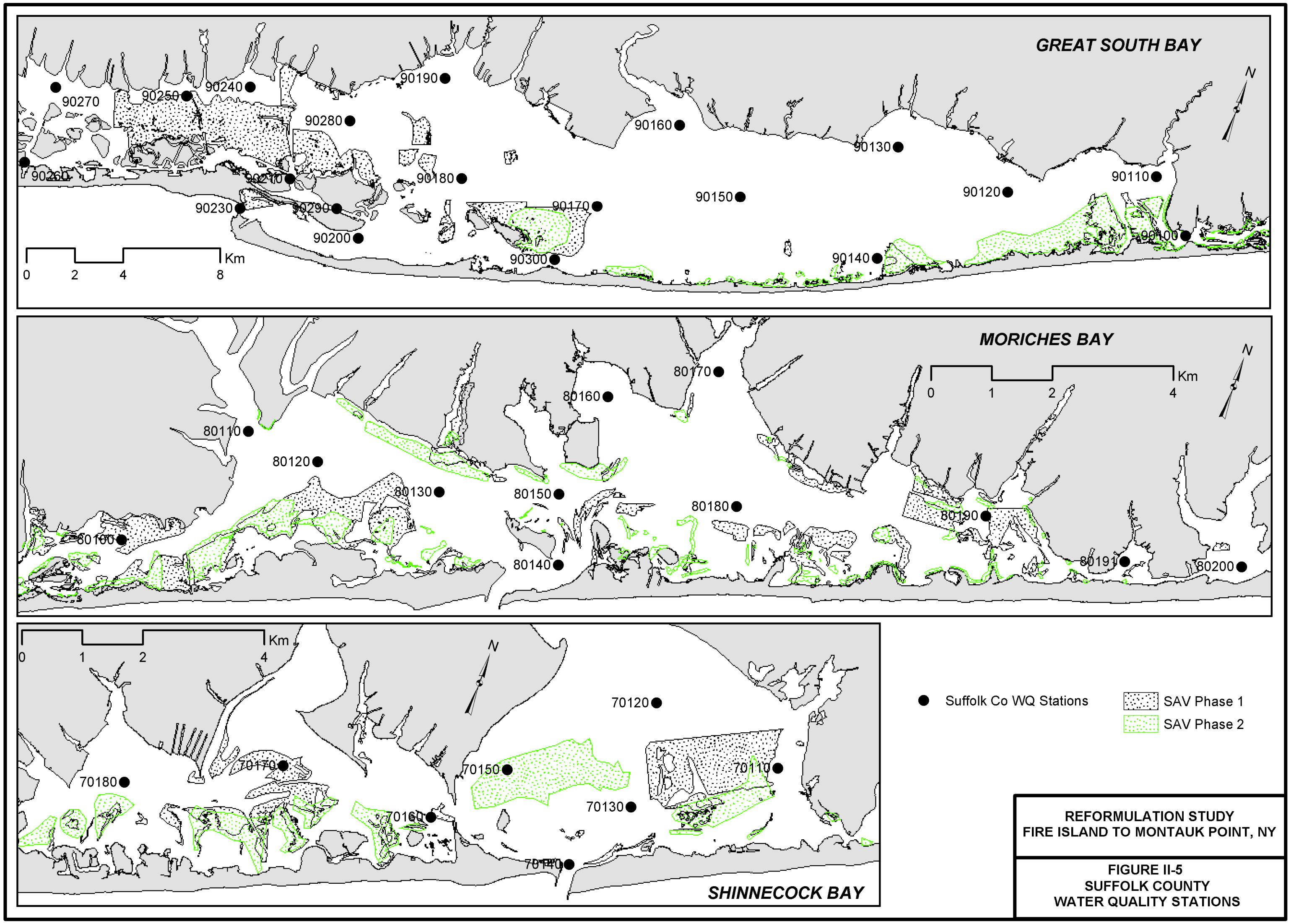
Source of maps is Jones and Schubel (1980)

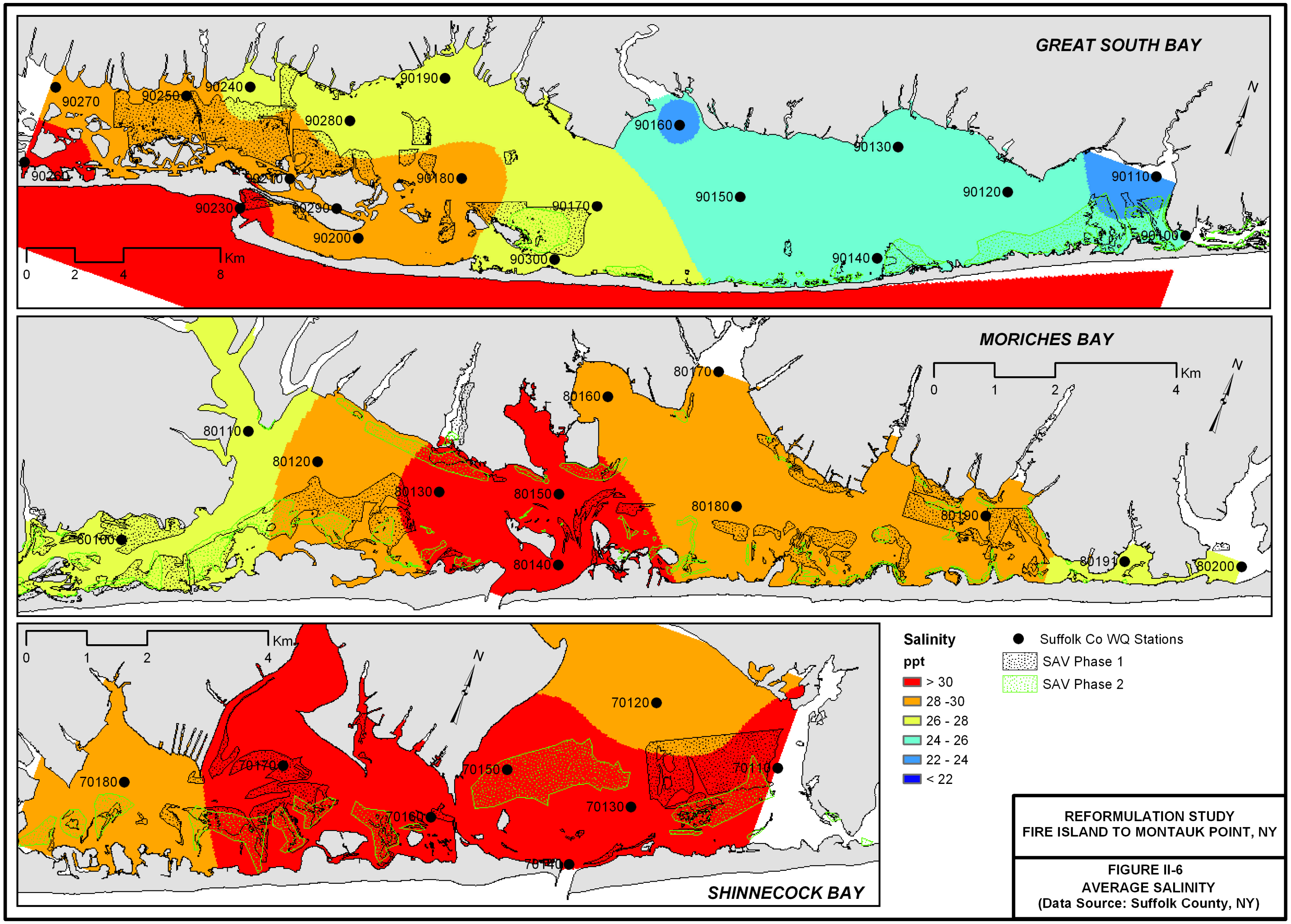
REFORMULATION STUDY
FIRE ISLAND TO MONTAUK POINT, NY

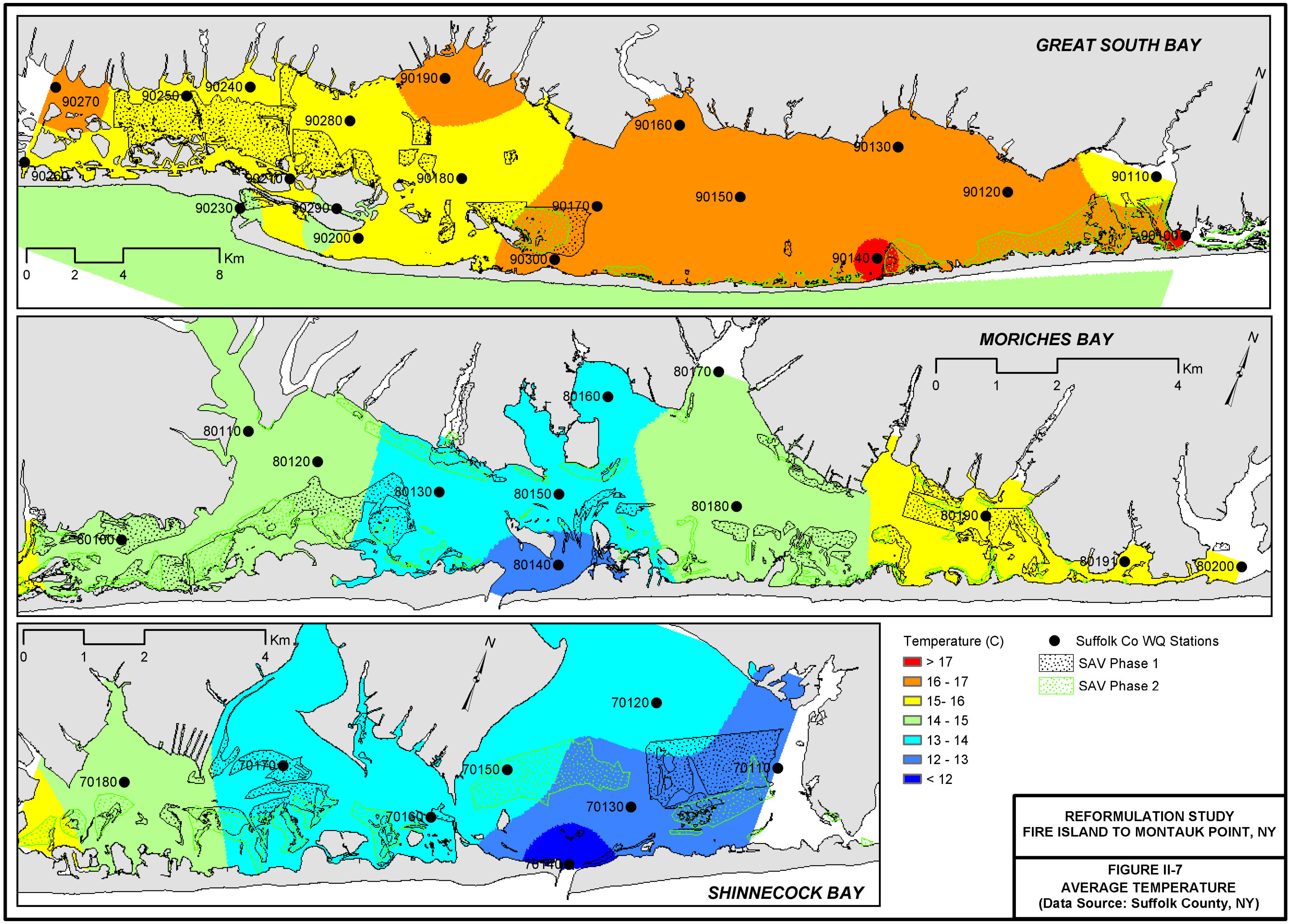
FIGURE II-2
SURFICIAL SEDIMENT CHARACTERISTICS IN GSB


GREAT SOUTH BAY
N
0 2 4 8 Km
MORICHES BAY
0 1 2 4 Km
N
0 1 2 4 Km
N
SHINNECOCK BAY
Tide Range (m)
0.9 - 1
0.8 - 0.9
0.7 - 0.8
0.6 - 0.7
0.5 - 0.6
0.4 - 0.5
0.3 - 0.4
0.2 - 0.3
< 0.2
SAV Phase 1
SAV Phase 2
REFORMULATION STUDY
FIRE ISLAND TO MONTAUK POINT, NY
FIGURE II-3
AVERAGE TIDAL RANGE


GREAT SOUTH BAY
N
0 1 2 4 6 8 Km
MORICHES BAY
0 1 2 4 Km
SHINNECOCK BAY
0 1 2 4 km
Max Tidal Current (m/s)
> 1
0.5 - 1
0.4 - 0.5
0.3 - 0.4
0.2 - 0.3
0.1 - 0.2
0 - 0.1
SAV Phase 1
SAV Phase 2
REFORMULATION STUDY
FIRE ISLAND TO MONTAUK POINT, NY
FIGURE II-4
MAX TIDAL CURRENT VELOCITIES

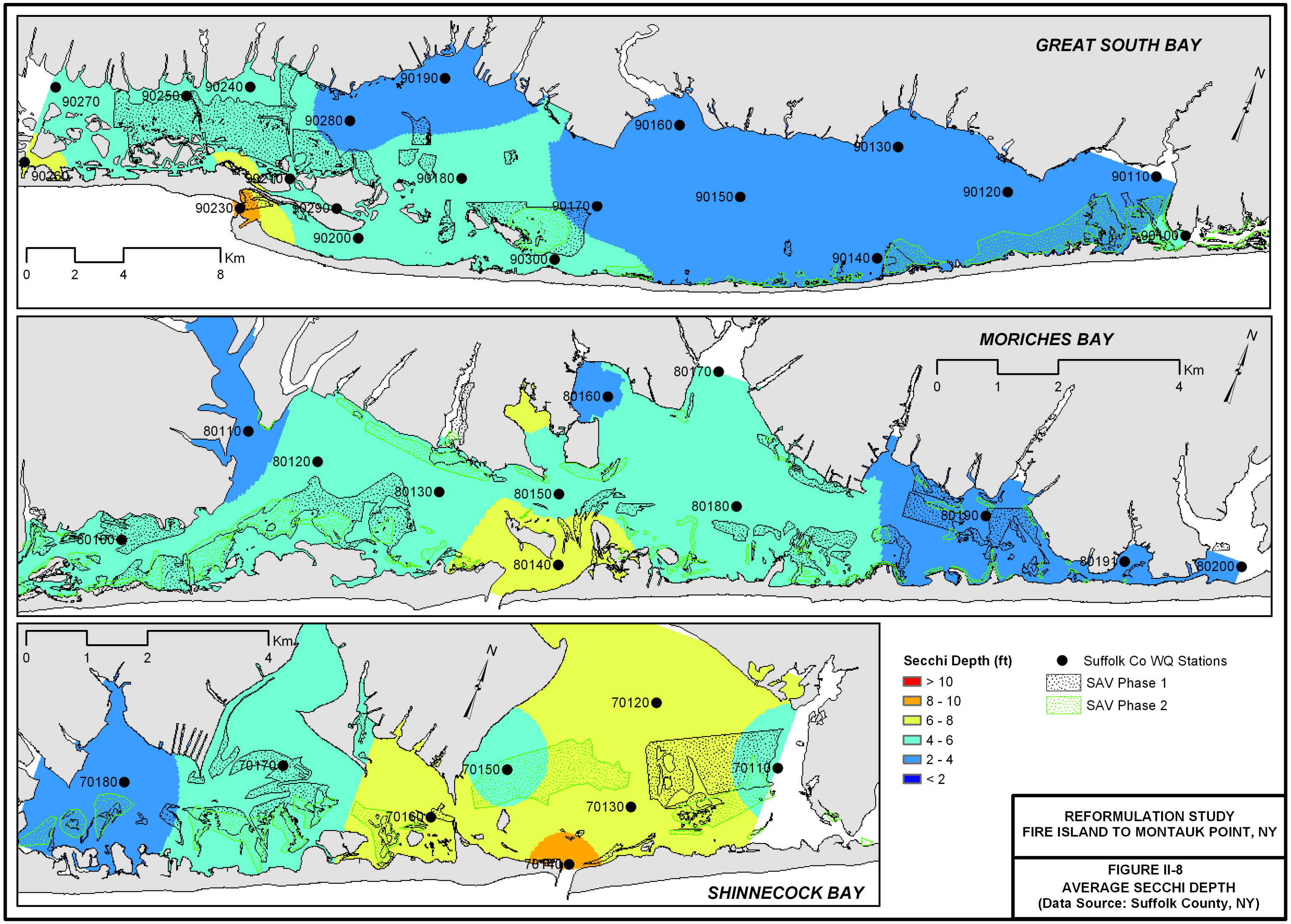

GREAT SOUTH BAY
N
90270
90250
90240
90190
90280
90160
90130
90260
90210
90180
90110
90230
90290
90170
90150
90120
90200
90300
90140
90100
Km
0
2
4
8
MORICHES BAY
N
Km
0
1
2
4
80170
80160
80110
80120
80130
80150
80180
80190
80100
80140
80191
80200
SHINNECOCK BAY
Km
0
1
2
4
N
70120
70170
70150
70110
70180
70130
70160
70140
Suffolk Co WQ Stations
SAV Phase 1
SAV Phase 2
REFORMULATION STUDY
FIRE ISLAND TO MONTAUK POINT, NY
FIGURE II-5
SUFFOLK COUNTY
WATER QUALITY STATIONS


GREAT SOUTH BAY
MORICHES BAY
SHINNECOCK BAY
Km
N
Salinity
ppt
> 30
28 -30
26 - 28
24 - 26
22 - 24
< 22
Suffolk Co WQ Stations
SAV Phase 1
SAV Phase 2
REFORMULATION STUDY
FIRE ISLAND TO MONTAUK POINT, NY
FIGURE II-6
AVERAGE SALINITY
(Data Source: Suffolk County, NY)



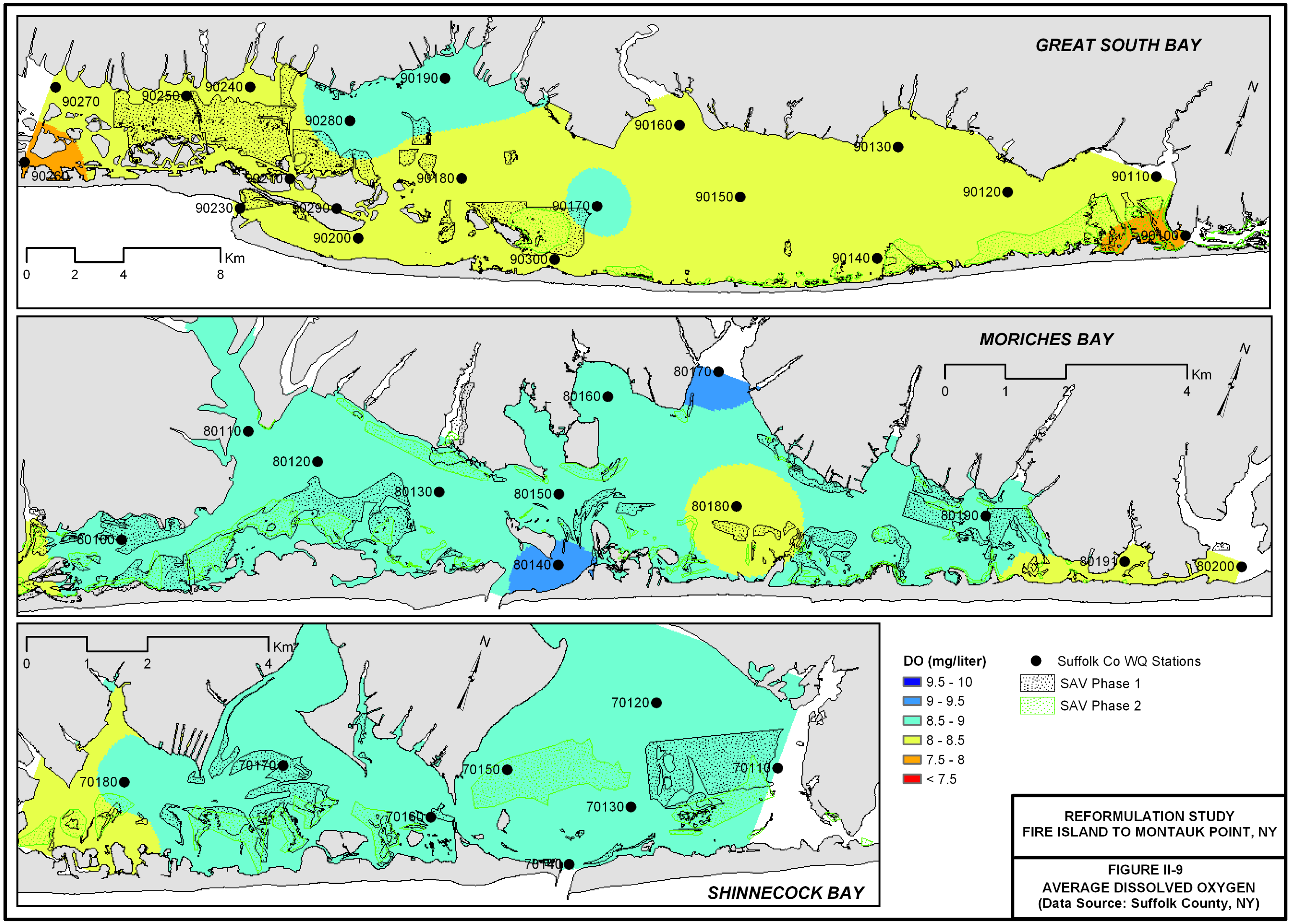
REFORMULATION STUDY
FIRE ISLAND TO MONTAUK POINT, NY

FIGURE II-7
AVERAGE TEMPERATURE
(Data Source: Suffolk County, NY)



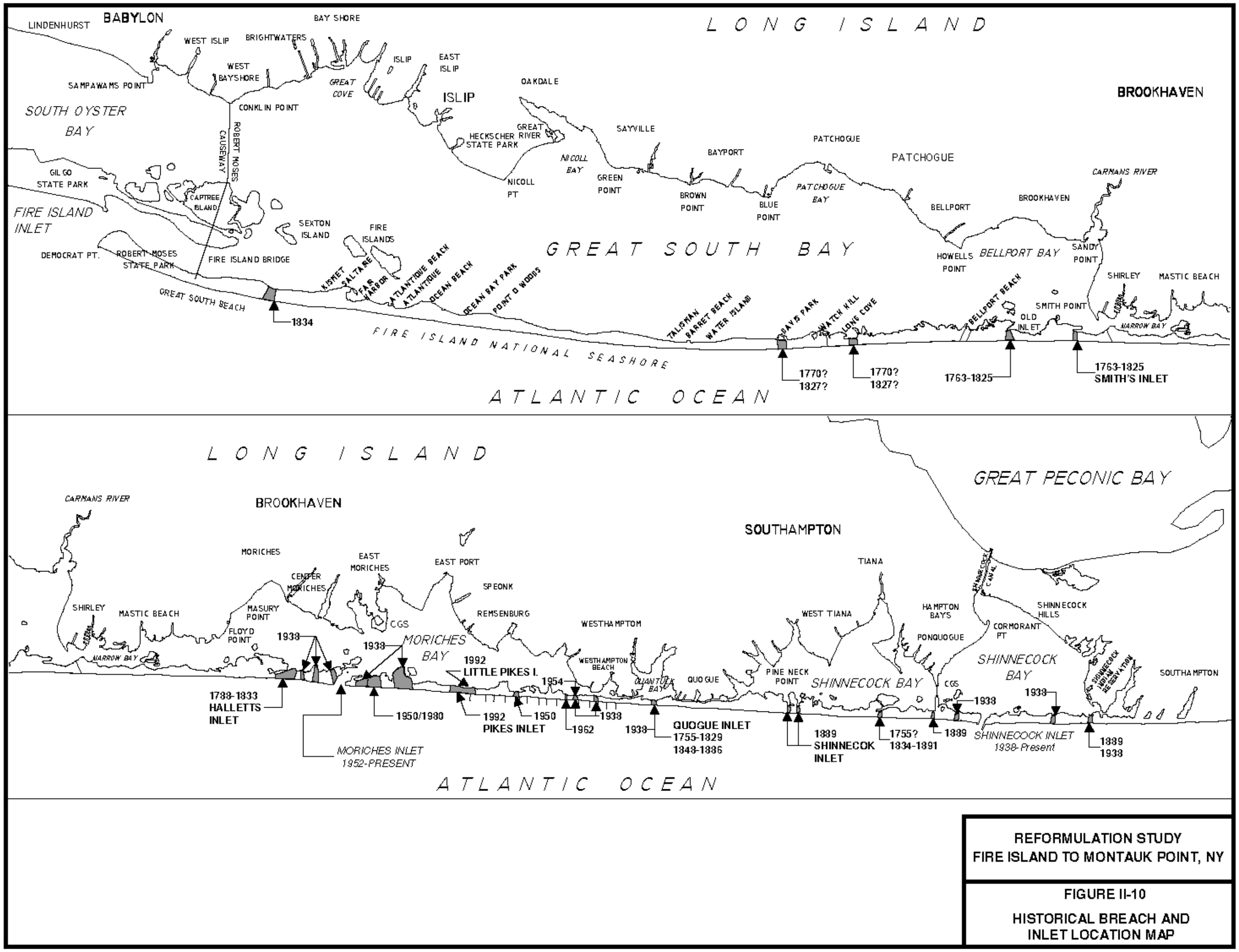
REFORMULATION STUDY
FIRE ISLAND TO MONTAUK POINT, NY

FIGURE II-8
AVERAGE SECCHI DEPTH
(Data Source: Suffolk County, NY)



REFORMULATION STUDY
FIRE ISLAND TO MONTAUK POINT, NY

FIGURE II-9
AVERAGE DISSOLVED OXYGEN
(Data Source: Suffolk County, NY)



REFORMULATION STUDY
FIRE ISLAND TO MONTAUK POINT, NY

FIGURE II-10

HISTORICAL BREACH AND INLET LOCATION MAP

Table II-1
General Habitat Requirements for NE Seagrasses

Common Name	Scientific Name	Tidal regime	Habitat	Depth	Salinity	Temp.	Turbidity	pH	Threats
Eelgrass	*Zostera marina*	Subtidal	Marine Littoral Zone; substrates of mixed mud to sand	below mean low water to 3-4 meters, strongly tied to light penetration	18 - 30 typical, up to 45 ppt; seed germination best at 18 ppt	Dormant below 10^{o}C; vegetative growth from 10^{o} -20^{o}C; flowering 15^{o}-20^{o}C; die-off above 20^{o}C	Secchi Depth > 1m;Total suspended solids <30 mg/l	not reported; 7.3-8.3 typical	reduced light intensity & turbid waters - threshold for light penetration is 20%; susceptible to wasting disease in higher salinities (30-45 ppt) & nutrient enriched waters; high nitrate levels; heavy metals & pesticides; sustained temps > 20^{o}C; drought
Widgeon Grass	*Ruppia maritima*	Subtidal	Estuarine, bays & brackish water pools; sandy to mucky substrates	0 - 4.5 meters; depth strongly tied to substrate particle size <1.5 m in silts & clays, >2 m in sands.	0-33 ppt	10^{o} - 30^{o} C	Secchi Depth > 1m	6.0-10.4; 7-8 preferred	prolonged turbidity; Sustained Temps>30^{o}C; rapid salinity fluctuations and turbulent waters

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Batiuk, R.A. et. al. 1992. Chesapeake Bay Submerged Aquatic Vegetation Habitat Requirements and Restoration Targets: A Technical Synthesis.

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Kantrud, Harold A. 1991. Widgeongrass (*Ruppia maritima* L.): A Literature Review. U.S. Fish and Wildlife Service, Fish and Wildlife Research 10. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/literatr/ruppia/ruppia.htm (Version 16JUL97).

Koch E.W. et. al. 1994. Draft - Environmental Monitoring, Seagrass Mapping and Biotechnology as a means of Fisheries Habitat Enhancement Along the Connecticut Coast

Thunhorst, G.A. 1993. Wetland Planting Guide for the Northeastern United States.

Table II-2 Annual Average Wind Directions	
Wind Direction(*)	**Percent-Occurrence**
North	10
Northeast	9
East	9
Southeast	6
South	9
Southwest	22
West	17
Northwest	17
Calm	1

Source: U.S. Coast Guard and Suffolk County Highway Department
(*) Defined as the direction from which the wind is coming

Table II-3
Bay Wave Hindcast Input Parameters

Estuary	Location	Fetch Length (km)	Wind Direction	Water Depth (m, MLLW)
Great South Bay	Brightwaters	7.9	Southeast	1.8
	Bayberry Point	7.1	Southeast	1.8
	Ocean Beach	5.8	Northeast	1.2
	Nicoll Point	16.4	Southeast	2.7
	Cherry Grove	14.0	Northeast	1.8
	Sayville	6.9	Southeast	2.7
	Patchogue Bay	7.2	Southeast	2.7
	Bellport	3.7	Southeast	0.9
	Shirley	20.1	Southwest	2.4
Moriches Bay	Old Mastic	5.2	Southeast	1.8
	Orchard Neck Creek	2.4	Southeast	1.8
	Havens Point	3.7	Southeast	1.8
	Remsenburg	2.4	West	1.2
	Hart Cove	5.6	Southeast	1.5
Shinnecock Bay	West Tiana	3.1	Southeast	1.5
	Wells Creek	1.9	Southeast	0.9
	Ponquogue	4.8	Southeast	3.0
	Shinnecock Hills	3.7	Southeast	3.0
	Phillips Point	4.3	Southeast	1.5

Table II-4
Bay Wave Hindcast Results

Return Period (yr)	Wave Height (ft)	Wave Period (sec)	Wave Height (ft)	Wave Period (sec)	Wave Height (ft)	Wave Period (sec)
	Great South Bay					
	Brightwaters		**Bayberry Point**		**Ocean Beach**	
2	1.8	2.7	1.8	2.6	2.0	2.7
25	3.3	3.4	3.2	3.3	3.5	3.3
100	4.1	3.7	4.0	3.6	4.4	3.6
	Nicoll Point		**Cherry Grove**		**Sayville**	
2	2.4	3.3	2.5	3.3	2.0	2.7
25	4.2	4.1	4.2	4.1	3.5	3.3
100	5.2	4.5	5.1	4.4	4.2	3.6
	Patchogue Bay		**Bellport**		**Shirley**	
2	2.0	2.7	1.3	2.2	2.6	3.5
25	3.5	3.4	2.5	2.7	4.0	4.2
100	4.4	3.7	3.2	3.0	5.0	4.5
	Moriches Bay					
	Old Mastic		**Orchard Neck Creek**		**Havens Point**	
2	1.7	2.5	1.3	2.0	1.5	2.3
25	3.1	3.1	2.4	2.5	2.8	2.8
100	3.8	3.3	2.9	2.7	3.5	3.0
	Remsenburg		**Hart Cove**			
2	1.5	2.1	1.7	2.5		
25	2.5	2.5	3.1	3.1		
100	3.1	2.7	3.8	3.4		
	Shinnecock Bay					
	West Tiana		**Wells Creek**		**Ponquoque**	
2	1.4	2.1	1.1	1.9	1.8	2.5
25	2.6	2.7	2.1	2.3	3.2	3.1
100	3.1	2.9	2.6	2.5	3.9	3.3
	Shinnecock Hills		**Phillips Point**			
2	1.6	2.3	1.6	2.4		
25	2.9	2.9	2.9	2.9		
100	3.6	3.1	3.5	3.1		

Table II-5
Suffolk Co WQ Data: Great South Bay

Station	Secchi Depth (ft)		Temperature (°C)		DO (mg/liter)		Salinity (ppt)	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
90100	4.4	2.0	17.1	7.1	7.5	1.7	25.3	2.6
90110	3.2	1.4	15.7	8.2	8.3	1.9	23.1	3.6
90120	3.1	1.5	16.0	8.2	8.4	1.9	24.7	2.3
90130	2.9	1.5	16.1	8.1	8.4	1.9	24.7	2.2
90140	3.5	1.5	17.0	6.8	8.2	1.8	25.9	2.3
90150	3.1	1.8	16.3	8.1	8.4	1.9	25.7	2.1
90160	3.2	1.7	16.0	8.1	8.5	1.9	23.9	3.8
90170	3.6	1.9	16.0	8.2	8.5	1.9	27.0	2.0
90180	4.3	2.5	15.7	7.9	8.3	1.8	28.3	1.8
90190	3.2	1.6	16.3	8.1	8.7	1.9	26.2	2.2
90200	5.5	2.8	15.1	7.1	8.4	1.7	29.5	1.6
90210	5.2	2.3	15.8	7.8	8.3	1.9	29.2	1.5
90220	12.8	6.0	14.7	5.8	9.0	1.5	31.3	0.8
90230	8.4	4.1	14.9	6.3	8.1	1.9	30.8	1.3
90240	4.7	1.5	15.9	7.8	8.5	2.0	27.6	2.1
90250	4.9	1.6	15.5	8.1	8.4	2.1	28.7	1.9
90260	6.2	1.6	15.7	6.9	7.9	1.8	30.7	1.2
90270	5.4	1.6	16.3	7.0	8.0	2.0	29.8	1.3
90280	3.5	1.6	15.6	8.4	8.6	1.9	27.2	1.7
90290	5.8	3.3	14.6	7.3	8.4	1.6	29.2	1.4
90300	5.3	2.8	16.2	7.1	8.5	1.4	27.3	2.4

Data source: Suffolk County Department of Health Services, Office of Ecology

Table II-6
Suffolk Co WQ Data: Moriches Bay

Station	Secchi Depth (ft)		Temperature (°C)		DO (mg/liter)		Salinity (ppt)	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
80100	4.0	1.6	14.7	7.9	8.6	2.1	27.1	2.6
80110	3.6	1.3	14.6	7.8	9.0	2.0	26.6	2.4
80120	4.6	1.9	14.4	7.2	8.7	1.9	28.5	2.5
80130	5.9	2.6	13.4	6.9	8.8	1.7	30.2	1.9
80140	7.2	3.7	12.1	6.3	9.1	1.6	30.9	1.2
80150	5.9	2.8	14.0	6.7	8.6	1.6	30.3	1.3
80160	4.0	1.3	13.9	7.4	8.9	1.9	29.6	1.3
80170	4.1	1.5	14.7	7.5	9.0	2.0	28.3	1.9
80180	4.4	2.1	14.8	7.4	8.4	1.8	29.8	1.0
80190	3.7	1.6	15.4	7.8	8.5	1.9	28.7	1.2
80191	3.9	1.6	15.3	7.9	8.2	2.2	27.5	1.2
80200	3.4	1.6	15.9	8.2	8.4	2.0	27.3	1.5

Data source: Suffolk County Department of Health Services, Office of Ecology

Table II-7
Suffolk Co WQ Data: Shinnecock Bay

Station	Secchi Depth (ft)		Temperature (°C)		DO (mg/liter)		Salinity (ppt)	
	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
70100	6.0	1.8	13.5	7.9	8.5	1.9	28.0	1.1
70110	5.9	1.8	12.7	7.2	8.7	1.9	30.0	1.2
70120	6.3	2.2	13.6	7.1	8.8	2.5	29.7	1.2
70130	6.8	2.5	12.1	6.5	8.9	1.6	30.4	1.2
70140	8.3	4.6	11.7	6.0	9.0	1.6	31.0	0.9
70150	5.7	2.0	13.5	6.8	8.6	1.5	30.2	1.0
70160	7.0	3.5	13.2	6.3	8.6	1.6	30.9	1.0
70170	4.9	2.1	13.8	6.6	8.6	1.5	30.7	1.0
70180	3.8	1.6	14.6	7.5	8.5	1.7	29.3	1.2
70190	3.4	1.5	15.4	8.0	8.3	2.0	28.1	1.2

Data source: Suffolk County Department of Health Services, Office of Ecology.

III. CURRENT SUBMERGED AQUATIC VEGETATION STUDY (USACE 2003)

A. Methodology

A field survey was designed to provide baseline data on finfish, invertebrates and flora associated with eelgrass habitats within the study area. The inventory included six submerged aquatic vegetation (SAV) beds comprised primarily of eelgrass, two in each of the three major bays located in the FIMP study area: Great South Bay (GSB), Moriches Bay (MB) and Shinnecock Bay (SH). Data from the field survey was used to further identify relationships between physiologic and historic data and current conditions.

Sampling was conducted from June through October 2003. A total of six stations were sampled along the backbay side of the barrier island coastline from Fire Island Inlet to Shinnecock Inlet: East Fire Island and Bellport in Great South Bay (Figure I-2), Great Gun and Cupsogue in Moriches Bay (Figure I-3), Tiana and Ponquogue East in Shinnecock Bay (Figure I-4). See Figure I-1 for overall project area map. The sites were chosen based on 1997 and 1999 aerial photography, as well as a reconnaissance survey conducted the previous year indicating the presence of SAV beds in the study area.

East Fire Island (GSB) is the westernmost station in the study area, located approximately 12.5 km (7.6 miles) east of Fire Island Inlet. The station at East Fire Island is one of two islands, the other being West Fire Island. The site is located approximately 0.8 km (0.5 miles) north of the barrier island situated between Robins Rest (to the west) and Corneille Estates (to the east). According to NOAA Chart 12353, the average depth at this sampling station is 0.6 meters at mean high water (MHW). (Note: while depth measurements were not taken in the field, the published values correspond with field observations). This area is subject to heavy recreational use during summer months. East Fire Island had large areas of eelgrass with some algae. The Bellport station is located approximately 2.8 km (1.73 miles) south of Bellport on the mainland and 0.4 km (0.25 miles) north of Bellport Beach on the barrier island. The site at Bellport (GSB) is approximately 15.5 km (9.6 miles) west of Moriches Inlet. Approximately 0.4 km (0.25 miles) to the southwest there are docks and bulkheading. The Bellport station is located near a navigation channel. This station is characterized by patchy eelgrass beds and algae throughout the entire bed. This site had an average depth at MHW of 0.2 m (NOAA Chart 12352).

The station at Great Gun (MOR) was sampled directly north of the barrier island, approximately 30 m offshore and 2 km (1.3 miles) west of Moriches Inlet. Great Gun was one of the deepest stations sampled, with an average depth at MHW of 1.5 m (NOAA Chart 12352). This station was characterized by heavy eelgrass beds with large patches of algae. A Town of Brookhaven beach facility and marina was located approximately 20 m south on the barrier island. Cupsogue station (MOR) was located approximately 1.6 km (1 mile) south of the mainland, to the southeast of the Moriches Coast Guard Station. The Cupsogue site was approximately 6.4 km (3.9 miles) east of Moriches Inlet. The barrier island, approximately 61-m south of the station, is densely developed and contains a large hotel docking facility. Intertidal marsh (*Spartina alterniflora)* was located to the south and west on the barrier island. The Cupsogue station had patchy amounts of algae throughout the eelgrass bed. The average depth of the Cupsogue site at MHW was 0.6 m (NOAA Chart 12352).

The station at Tiana (SH) was located approximately 2.8 km (1.75 miles) south of the mainland, 0.4 km (0.25 miles) north of the barrier island and 4.6 km (2.8 miles) west of Shinnecock Inlet. The mainland was characterized by bulkheading. Hampton Bays was located on the barrier island south of the site. Dense residential development, bulkheading and sparse patches of marsh characterized the barrier island shoreline. This station was one of the shallowest with an average depth of 0.3 meters (NOAA Chart 12351). Tiana was characterized as a patchy eelgrass bed with areas of algae. Ponquogue East (SH) was the easternmost station sampled, located approximately 3 km (1.9 miles) south of the mainland and 12.8 km (0.8 miles) north of the barrier island. This station was located east of Ponquogue Bridge and approximately 1.8 km (1.1 miles) east of Shinnecock Inlet. The site was located south of the Shinnecock Coast Guard Station. The barrier island shoreline supports a densely populated marsh. There was minimal disturbance; e.g., no bulkheading on the shore. This station was one of the deepest with an average depth at MHW of 0.6 m (NOAA Tide Chart 12351). The station was characterized by a long stretch of narrow eelgrass beds and algae. Sandy patches were found in the eastern section of the bed. A sandy beach was located south of the station along the barrier island.

Once on site, a portion of the SAV bed was chosen as the sampling area and the perimeter of this area mapped using a Garmin 185 Global Positioning System unit (GPS) (Table I-1). The program included collections of floral and faunal species found in the eelgrass beds using a beach seine and snorkeling techniques. The program was primarily focused on forage finfish and macrobenthic species that reside in eelgrass habitats. Additional elements of the program included collection of water quality data, visual assessment of biota and a quantitative assessment of eelgrass height and density.

1. Biological

a. SAV Seine Survey

Sampling was conducted from June through October 2003 to cover the period of peak productivity of the eelgrass beds which occurs between July and September, as well as one-month periods both and after the peak production. Sampling was conducted bimonthly (twice per month, typically every other week). A 20-foot long by 6-foot tall (1.25 inch mesh size) beach seine was hauled through each of the SAV beds. The seine net was fitted with flotation buoys on top, extra weighted bottom line, reinforced corners to tie to poles and a center pocket. The dimensions of the center pocket were 3-foot by 3-foot taper to 10 inches with a tie off. A smaller net (12-foot long by 4-foot high fitted with flotation buoys on top and extra weighted lead line on the bottom) was used during the first round of sampling in June. From July through October the larger net was used for sampling (Figure III-1). There was no substantial difference between faunal species composition caught in the two nets.

Five seine hauls were conducted at each site. Each seine haul was pulled through the SAV bed in a different location, typically in a patterned five-point direction around the bed. The seine net was hauled through the bed at a constant rate of speed for approximately 50 feet. When pulling the seine through the SAV bed, an effort was made to minimize damage to the SAV. The net was then lifted in the water column and rolled to gather all organisms in the center of the net (Figure III-2). The contents of the seine net were then transferred to the boat for processing using one of two methods. The first method involved transferring the contents of the net from the center pocket into buckets on board the boat. A second method was employed when excessive algae was caught in the net to minimize fish mortality. This second method involved sorting all organisms in the water and placing the sorted finfish in a bucket that was transferred to the boat for processing. On the boat, the contents of all buckets for each replicate were combined and sorted. Similar species of finfish were placed in buckets/beakers for weighing and measuring. All invertebrates were identified and enumerated as described in the following paragraph.

Finfish and invertebrates were collected and identified to species level. The common and scientific names of all species identified are presented in the Appendix Tables 1 and 2. All finfish were counted and measurements of length and weight were recorded for up to 30 individuals of each species (Figure III-3). Fish were measured to the nearest millimeter and collective weights measured to the nearest gram. Invertebrates were identified either to species or lowest practical taxonomic level. Nine groups of animals were identified to higher taxonomic groupings: amphipods, anemones, ctenophores, holothuroids, hydroids, isopods, polychaetes, sponges and tunicates. Crabs were counted while other species of invertebrates were either noted if present or ranked on a scale of abundance. When crab species were present in extremely high quantities, their abundances were ranked. This occurred for three species of crabs: Say mud crab (*Dyspanopeus sayi),* longwrist hermit crab (*Pagurus longicarpus),* Atlantic mud crab (*Panopeus herbstii).* Crustaceans and polychaetes were ranked on a scale of zero to four as follows:

0 = none,
1 = number of organisms on the order of tens
2 = number of organisms on the order of hundreds
3 = number of organisms on the order of thousands

Ctenophores, hydroids and sponges were ranked on a qualitative biomass percentage scale of zero to four as follows:

0 = none
1 = organisms constitute less than 25% of the catch
2 = organisms constitute between 25% and 50% of the catch
3 = organisms constitute between 50% and 75% of the catch
4 = organisms constitute between 75% and 100% of the catch

This methodology follows similar protocols to those implemented in studies conducted by the NYSDEC during their fisheries surveys. All animals were returned to the water post-processing. If either a fish or invertebrate was unidentifiable in the field, a sample and/or photograph was taken back to the lab for analysis. In some instances, body characteristics of the organism were recorded for later identification.

b. Direct Observation and Site Maps

Snorkeling was conducted in the eelgrass beds in order to note the presence of macroalgal species, as well as organisms that may not have been collected in the seine net. Field personnel conducted a visual assessment of the eelgrass beds using a mask, fins, snorkel and aquascope. The aquascope is a device used for underwater viewing, made of a 26-inch tube lined with black interior, a neoprene viewing mask and a transparent submerged disk on the end. The visual survey was conducted throughout the entire SAV bed. In instances when water clarity was low and visibility minimal (due to turbidity) snorkeling observations could not be made. Observations on the presence and abundance of fauna and flora were recorded.

The location of each seine haul, along with snorkeling information, was mapped during each site visit from the middle of July until the end of the survey. Notational information is recorded on the patchiness of the SAV beds, distribution of flora and fauna, surrounding features of the bed, weather and visibility. These maps are qualitative and available for future reference.

c. Eelgrass Quadrat Analysis

A quantitative assessment of eelgrass height and density was made in order to evaluate relative comparisons between eelgrass beds. On site, a 1–foot square quadrat, constructed of 1.5 inch PVC pipe and weighted with sand, was randomly tossed in the area where the seine net was hauled (Figure III-4). The weighted quadrat sank to the bottom of the bay. Within the quadrat, eelgrass was measured for height and density. Height was measured with a yardstick to the nearest 0.5 inches. Height measurements were taken from the months of July through October. Density was ranked as percent area coverage as follows:

Rank 0 = no eelgrass
1 = less than 25% coverage
2 = 25% to 50% coverage
3 = 50% to 75% coverage
4 = 75% to 100% coverage

During the June sampling, one toss was made at each station. Starting with the July sampling, five replicate tosses were performed at each station to be consistent with the number of seine hauls being taken. For data analysis, the eelgrass height and density were averaged over the five replicate tosses. The mean height was calculated as the sum of the five replicate heights divided by five. The mean percent cover was calculated by first adding the five replicate values for percent cover, then dividing by five to obtain a mean and finally multiplying by twenty-five percent to convert the rank value to a percentage.

2. <u>Water Quality</u>

Water quality measurements were taken at each site for temperature, dissolved oxygen, salinity, and turbidity. All water quality measurements, except turbidity, were recorded at the water's surface with a Yellow Springs Instruments (YSI) R85-10 meter. Temperature was measured in degrees Celsius, dissolved oxygen in milligrams per liter, salinity in parts per thousand and turbidity in nephelometric turbidity units (ntu). NTU can be defined as the intensity of light at a specified wavelength scattered or attenuated by suspended particles, or absorbed at a method-specified angle, usually 90 degrees, from the path of the incident light compared to a synthetic chemically prepared standard. (Ziegler, 2002)

A surface water sample was collected in a vial that had been rinsed three times, for turbidity measurements. Turbidity was measured with a Hach portable laboratory turbidimeter model 16800 and Hach portable 2100P turbidimeter, which use a 90-degree angle detector. Monthly means were calculated and used for data analyses. Additional measurements of tidal stage and lunar cycle were recorded along with time of day, for use in future discussions.

B. Results

1. Biological

a. SAV Seine Survey

i. Finfish

- Temporal Trends

As part of the SAV survey, finfish were identified, enumerated, measured and weighed. Data were analyzed to determine temporal trends throughout the course of the study. Nearly 6,000 fish were measured to determine length frequency distributions. Fish ranged in length from 2 to 940 mm (Figure III-5). The largest fishes were the American eel (*Anguilla rostrata*) and bluespotted cornetfish (*Fistularia tabacaria*), while the smallest were the fourspine stickleback (*Apeltes quadracus*), Atlantic silverside (*Menidia menidia*) and northern puffer (*Sphoeroides maculatus*). Most fish ranged in length from 41-60 mm, representing nearly half of the measured catch (45%). The lengths between 21-40 mm and 61-80 mm represented 19% and 18% of the catch, respectively. Nearly all of the catch (82%) ranged in length from 21 to 80 mm.

The total number of finfish collected from June through October was 16,413, representing 49 species (Technical Appendix Table 1). The total numbers of finfish collected each month were similar throughout the season, ranging from the lowest catch in June (1,309) to the highest in August (4,871). As expected, species richness (defined as the total number of species) followed a similar trend to fish abundance. Finfish species richness was lowest in June (15) and peaked in August (32). Monthly total abundances and total number of species are plotted in Figure III-6. The total weight of fishes collected during the season was 40,351 grams (Technical Appendix Table 2). The total monthly weight ranged from 1,119 grams in June to 17,153 grams in August (Figure III-7). Weight varied on a monthly basis with August and September values on the order of two to fifteen times higher than other months. The species comprising most of the weight (22%) was the blackfish (*Tautoga onitis*). Other species contributing more than 10% to total weight were fourspine stickleback, grubby (*Myoxocephalus aenaeus*), Atlantic silverside and cunner (*Tautogolabrus adspersus*). Temporally, finfish biomass and abundance followed expected monthly trends with highest catches occurring during peak summer months of August and September.

The dominant finfish species collected in the SAV beds was the fourspine stickleback (Figure III-8). Figure III-8 is a pie chart showing the ten most abundant fish species and their percent composition of the total catch. The fourspine stickleback represented 32% of the total catch. The next most abundant species, in order, were Atlantic silverside (16%), blackfish (15%) and grubby (10%). The remaining species all represent less than 10% of the total catch. An interesting note was the presence of the lionfish (*Pterois volitans)* that was collected in September at Ponquogue East. This non-native, tropical species and other tropical expatriates will be referred to in the discussion section. Expatriates identified in this study are those fish typically found in tropical waters. The following five species outranked all others for both abundance and weight measurements on a monthly basis: fourspine stickleback, Atlantic silverside, blackfish, grubby and cunner.

- Spatial Trends

The total number of species at any one station ranged from 15 (East Fire Island-GSB) to 32 (Ponquogue East-SH). The total number of fish and fish species collected at each station during the survey (all months combined) is listed in Technical Appendix Table 3. Total numbers of finfish collected at each station ranged from the lowest catch at East Fire Island in GSB (913) to the highest catch at Ponquogue East in SH (4,127). High catches were also recorded at Great Gun in MOR (total overall abundance = 4,068). In general, Great South Bay had the lowest abundances, while Moriches and Shinnecock were similar. Of all the sites, Ponquogue East had both the highest catch and total number of species. Generally, it appears that both species richness and abundance increase from west-to-east. Two exceptions are noted: species richness at Cupsogue (MOR) is lower than at Great Gun which is located directly west of Cupsogue; and a spike in fish abundance at Great Gun (MOR). This trend in species abundance and diversity is shown on Figure III-9. The highest abundances were observed at both Ponquogue East (SH) and Great Gun (MOR), the two sites located nearest to inlets. Mean abundances of finfish for each bay are as follows: GSB = 2,301; MOR= 6,683; SH= 7,429. The mean species richness for each bay is GSB = 16; MOR = 21; and SH = 29.

Total finfish weights for each station ranged from a low of 1,614 g at East Fire Island to a maximum of 13,116 g at Ponquogue East. The weights were lowest in Great South Bay and highest in Shinnecock Bay. Average weights for each bay were GSB= 1,840 g; MOR= 7,273 g; SH= 11,063 g. In addition to the five prominent fish species contributing to overall weight (see previous section), winter flounder (*Pseudopleuronectes americanus*) contributed significantly to the weights at Ponquogue East (SH) and East Fire Island (GSB). At these sites, winter flounder represented 15% and 11% of the total weights, respectively. The total weight of each species of fish calculated for each station is given in Technical Appendix Table 4.

ii. Invertebrates

- Temporal Trends

The dominant species collected in the seine net were the green crab (*Carcinus maenas*), Atlantic mud crab, ctenophores, eastern mudsnail (*Ilyanassa obsoleta),* grass shrimp (*Palaemonetes vulgaris)*, golden star tunicate (*Botryllus schlosseri)* and red beard sponge (*Microciona prolifera).* A total of 50 invertebrate species were collected during the survey. Species richness, represented by the total number of species, was similar throughout the season, ranging from 25 to 31 species monthly. Total invertebrate abundance and diversity were greatest in August. Technical Appendix Table 5 lists number, rank value and presence of invertebrates collected during each month of the study.

Green crabs dominated the invertebrate catch comprising 88% of the total number. Five-percent of the catch was represented by the economically important blue crab, *Callinectes sapidus.* The lady crab (*Ovalipes ocellatus),* rock crab (*Cancer irroratus)* and portly spider crab (*Libinia emarginata)* each represented 2% of the catch. The remaining crab species each accounted for less than one percent of the catch. Note that although they were not counted, Atlantic mud crabs contributed significantly to the catch and were present all months. Although they were not dominant species, the Say mud crab and longwrist hermit crab (*Pagurus longicarpus*) were present every month of sampling. Crab species richness is fairly constant throughout the survey ranging from 4 to 7 species per month. Crab abundance follows expected monthly trends, increasing from June to August and decreasing in September and October. Crab abundances showed a sharp increase from July to August, then a sharp decline from August to September.

- Spatial Trends

Invertebrate species richness at all stations was similar, ranging from 23 species at East Fire Island (GSB) and Cupsogue (MOR) to 30 species at Tiana (SH). Invertebrate species richness was similar for all three bays with slightly higher values in Shinnecock Bay. Mean species richness for each bay was GSB and MOR= 24; SH= 28. Crab species richness and abundances fluctuated randomly across all sites. In general, the number of crab species encountered at each site was low, ranging from 2 species at East Fire Island (GSB) to 8 species at Great Gun (MOR) (Figure III-10). Crab abundances fluctuated across all sites ranging from 20 to 1,396 (Technical Appendix Table 6). Sites with the lowest abundance values were Cupsogue in MOR (20) and East Fire Island in GSB (27). The highest abundances were found at Ponquogue East in SH (1,397). This was due to the high catch of green crabs. Collections of other crab species at Ponquogue East (SH) were similar to numbers collected at the other five sites. Additionally, it appears that the stations nearest the inlets have the highest crab abundances with 574 collected at Great Gun (MOR) and 1,397 collected at Ponquogue East (SH). Crab numbers varied from site to site within each bay. Mean total crab abundances for each bay were GSB= 56; MOR= 297; SH= 821. From this data, there appears to be a trend of increasing crab abundances heading from west to east. The total number of all invertebrates (rank, presence/absence) collected at each station is shown in Technical Appendix Table 6.

b. Finfish and Invertebrate Interactions

The relationship between finfish and invertebrates was examined for each month and station. The number of invertebrate species did not vary much during the sampling season. In contrast, there was higher variation in the number of finfish species. This relationship indicates an influx of finfish species to the bays during the summer months.

c. Eelgrass Height and Density

i. Temporal and Spatial Trends

Eelgrass height and density was measured at each site for each month (Figure III-11, Technical Appendix Table 7). The tallest eelgrass bed was found at Cupsogue (MOR) in July, with a mean height of 21.2 inches. The shortest eelgrass bed was located at Bellport (GSB) in June with a mean height of 3.0 inches. Eelgrass percent cover was greatest at Cupsogue (MOR) in August (83%) and least at Ponquogue East (SH) in June (25%).

In Great South Bay, average eelgrass height at East Fire Island peaked in July then steadily decreased, while eelgrass density appeared to increase throughout the study period. At Bellport (GSB) eelgrass height remained low throughout the study period. Meanwhile, eelgrass density at Bellport increased from July through October, with a peak in September.

In Moriches Bay, both stations showed well-correlated eelgrass height and density. Eelgrass height at Great Gun fluctuated slightly throughout the sampling period, reaching a peak in August. Eelgrass density at Great Gun fluctuated closely with height, also reaching a peak in August. Eelgrass height at Cupsogue (MOR) increased from June and July into August. During September and October, average eelgrass height was lower in Cupsogue reflecting new growth. Eelgrass density at Cupsogue (MOR) rose steadily until reaching a peak in August, and then began to decrease.

In Shinnecock Bay, eelgrass density and height appeared to be closely correlated. Eelgrass height at Tiana reached a peak in July, decreased through September, and began to rise again in October. Eelgrass density showed a similar trend, maintaining a high in June and July, and then decreasing steadily through October. Eelgrass height at Ponquogue East (SH) remained lower than Tiana throughout the study, but reached a peak in July and August. Fluctuations in eelgrass density at Ponquogue closely mimicked the height through August, then reached a peak in September and decreased into October.

Both eelgrass height and density were measured at each site and analyzed by season. Figure III-11 depicts mean monthly eelgrass density and height for each bay. Seasonally, eelgrass height was generally greatest at Moriches Bay and lowest in Great South Bay throughout the sampling period. Note that by October, mean eelgrass height in Shinnecock Bay reached similar values to Moriches Bay. The maximum eelgrass height was observed at

Moriches Bay in August and the minimum height was recorded at Great South Bay during June. A comparison of eelgrass density indicated that the greatest overall density was found during August in Moriches Bay and lowest density was in Shinnecock during October. Eelgrass density was highest in Moriches Bay from June through August. However, during September and October, the density of eelgrass was highest in Great South Bay. Density of eelgrass was lowest in Shinnecock Bay for all months except July (GSB) and September (MOR).

ii. Faunal Interactions and Eelgrass

The occurrence of finfish and invertebrates was analyzed in conjunction with eelgrass height and density for each month and station. The data indicate that there is a peak in eelgrass density in August, which corresponds to a peak in finfish and invertebrate abundance and diversity (Technical Appendix Tables 1, 5 and 7).

Analyzed by station, eelgrass density decreases consistently west to east from Moriches Bay into Shinnecock Bay, yet the mean height remains essentially unchanged (Figure III-11, Technical Appendix Table 7. Furthermore, in Great South Bay eelgrass height is higher in East Fire Island and relatively lower in Bellport. Eelgrass density remains fairly constant across all study sites with the exception of Bellport (GSB), where it is the least. In Great South Bay and Shinnecock Bay, the trend in fish and invertebrate species richness displays an opposite pattern to that of eelgrass height and density. No apparent pattern is observed in Moriches Bay where eelgrass density is relatively constant; however, faunal abundances decline sharply from Great Gun to Cupsogue.

iii. Qualitative Observations

- Direct Observation

This section describes direct underwater observation using mask and snorkel to identify faunal and algal species that may not have been collected in the seine net. Faunal observations made while snorkeling in the SAV beds did not identify any additional species other than those collected in the seine net. Algae were identified from both the snorkeling survey of the site, as well as the collection in the seine net. Appendix Table 3 presents a list of all algae species identified during the survey. Where possible, algae are identified common name; however, several types do not have common names. Fifteen genera of algae were identified, with wire weed (*Ahnfeltia plicata),* banded weeds (*Ceramium* sp*.),* and filamentous green algae (*Chaetomorpha* sp.*)* predominant in the samples (Figure III-12).

- Temporal Trends

The presence of algae species by month and station are listed in Appendix Table 4. The monthly distribution varied from six species in June to twelve in August. The following types of algae were present during all months: banded weeds, dead man's fingers (*Codium fragile),* and hollow greenweed (*Enteromorpha sp.)*. Irish moss (*Chondrus crispus)* and rockweed (*Fucus* sp.) were present during August only.

- Spatial Trends

The stations with the lowest algal diversity, represented by the number of algal types, were East Fire Island in GSB (7) and Cupsogue in MOR (6) (Appendix Table 4). Highest algal diversity was at the Ponquogue East (11) site in SH. Three types of algae were found at all stations: banded weed, red weed (*Gracilaria sp.),* and sea lettuce (*Ulva lactuca).* Wire weed was only found at Bellport (GSB). Although the density of the algae was not measured quantitatively at the sites, relative comparisons were made between sites based on visual observations. From these visual assessments, it appeared that Great Gun (MOR) had the highest density of algae particularly from June through September. There was also a period from June through August (most notably in June and July) when heavy 'gelatinous-like' mats of the filamentous brown algae (*Ectocarpus sp.)* were encountered at East Fire Island (GSB) and to a lesser extent at Tiana (SH) and Ponquogue East (SH). Other significant observations included a die-off of eelgrass occurred in October at the East Fire Island site (GSB). It was also noted that another type of SAV, widgeon grass, was observed at the Bellport station (GSB) in June and August. Observations were made of organisms growing on eelgrass blades. Cases of the hard tube worm (*Spirorbis spirillum*) were consistently found on eelgrass blades at East Fire Island (GSB), Bellport (GSB) and Cupsogue (MOR). Blue mussels (*Mytilus edulis*) were found on eelgrass at Great Gun (MOR), Cupsogue (MOR) and Ponquogue East (SH). Blue mussels were also found to grow heavily at East Fire Island (GSB) and Tiana (SH) on the macroalgae, sea lettuce.

2. Water Quality

Technical Appendix Table 8 summarizes the water quality data. Temperature, salinity, dissolved oxygen and turbidity values are listed for all stations by month. Technical Appendix Table 8 shows both tables and plots of mean monthly values at each station.

a. Temporal Trends

Temperature showed an expected seasonal trend at all stations, increasing from June to August and decreasing through September to the lowest observed temperatures in October. Temperature values ranged from 11.85 ºC at Tiana (SH) to 26.15 ºC at East Fire Island (GSB). The smallest range was observed in September when temperatures at all sites were between 20.10 ºC and 21.35 ºC. Ponquogue East (SH) and Great Gun (MOR) remained cooler through June, July, and August than other stations. Great Gun (MOR) showed the smallest change in temperature over the sampling period, ranging from 14.60 ºC to 22.80 ºC.

Dissolved oxygen values showed only small temporal variation at all stations throughout the sampling period, ranging from 5.56 mg/L at Cupsogue (MOR) to 9.49 mg/L at Great Gun (MOR). All values were above 4.8 mg/L, which is the EPA specified criteria for chronic and acute effects (USEPA 1999). Ponquogue East (SH) and Great Gun (MOR) both showed an expected seasonal trend in dissolved oxygen, with levels decreasing from June to August and then increasing through September and October. The greatest variability in dissolved oxygen was observed at East Fire Island (GSB) and Cupsogue (MOR). At these stations dissolved oxygen increased in August by 3 mg/L and 1 mg/L, respectively, before returning to an expected seasonal trend of decreasing dissolved oxygen during summer months. The smallest change occurred at Tiana (SH) where dissolved oxygen changed by only 0.87 mg/L over the sampling period.

Salinity values ranged from 19.75 ppt at Bellport (GSB) to 30.55 at Cupsogue (MOR). Observations at both Shinnecock sites, Ponquogue East and Tiana, showed little variability other than a slight increase in salinity from August to September. Bellport (GSB) was observed to have the lowest salinity over all months (averaging only 23.03 ppt) with the exception of September, during which the salinity peaked at 27.60 ppt and the East Fire Island site was lower at 24.40 ppt. The observed salinity minimum occurred in June or July at all stations except Cupsogue, which was at its lowest in June.

Turbidity values were fairly constant, ranging from 0.71 nephelometric turbidity units (ntu) at Cupsogue (MOR) to 3.10 ntu at Bellport (GSB). Mean turbidity at all stations for the entire sampling period was between 1.37 ntu at Great Gun (MOR) and 2.18 ntu at Bellport (GSB). Although turbidity values were low there appears to be a consistent pattern of decreasing turbidity from September through October, at which time all stations were at their minimum. Bellport (GSB) shows the largest change in turbidity, from 1.48 ntu to 3.10 ntu.

b. Spatial Trends

Water quality parameters were averaged for each bay and plotted by month in Figure III-13. Temperature values were similar and closely associated for each bay, with no observed spatial trend. Dissolved oxygen values followed a similar trend in Moriches and Shinnecock Bays. In these areas, dissolved oxygen decreased from June to July, stabilized July to September, and then increased into October. In Great South Bay, dissolved oxygen decreased June to July, increased July to August then stabilized through October. Salinity values were similar for Shinnecock and Moriches bays, although slightly higher in Shinnecock for all months except September. This is expected since the Shinnecock Bay sites were closest to the inlet. Generally, salinity values increased from west to east, with the lowest mean temperatures observed in Great South Bay, and the highest in Shinnecock Bay, with the exception of Moriches Bay in September. Mean turbidity values were consistently higher at Great South Bay throughout the sampling season.

c. Environmental Variables and Faunal Abundances

Data were analyzed to determine if variability in environmental factors showed any observed relationships with spatial and temporal changes in faunal abundances and diversity.

i. Temporal

Technical Appendix Figure 1 shows finfish and invertebrates plotted by month with temperature. These values represent seasonal variability and are the mean temperature values of all stations recorded during the sampling period. Finfish and invertebrate species richness peak in August, corresponding to the highest observed mean temperatures. Temperature and diversity of inverts and finfish follow a trend of increasing from June to August and then decreasing until October, with the exception of a decrease in invertebrate diversity between June and July.

Dissolved oxygen levels decrease slightly from July to September. However, there does not appear to be any relationship between faunal abundance and diversity since dissolved oxygen levels remain high over the entire sampling period. Mean salinity values also remained constant throughout the study period. Due to the lack of variability in salinity, and the tolerance of the observed faunal species to salinity fluctuations in estuarine environments, it is unlikely salinity had an effect on faunal distributions. Monthly mean turbidity never exceeded 2 ntu, which is within the management guideline for supporting marine aquatic life of <8 ntu (Singleton 2001). For this reason it is unlikely that turbidity had an impact on faunal occurrences.

ii. Spatial Trends

Since there was no significant change in temperature between stations, no relationship can be identified with faunal abundance or diversity. Mean temperatures for each station ranged from 19.2 ℃ to 21.1 ℃ (Technical Appendix Table 8).

Mean dissolved oxygen levels were between 7 mg/L and 8 mg/L for all sites. Cupsogue (MOR) had the lowest dissolved oxygen (7.05 mg/L) and although there was a corresponding decrease in finfish diversity, there was no overall trend.

Mean salinity values increased slightly from west to east, with the lowest value recorded at Bellport in GSB (23.0 ppt). The number of invertebrate species also increases slightly from west to east, while finfish diversity fluctuates between stations. Finfish and crab abundances do not appear to correspond to salinity trends across sites.

Although variation in turbidity was minimal, several observations were made. The highest mean turbidity values were found in Great South Bay (>2 ntu). Moriches and Shinnecock bays had similar mean turbidity values ranging from 1.3 ntu to 1.6 ntu. Invertebrate abundance shows an opposite trend to the variation in turbidity across stations, increasing from west to east. Finfish abundance and diversity and crab diversity do not appear to vary with turbidity across stations.

d. Environmental Variables and Eelgrass

With the exception of temperature, no relationships between the measured environmental variables and eelgrass height and density were apparent (Figure III-15, Appendix Table 5). This is due to the minimal variation in most environmental variables during this study (except temperature). Figure III-16 is a plot of the station variation for the eelgrass and water quality parameters. For the most part, variation is minimal, however a trend is observed from East Fire Island (GSB) to Bellport (GSB) and Great Gun (MOR). From East Fire Island (GSB) to Bellport (GSB), there is a dip in both percent eelgrass cover and eelgrass height. From Bellport (GSB) into Great Gun (MOR) these parameters increase, and from Cupsogue (MOR) to Ponquogue East (SH), they decrease.

C. Comparison of USACE Current Field Program with Previous Studies

The following section discusses field observations on eelgrass habitats and faunal distributions. Other studies have been conducted in the northeast United States that describe faunal species interactions with, and their dependency on SAV beds. The findings from these previous studies are compared with the current USACE 2003 field study in an effort to identify associations between eelgrass and faunal interactions.

Heck *et al.* 1989 showed that eelgrass meadows support high animal diversities and abundances. In their study, Heck *et al.* (1989) trawled eelgrass beds and an unvegetated sandy site off of Cape Cod, MA. In their study, they collected finfish and decapod crustaceans. Although they found their species composition to differ from the more southerly studies, the community structure was found to be similar to the findings from the current field survey. Heck *et al.* (1989) found that their eelgrass sites were dominated by three decapods: sevenspine bay shrimp, green crab and rock crab. Similar species were found in this USACE field survey, however, invertebrates were dominated by green crab, Atlantic mud crab and grass shrimp. Heck *et al.* (1989) found fifteen finfish species during daytime sampling, with six species making up 98% of the total catch: threespine stickelback (56%), fourspine stickelback (30%), mummichog (5%), winter flounder (4%), northern pipefish (2%), grubby (1%). Similar species were collected in the seine program of the current USACE study (2003) (Appendix Table 1). Technical Appendix Table 1 shows the top contributors to the catch from the current USACE study were fourspine stickelback (32%), Atlantic silverside (16%), blackfish (15%), grubby (10%), cunner (9%), northern pipefish (*Syngnathus fuscus)* (6%), winter flounder (6%).

Briggs and O'Connor (1971) conducted a seine study in Great South Bay (also located in the FIMP study area) and found that the following finfish dominated eelgrass habitats: fourspine stickelback, Atlantic silverside and mummichog. Species that preferred sandy bottoms were Atlantic silverside, striped killifish, fourspine stickelback and sheepshead minnow. They also noted that of 40 species collected, 17 preferred eelgrass, 6 preferred sand, and the remaining 17 had no preference. The Briggs and O'Connor (1971) study found a link between the diversity of bay fishes and aquatic vegetation. They concluded that eliminating vegetation would potentially decrease species richness and, for some species, population density. Similar findings were reported in a 1981 USFWS study in Great South Bay. In addition to bottom type, the 1981 USFWS study states that bay fish species distributions were affected by physical parameters such as proximity to the ocean, wind velocity, salinity, temperature, oxygen substrate and current velocity.

This study has also demonstrated that sites located near inlets are potentially important areas supporting a higher number of species. This is most apparent at Ponquogue East (SH) where several species of tropical fishes were collected. These fish are termed "expatriates" because they are typically found in tropical waters. These "expatriates" are carried from the south to the north with the warm waters of the Gulf Stream and transported into the bays by circular eddies spinning off the Gulf Stream. During this survey the following expatriates were collected: doctorfish (*Acanthurus chirurgis),* crevalle jack (*Caranx hippos),* spotfin butterflyfish (*Chaetodon capistratus),* foureye butterflyfish (*Chaetodon ocellatus),* yellowedge grouper (*Epinephelus flavolimbatus),* scrawled cowfish (*Lactophrys quadricornis),* red goatfish (*Mullus auratus),* and lionfish. Figure III-17 shows pictures of lionfish and other finfish species collected during the study.

In 1997, Raposa and Oviatt conducted a study in Great South Bay for the National Park Service. In this study, three habitat types were studied: Z*. marina* eelgrass beds, *Spartina* salt marshes and unvegetated intertidal beaches. Similar to other studies, Raposa and Oviatt (1997) found that vegetated areas supported higher densities and numbers of nekton species than unvegetated areas. They hypothesized that this is probably due to the role vegetation play as a shelter from predation by providing more abundant food supplies and a quiescent environment. In the Raposa and Oviatt (1997) study, northern pipefish, winter flounder and grass shrimp preferred eelgrass beds, while sevenspine bay shrimp and fourspine stickelback preferred macroalgae. Total nekton abundance and biomass were higher along beach shorelines primarily due to Atlantic silverside and sevenspine bay shrimp. The study also found species richness to be higher along salt marsh shorelines.

In addition to nekton diversity and abundance, studies have indicated that invertebrate abundances are higher in SAV areas. den Hargot (1977) has shown that infauna and epifauna abundances are often higher in seagrass meadows than adjacent sandflats in western Europe. Studies have attributed these higher invertebrate abundances to increased sediment stability (Orth, 1977). Several studies have been conducted on the blue mussel, *Mytilus edulis,* in eelgrass beds and its effect on their survival. In this study, the blue mussel was found attached to both eelgrass and sea lettuce, with higher abundances found on the algae. Eelgrass has been shown to affect mussels in two ways: by altering drift distances of blue mussel patches and preventing destruction of patches from low level disturbances (Reusch and Chapman, 1995).

D. Summary and Conclusions

Major findings of the USACE 2003 SAV Bed Characterization field program are summarized in the following paragraphs. Sampling was conducted from June through October, 2003 at six SAV sites, two each in Great South, Moriches and Shinnecock Bays. Survey collections included: fish, macroinvertebrate and algae data using the seine net; qualitative observations of fish and SAV using snorkeling; quantitative eelgrass densities using the quadrat, and in-situ water quality data.

The following faunal relationships, as associated with eelgrass trends, can be reported from the current field program conducted by the USACE in 2003. In making conclusions based on this study and comparison with other studies, it is important to note that the SAV site sampling was of a discrete area and time interval (5 months). The historical analysis, on the other hand, was based on baywide phenomena observed over an extended time period of decades. General observations based on the current USACE field program are described following.

Eelgrass density ranged from 25% to 83% per site. The highest eelgrass density was recorded at Cupsogue (MOR) and the lowest at Ponquogue East (SH). Mean values of eelgrass density did not appear to differ distinctly between Great South, Moriches and Shinnecock Bays. Average densities in each bay were 52% in GSB, 58% in MOR and 43% in SH. A slightly higher mean eelgrass density was observed in Moriches Bay and a slightly lower value in Shinnecock Bay. Distributions of eelgrass were patchy throughout each of the study sites. Density of eelgrass was greatest during August, which corresponded with highest water temperatures. This also corresponded with a peak in finfish and invertebrate diversity and abundance. The increase in finfish diversity during summer months was most likely the result of an influx of species from the ocean to the bay, and not primarily the result of an increase in resident species.

Seine net collections of finfish totaled 16,413 specimens representing 49 species. Dominant species listed in order were: Fourspine stickleback, Atlantic silverside, blackfish, grubby, cunner, northern pipefish (*Syngnathus fuscus)* and winter flounder. Seine net collections of invertebrates were dominated by: green crab, Atlantic mud crab, ctenophores, eastern mudsnail, grass shrimp, golden star tunicate, and red beard sponge. Fifty species of invertebrates were represented in these collections.

Although eelgrass density was similar at all six SAV sites (~50%) eelgrass height differed among sites. Eelgrass height was variable with mean values ranging from 3 inches to 21 inches. The lowest eelgrass were recorded at Bellport (GSB) and the tallest at Cupsogue (MOR). The tallest stands of eelgrass were observed in Moriches and Shinnecock Bays during July and August. In addition, water clarity was qualitatively observed to be greater in Moriches and Shinnecock than Great South Bay. Finfish species richness and abundance was generally found to increase from west to east. However, invertebrate species richness and crab abundance remained similar across all bays. An examination of eelgrass and faunal trends associated with inlets revealed that the two stations nearest inlets (Ponquogue East in SH and Great Gun in MOR) had differing results. Great Gun (MOR) had high average eelgrass heights and densities, while Ponquogue East (SH) had a lower average eelgrass height and the lowest eelgrass density. Due to their proximity to inlets, water temperatures at these two stations were slightly lower than at other sample locations. The lower water temperature and increased circulation associated with inlets can explain certain trends in floral and faunal distributions, such as a higher abundances and diversity. For example, a greater diversity of tropical finfish species (expatriates) was found at sample sites in close proximity to inlets, transferred from the ocean to the bay. It is assumed that these tropical occurrences were due to Gulf Stream transport effects during late summer months.

Eelgrass was typically the dominant seagrass at all study sites; however, widgeon grass was also observed from June through August at the Bellport site in GSB. Although not studied during this program, widgeon grass was also observed at Old Inlet in GSB. In addition to seagrasses, macroalgae was observed at all sites in varying degrees. Snorkeling and seining observations identified fifteen types of algae. Dominant types of algae were wire weed

(*Ahnfeltia),* the red algae *Ceramium,* and the green algae *Chaetomorpha.* Finfish and invertebrates observed during snorkeling were consistent with seine collections. The highest algal diversity was noted at Ponquogue East (SH), the site where faunal diversity was also greatest.

Water quality values (temperature, salinity, dissolved oxygen, and turbidity) followed expected seasonal trends and did not vary significantly between stations. Although turbidity (water clarity) has been observed to have an effect on eelgrass distribution, the scale of this field program did not observe any significant trends. A qualitative observation was made indicating that water clarity was reduced in GSB, where eelgrass beds appeared to be slightly shorter. The only water quality parameter observed to have a correlation with faunal abundances and diversity was temperature (as discussed above). No consistent correlations were found in faunal representation against the other water quality variables measured in this study, e.g.; salinity, dissolved oxygen, turbidity. This finding is only relevant to the scale at which the current study was performed, and is not intended to imply that no relationships exist.

It is important to continue baseline surveys of the bay habitats, especially seagrass meadows, as a means of tracking impacts over time. The potential for destruction of seagrass beds from anthropogenic sources needs to be considered in future management strategies. Seagrass meadows are proven to be productive habitats and information on biological populations (presence/absence, abundance, and diversity) can aid in the assessment and determination of environmental impacts. This survey provides a critical missing link in the knowledge of SAV habitats in the northeastern Atlantic. Additionally, this survey will enable changes in species composition and abundance to be tracked over time, allowing the monitoring of habitat changes resulting from environmental stressors and the prediction of impacts due to human and/or natural events.

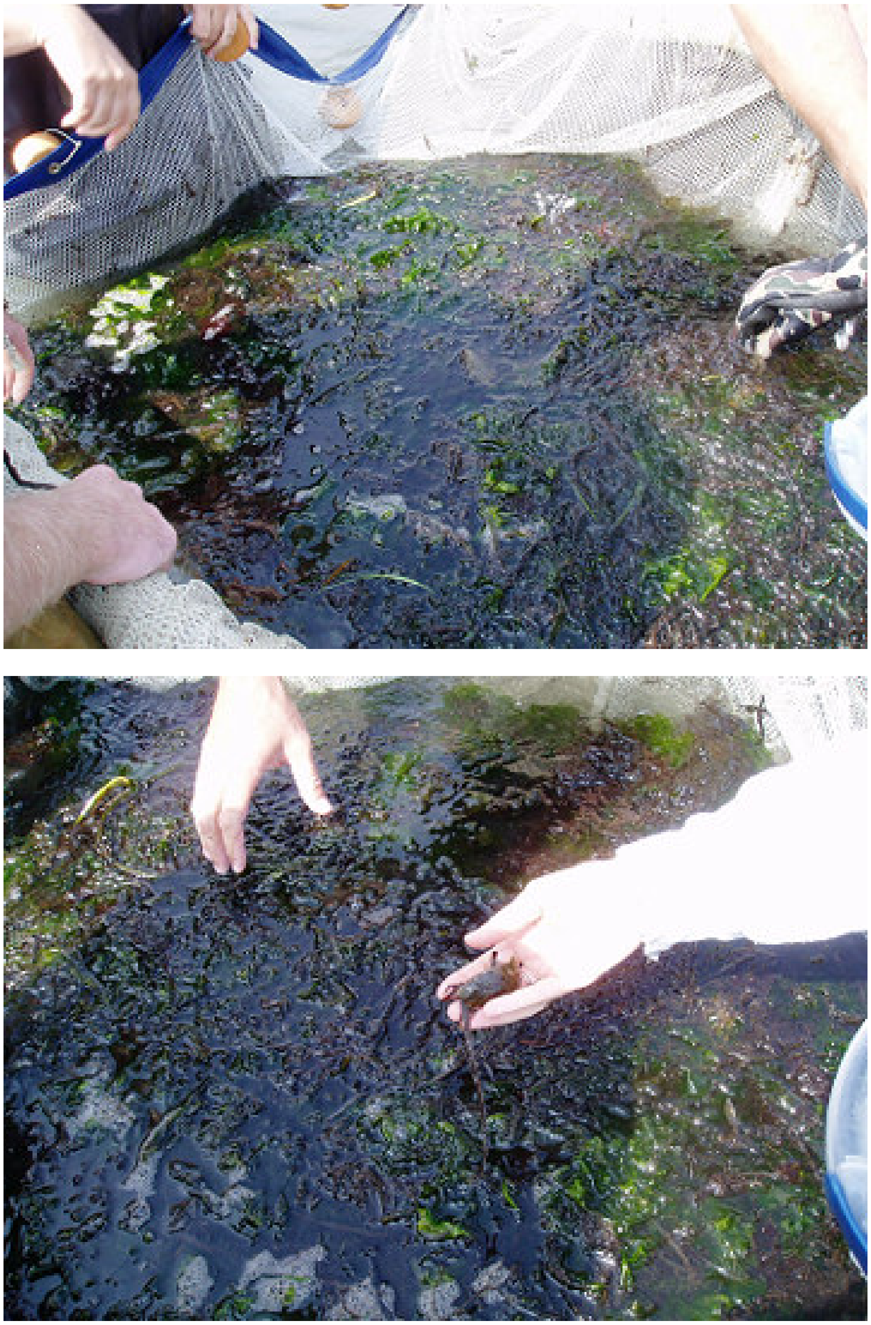
FIGURE III-1

Seine Net Used in Survey

Twenty-foot seine net

FIGURE III-2

Seine Net Contents



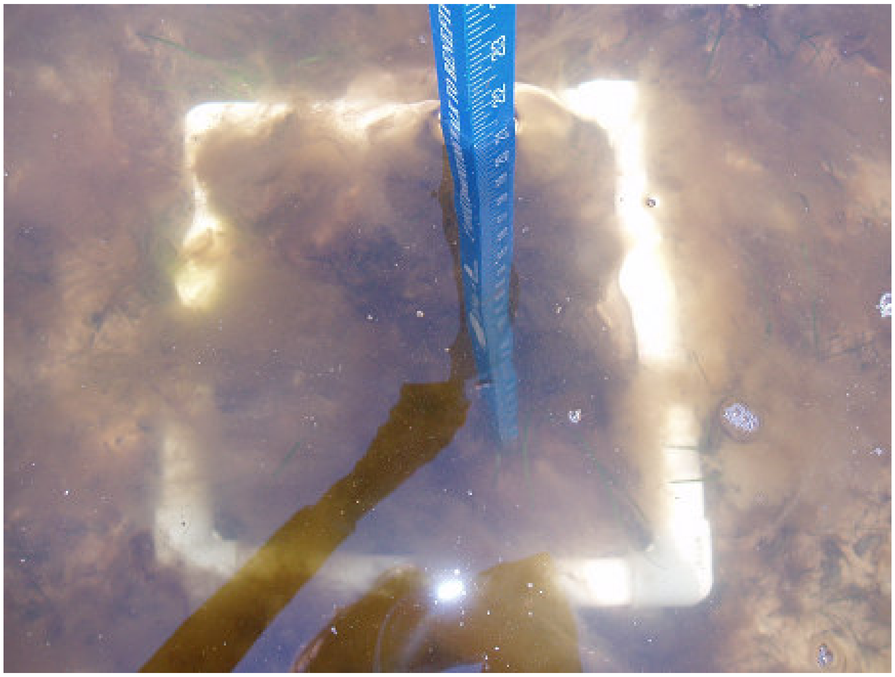
Contents of seine net after being hauled through eelgrass. Contents of net were processed by hand and all organisms removed. Pictured contents are primarily algae and green crab in hand.

FIGURE III-3

Processing Samples

FIGURE III-4

A. Eelgrass Quadrat



Pictured are 1-foot square eelgrass quadrat and ruler.

Density of eelgrass within the quadrat was ranked.

Height of eelgrass within the quadrat was measured.

1 ft.

FIGURE III-5

Finfish Length Frequency Distribution

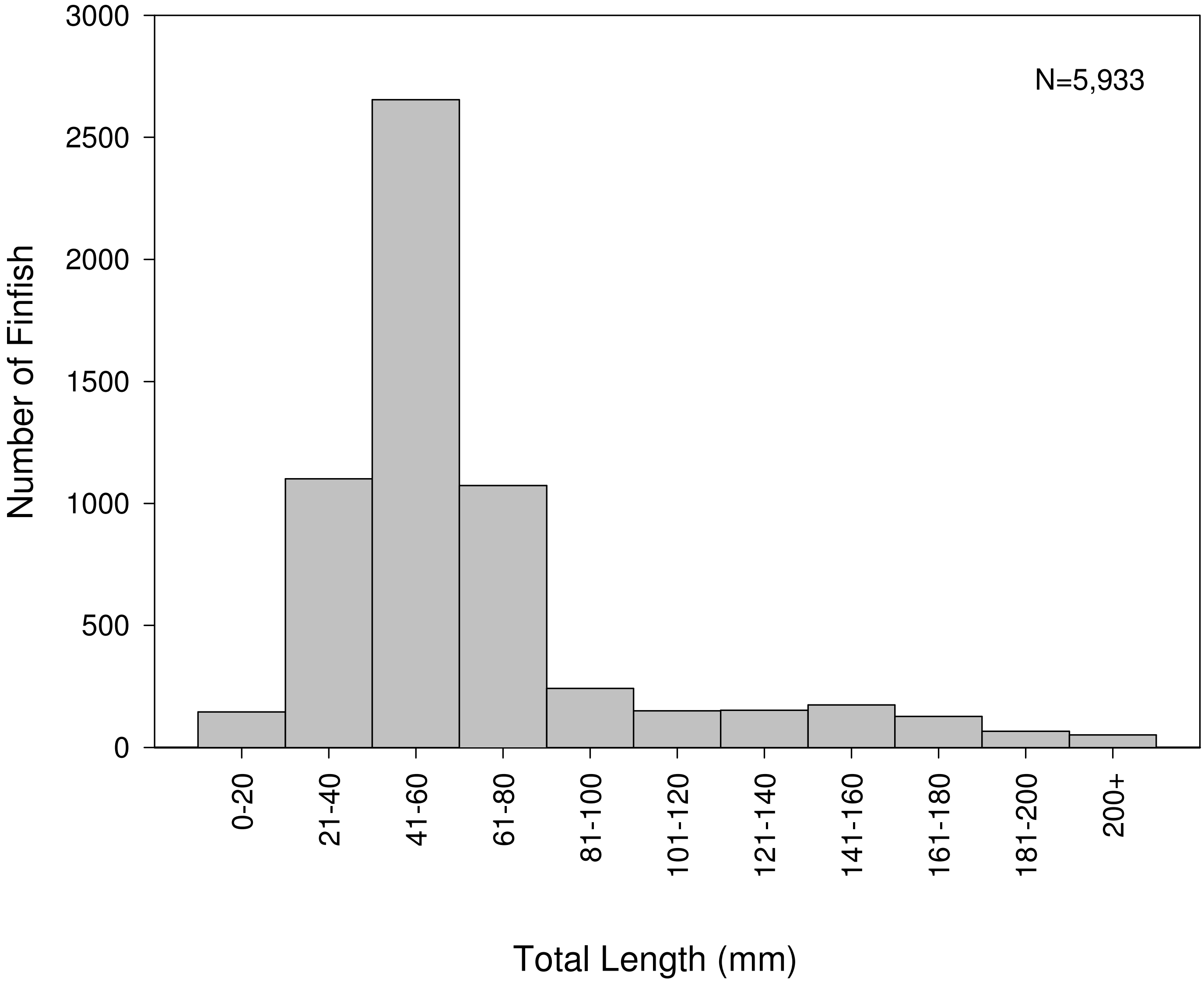


FIGURE III-6

Total Number of Finfish and Species per Month

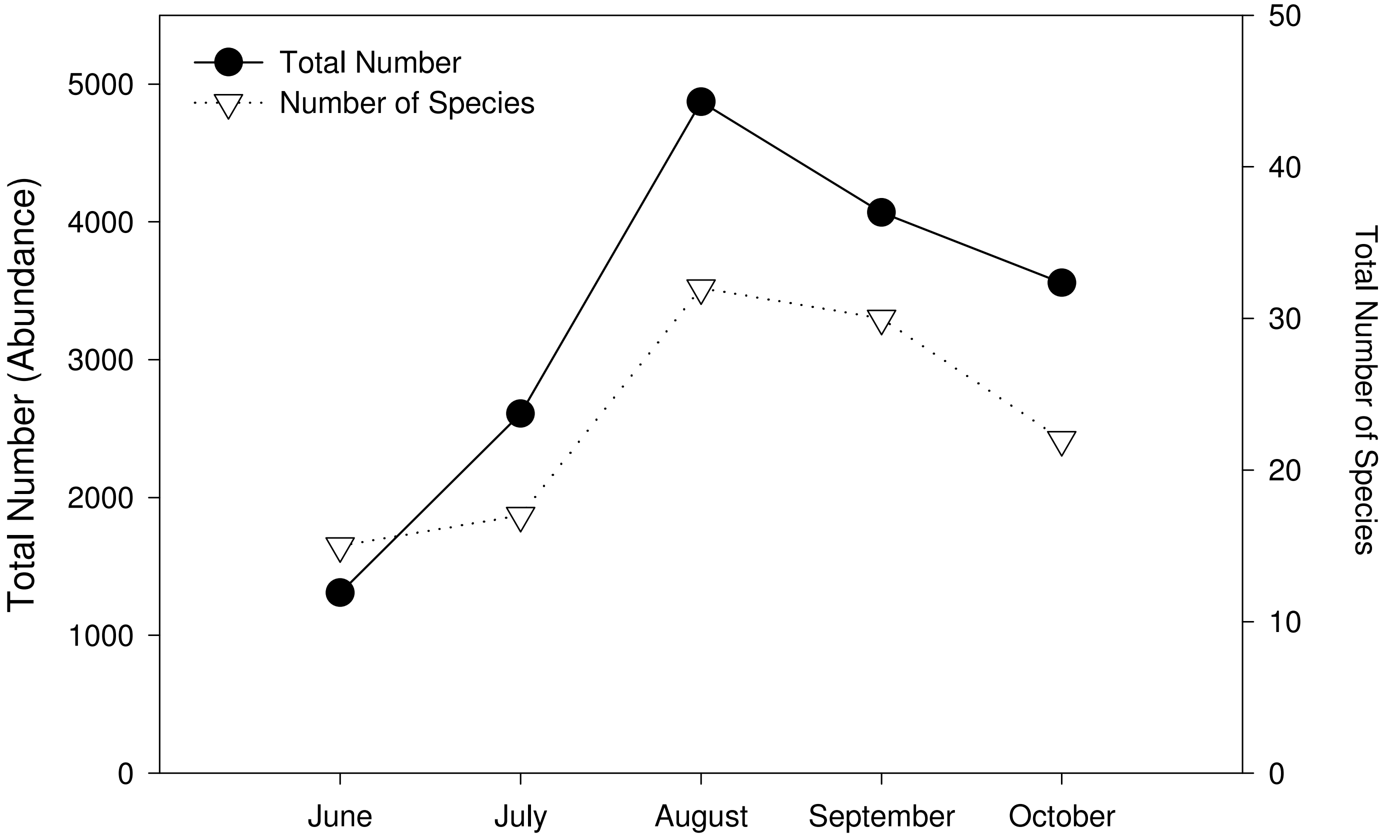


FIGURE III-7

Total Weight (g) of Finfish per Month

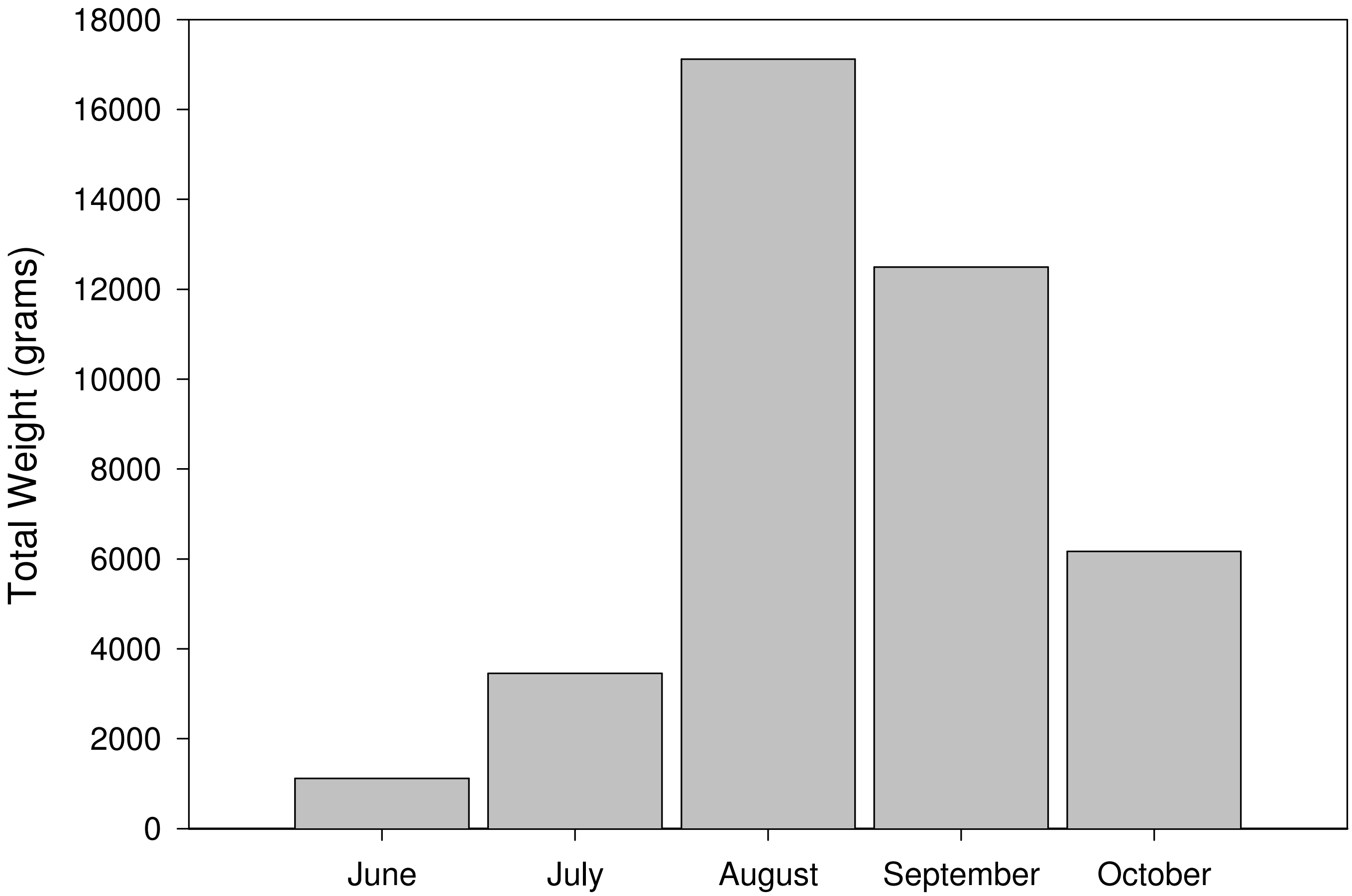
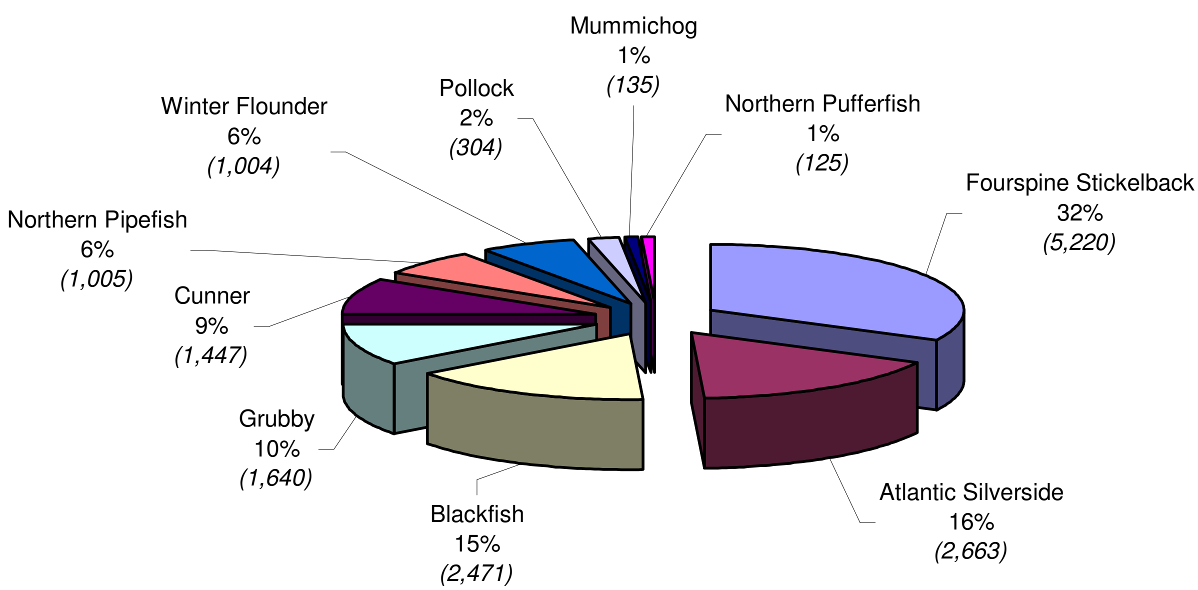
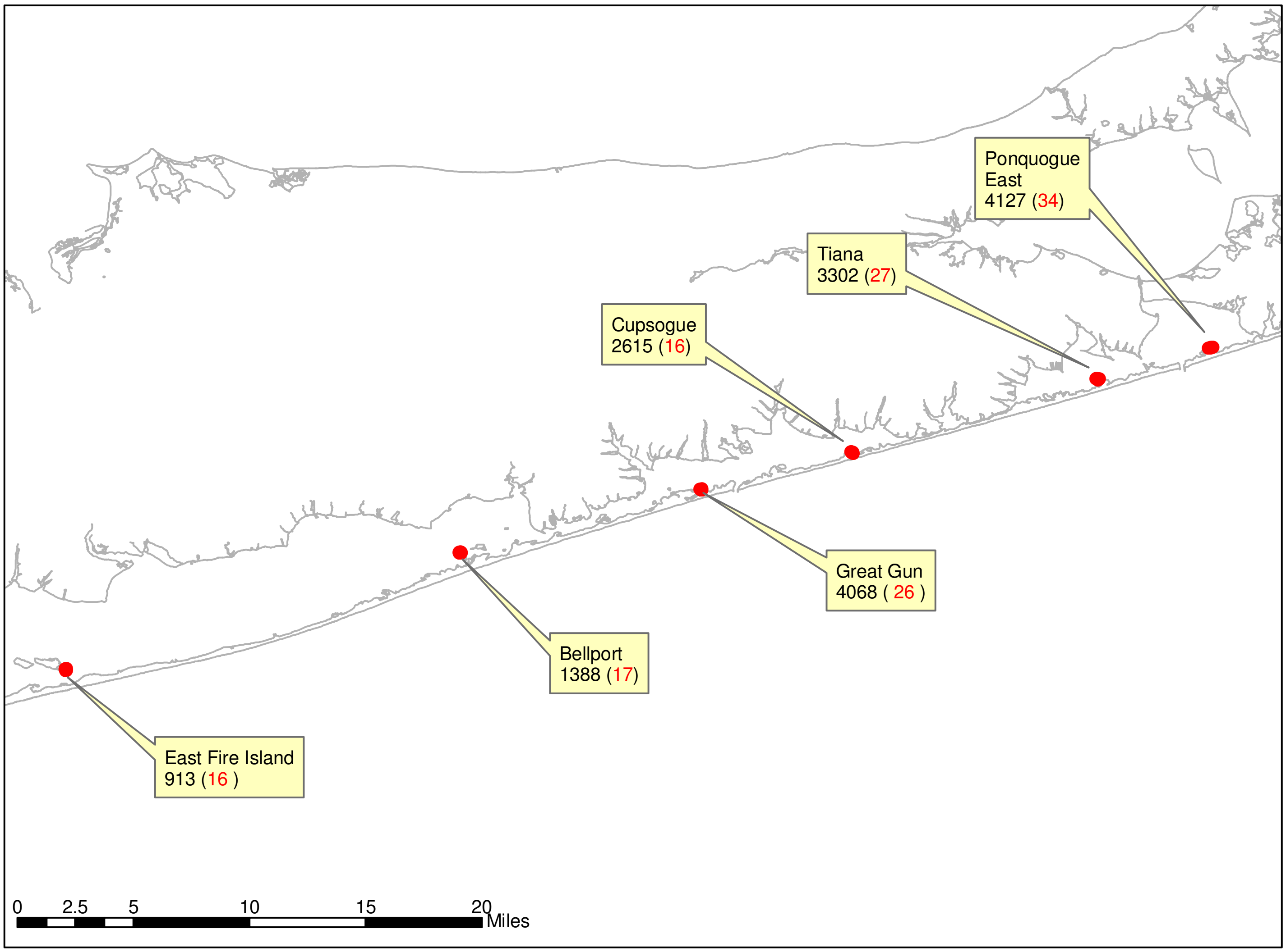


FIGURE III-8
Percent Composition of Ten Most Numerous Finfish Species



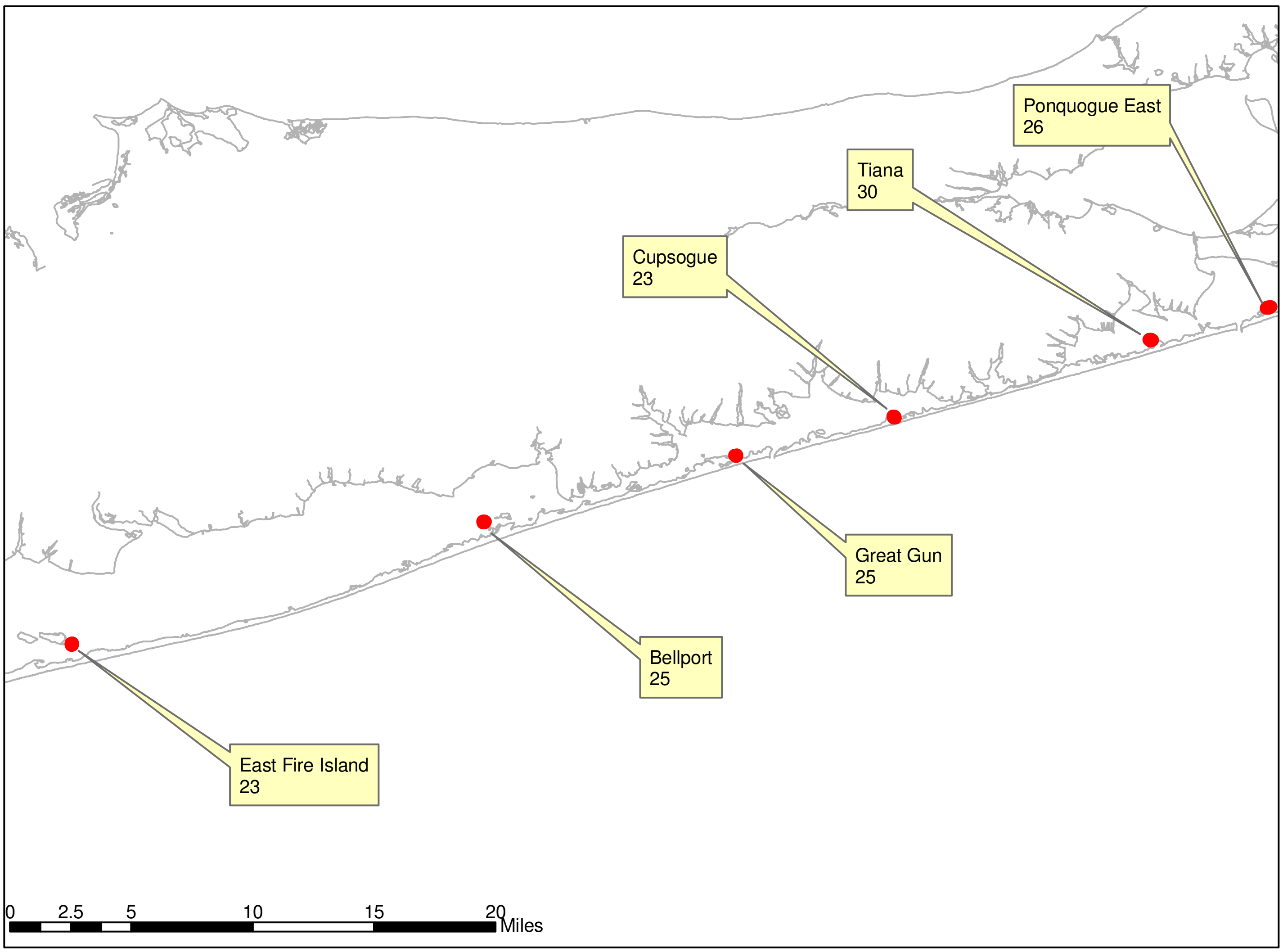
Note: Values italicized in parentheses denote total number of finfish collected during the entire survey period.

FIGURE III-9
Finfish Abundances and Number of Species at Each SAV Site



Finfish abundances in black. Number of species values in red.
See text for distances between inlets and station locations.

FIGURE III-10
Number of Invertebrate Species at Each SAV Site



See text for distances between inlets and station locations.

FIGURE III-11

Eelgrass Density and Height Monthly Mean by Station

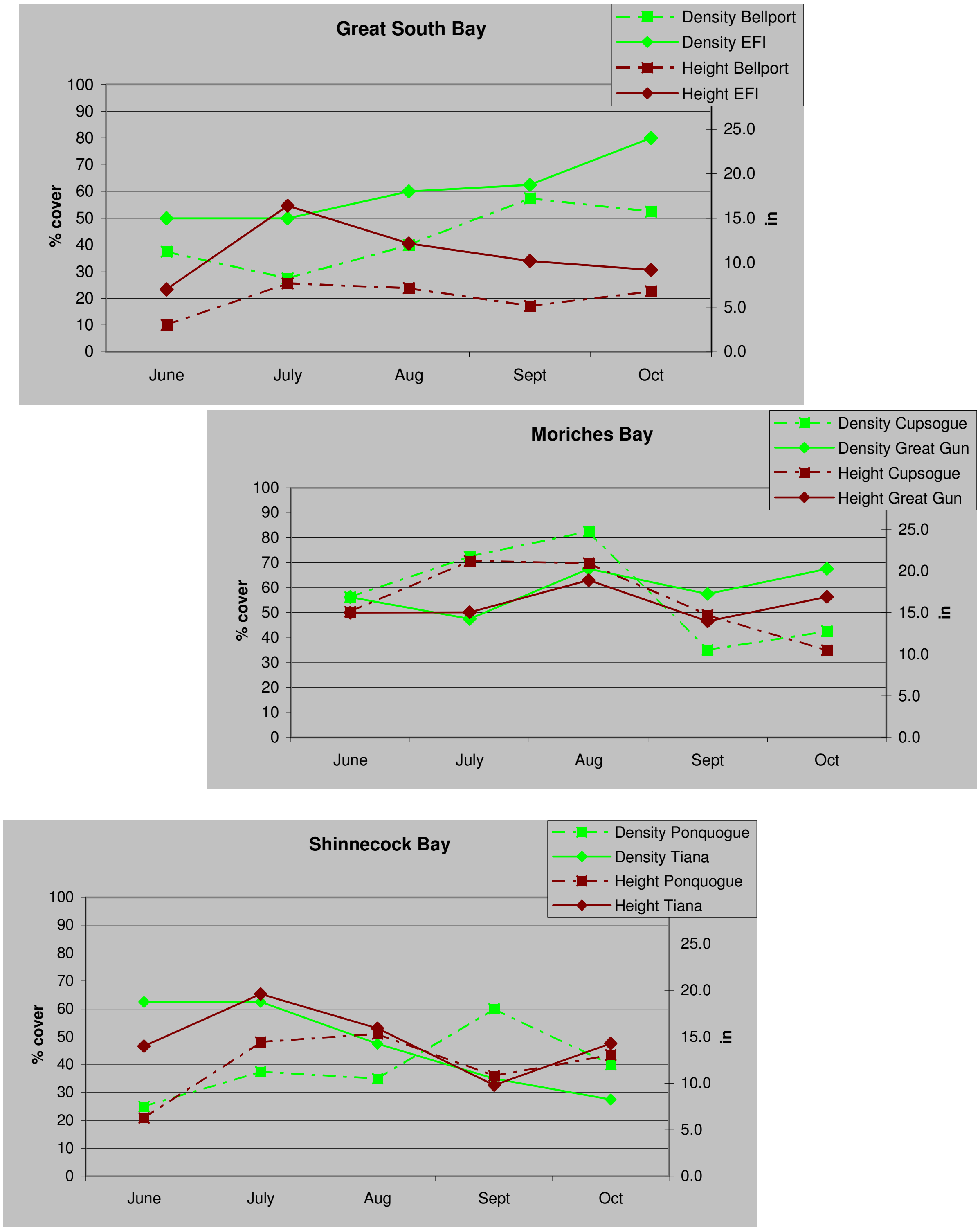


FIGURE III-12

Representative SAV and Algal Species Observed In Study

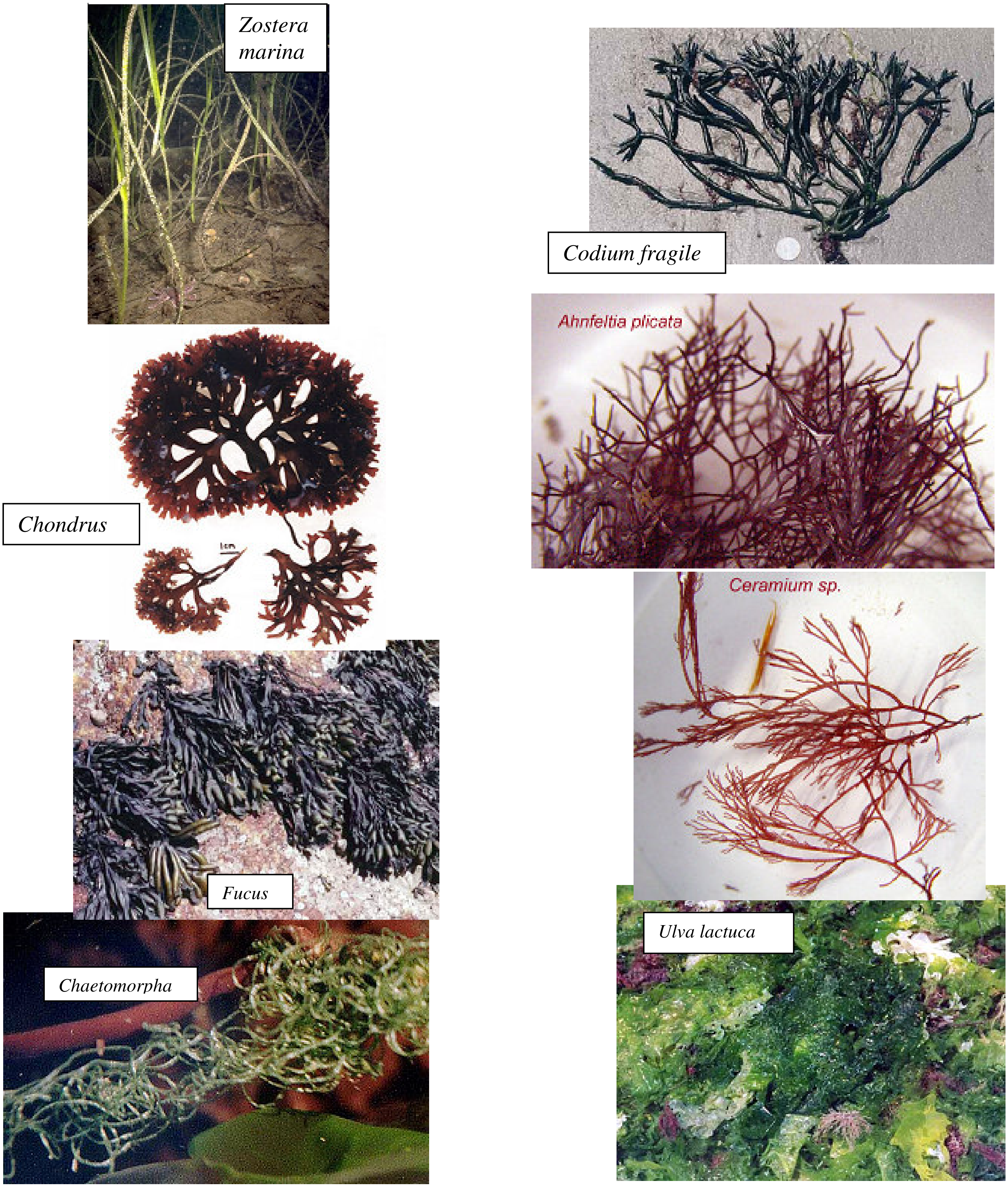


FIGURE III-13
Water Quality Variables by Month

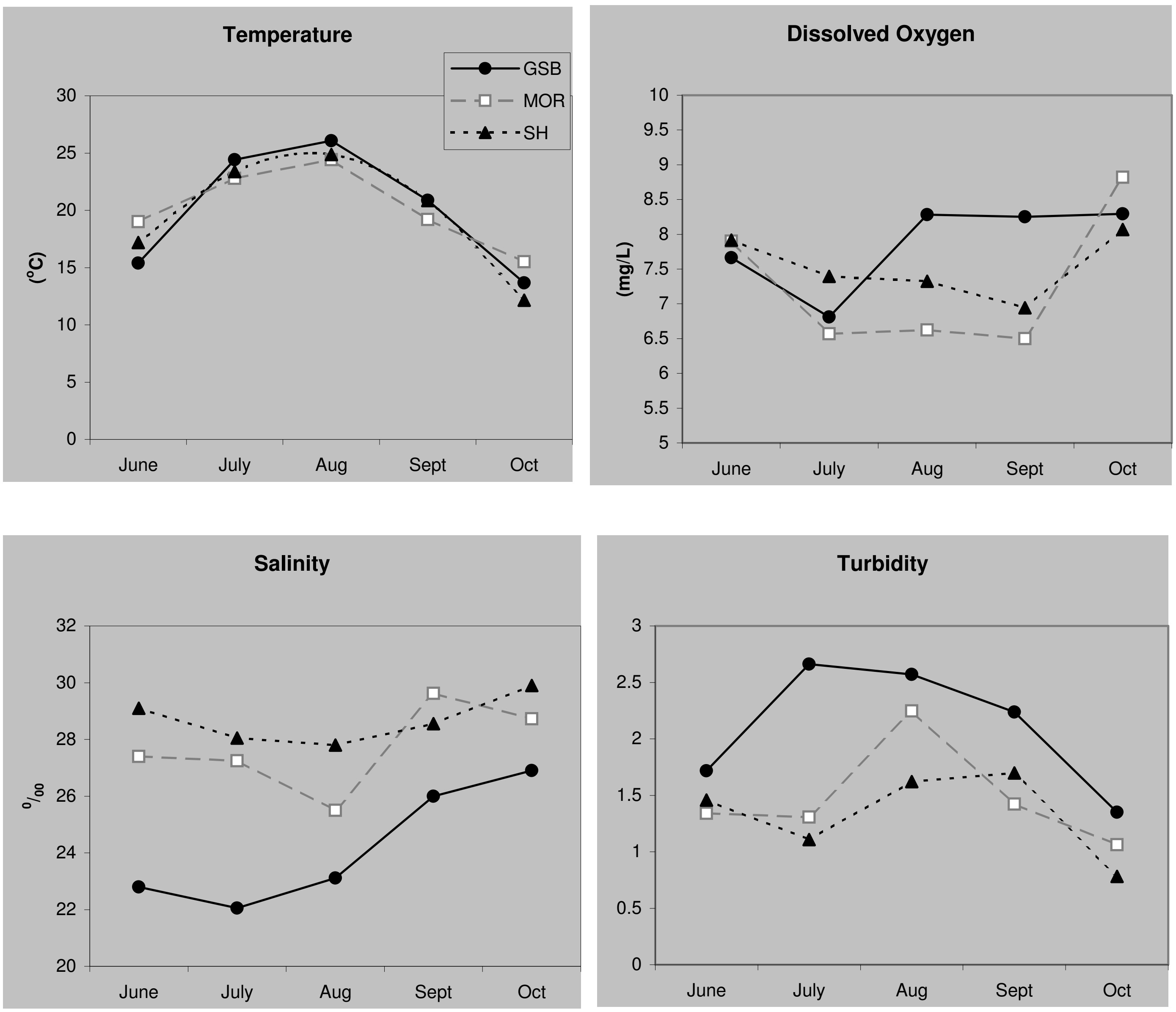
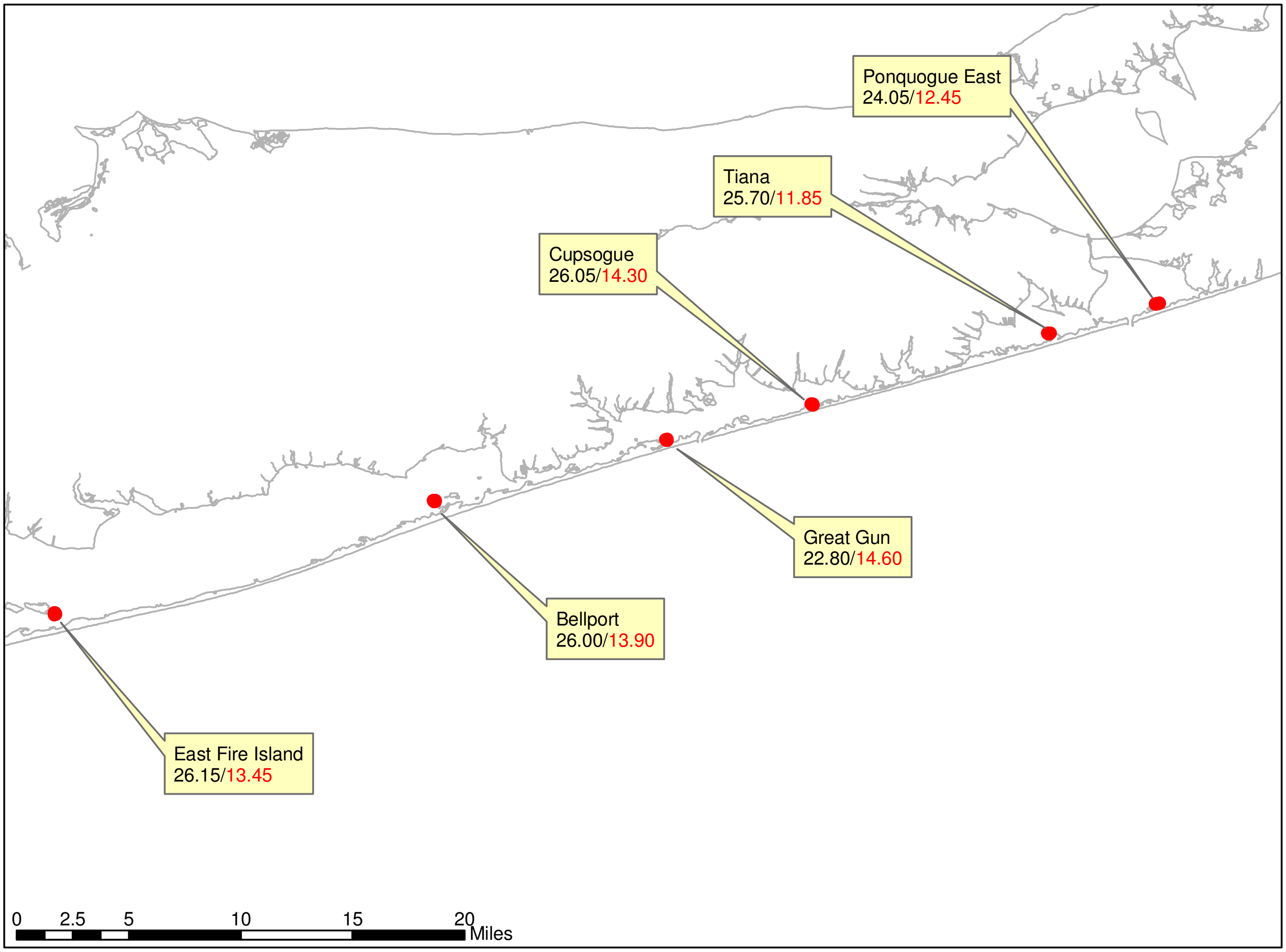


FIGURE III-14
Temperature (^{o}C) Values at Each SAV Site



Maximum values in black. Minimum values in red.
See text for distances between inlets and station locations.

FIGURE III-15

Monthly Eelgrass Height and Density
vs.
Environmental Variables

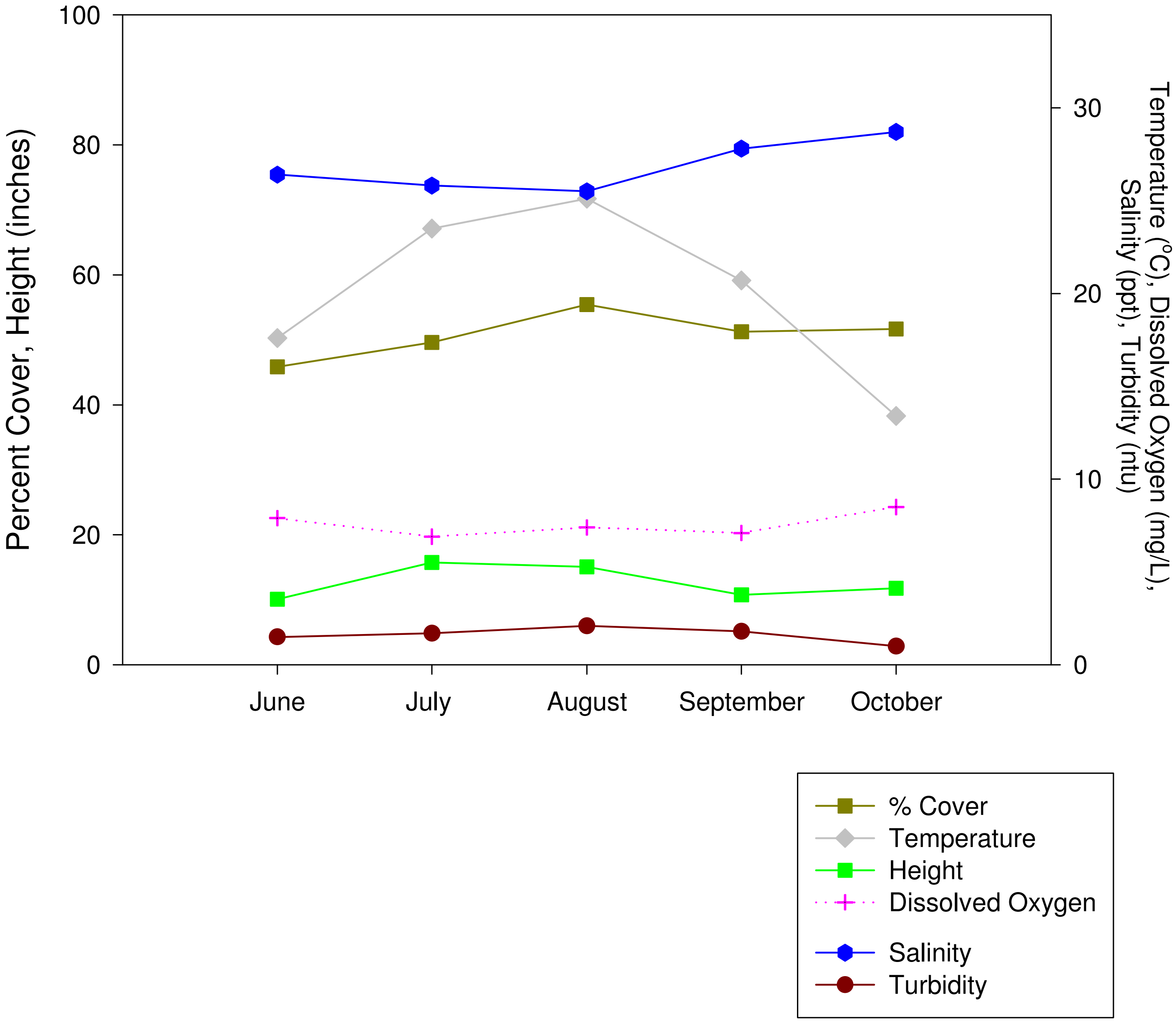


FIGURE III-16

Eelgrass Height and Density
vs.
Environmental Variables by Station

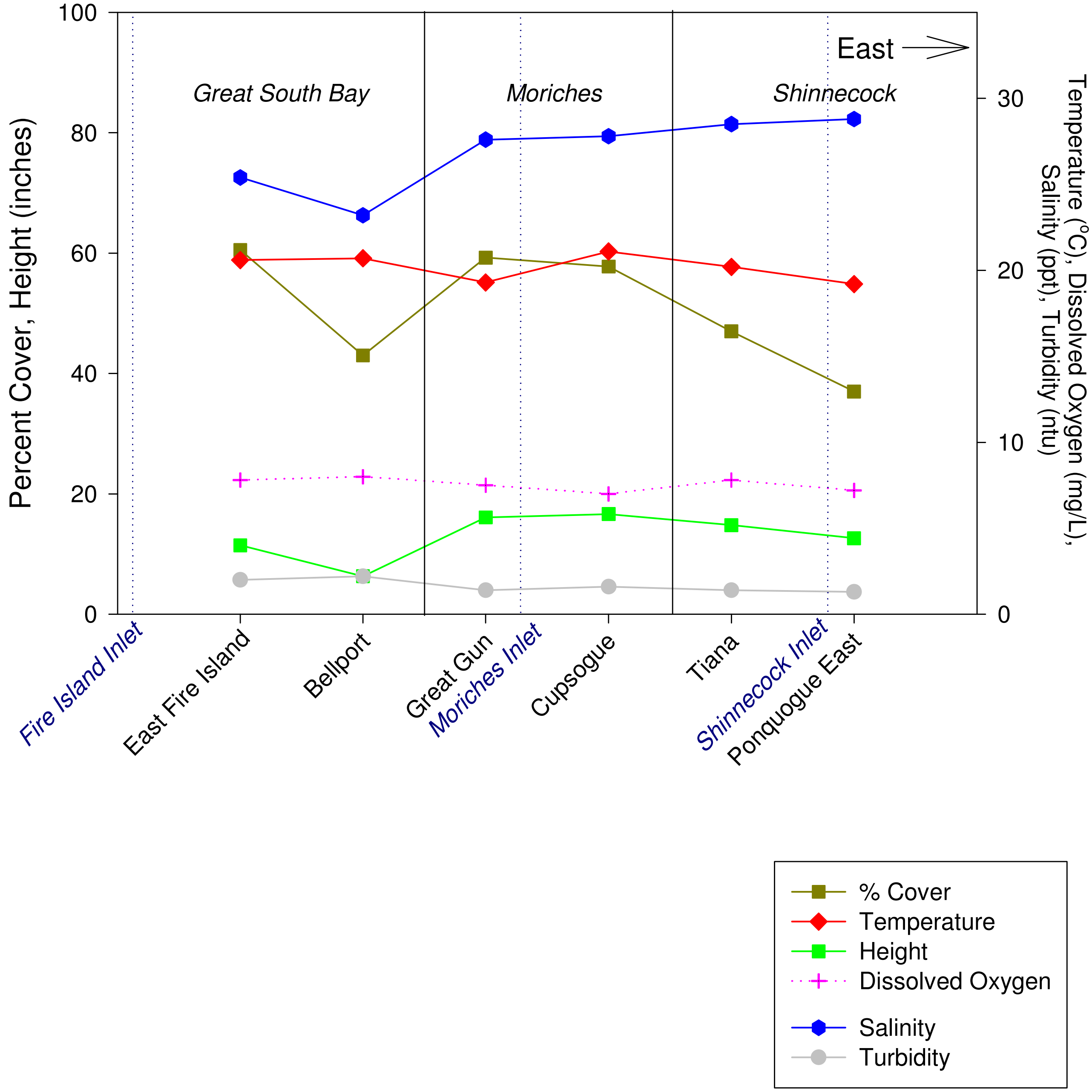


FIGURE III-17

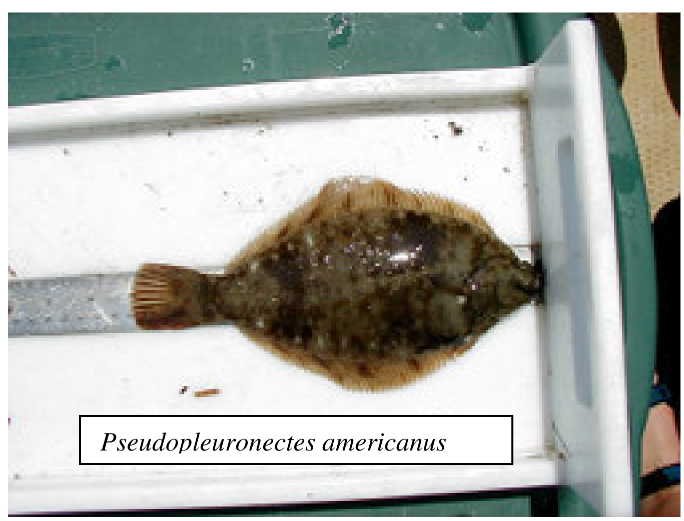
Finfish Collected in Samples


Acanthurus chirurgus


Pterois volitans


Apeltes quadracus


Myoxocephalus aenaeus


Pseudopleuronectes americanus

IV. OVERALL SUMMARY & CONCLUSION

This report provides a summary of available historic and current biological and physiological data relevant to SAV and an analysis of possible relationships between environmental variables and SAV. In addition, this report presents the study design, methodologies and results from a seasonal survey of the SAV beds in the backbays of the FIMP study area conducted in 2003. The following paragraphs summarize significant conclusions concerning the relationship between SAV coverage, available physiological data, additional data collected as part of this study, and historic overwash and breaching processes.

Comparison of available SAV mapping in Great South Bay conducted in the late 1970's generally corresponds well to the recent mapping conducted by the USACE. However, it appears that over the past 25 years, there has been a loss of SAV beds fringing the mainland south shore or northerly side of Great South Bay from Howell's Point in Bellport west to the Robert Moses Causeway. The exact causes are unknown, but it is likely tied to increased environmental stresses on SAV beds that were formerly occupying less than optimal substrate conditions.

SAV distribution in the south shore embayments appears to be strongly correlated with depth (generally less than 2 m) and a combination of environmental factors. The SAV beds appear to be confined to shallower depths (1-m average depth in Great South Bay for the largest beds) in areas of reduced light penetration, as a result of poor tidal flushing or presence of a relatively high percentage of fines and organics in the bottom substrate. SAV beds are found at greater depths (1.5 m in Moriches Bay, and 2-4 m in Shinnecock Bay) in areas with more flushed bay conditions and clearer water. The SAV depths recorded in the 2003 study generally confirmed these findings. The current field program observed the healthiest eelgrass beds at some of these greater depths in Moriches and Shinnecock Bay.

Historic and recent USACE mapping suggests SAV spatial distribution does not appear to correlate with a specific tidal range as SAV beds are found in areas with tidal ranges from the minimum (0.3 m in Great South Bay) to the maximum (0.9 m in Shinnecock Bay) observed in the FIMP area. Nonetheless, a larger bay tidal range is typically associated with higher flushing rates and better water clarity conditions. Field data from the 2003 study suggests that under these conditions SAV can be found at deeper bay bottom elevations. Moreover, the tallest stands of eelgrass were observed at Ponquogue East (SH), which is located in an area with high flushing rates but protected from high currents. In addition, a spatial trend was observed in the recent field data suggesting that percent eelgrass cover and eelgrass height are reduced in areas with lower average salinity and reduced tidal flushing (i.e., Bellport in GSB).

Finfish abundance was more than three times greater in Moriches and Shinnecock bays than in Great South Bay. Invertebrate species data collected during this study also suggest a trend of increasing abundance from Great South Bay to Moriches and Shinnecock Bays. Although the trend is not as clear, finfish and crab abundance appears to increase from west (GSB) to east (SH).

Although salinity gradients alone do not appear to directly affect SAV distribution in the FIMP study area (see Section II), a potential shift in representative species could occur if salinities were altered. For example, widgeon grass is observed in more brackish waters, as was observed at Old Inlet. In addition to seagrasses, the macroalgal distribution could also be affected in the event of a long-term change in salinity.

Although very limited project-specific historic data is available, the general understanding of overwash processes suggests that relatively large overwashes extending into subtidal areas of the backbay, which will only occur during rare extreme events, are more likely to negatively impact existing SAV beds than to generate a net increase in areas suitable for SAV growth.

The location of shallow relict flood shoals created by breaches and inlets during historic storms relative to mapped SAV beds suggests inlet flood shoals may serve as platforms supporting SAV growth. However, storm breaches and new inlets, depending on their location relative to pre-existing SAV beds, may also lead to the scouring or smothering of these SAV beds. The lack of historic SAV mapping that could be correlated to historic breaching prevents a more conclusive assessment concerning the net effects of breaching on SAV.

The initial increases in tidal flushing and water clarity that would likely benefit SAV growth immediately after a breach/inlet opening would not continue in the long-term and they might actually be reversed unless at least one of the inlets is maintained through regular dredging.

Stabilized inlets have led to significant increases in bay flushing and water quality relative to pre-stabilization conditions at Moriches and Shinnecock Bays. It is likely that these benefits have resulted in increased SAV growth relative to pre-stabilized conditions. There is insufficient historic bathymetric data, however, to speculate what the net effect of inlet stabilization has been on overall sediment accumulation in the bays and concomitant creation of shallow areas supporting SAV growth.

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APPENDIX A

APPENDIX A:

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APPENDIX A TABLE 1
Finfish Species List

Scientific Name	Common Name
Acanthurus chirurgis	Doctorfish
Alosa aestivalis	Blueback Herring
Alosa pseudoharengus	Alewife
Anchoa mitchilli	Bay Anchovy
Anguilla rostrata	American Eel
Apeltes quadracus	Fourspine Stickleback
Brevoortia tyrannus	Atlantic Menhaden
Caranx hippos	Crevalle Jack
Centropristis striata	Black Seabass
Chaetodon capistratus	Foureye Butterflyfish
Chaetodon ocellatus	Spotfin Butterflyfish
Chilomycterus schoepfi	Striped Burrfish
Cynoscion regalis	Weakfish
Cyprinodon variegatus	Sheepshead Minnow
Enchelyopus cimbrius	Fourbeard Rockling
Epinephelus flavolimbatus	Yellowedge Grouper
Epinephelus nigritus	Warsaw Grouper
Fistularia tabacaria	Bluespotted Cornetfish
Fundulus heteroclitus	Mummichog
Fundulus majalis	Striped Killifish
Gasterosteus aculeatus	Threespine Stickleback
Gobiosoma bosc	Naked Goby
Hippocampus erectus	Lined Seahorse
Lactophrys quadricornis	Scrawled Cowfish
Menidia menidia	Atlantic Silverside
Menticirrhus saxatilis	Northern Kingfish
Microgadus tomcod	Atlantic Tomcod
Micropogonias undulatus	Atlantic Croaker
Monacanthus hispidus	Planehead Filefish
Mugil cephalus	Striped Mullet
Mullus auratus	Red Goatfish
Mycteroperca microlepis	Gag
Myoxocephalus aenaeus	Grubby
Opsanus tau	Oyster Toadfish
Paralichthys dentatus	Summer Flounder
Pholis gunnellus	Rock Gunnel
Pollachius virens	Pollock
Pomatomus saltatrix	Bluefish
Prionotus evolans	Striped Searobin
Prionotus carolinus	Northern Searobin
Pseudopleuronectes americanus	Winter Flounder
Pterois volitans	Lionfish
Sphoeroides maculatus	Northern Puffer
Sphoeroides spengleri	Bandtail Puffer
Strongylura marina	Atlantic Needlefish
Syngnathus fuscus	Northern Pipefish
Tautoga onitis	Blackfish/Tautog
Tautogolabrus adspersus	Cunner
Urophycis chuss	Red Hake
Urophycis regia	White Hake

Sources: AFS Spec. Pub. 20 (Fifth Ed). Common and Scientific Names of Fishes from the United States and Canada
Robins and Ray. 1986. Peterson Field Guides: A Field Guide to Atlantic Coast Fishes: North America

APPENDIX A TABLE 2
Invertebrate Species List

Scientific Name	Common Name
Amphipods	
***Anachis* sp.**	Dovesnails
Anemone	
Argopecten irradians	Bay Scallop
Asterias forbesi	Common Sea Star
Aurelia aurita	Moon Jelly
Botrylloides diegensis	Pacific Colonial Tunicate
Botryllus schlosseri	Golden Star Tunicate
***Busycon carica* Egg Cases**	Knobbed Whelk
Busycotypus canaliculatus	Channeled Whelk
Calappa flammea	Shamefaced Crab
Calcareous worm tubes	
Callinectes sapidus	Blue Crab
Cancer irroratus	Rock Crab
Caprellid Amphipods	
Carcinus maenas	Green Crab
***Cerebratulus lacteus* Egg Cases**	Ribbon Worm Egg Cases
Crangon septemspinosa	Sevenspine Bay Shrimp
Crepidula fornicata	Common Atlantic Slippersnail
Ctenophores	
Cyanea capillata	Lion's Mane Jellyfish
Diopatra cuprea	Junk Worm
Dyspanopeus sayi	Say Mud Crab
Ensis directus	Common Razor Clam
Eupleura caudata	Thick-Lip Drill (snail)
***Euspira heros* egg cases**	Northern Moonsnail
Geukensia demissa	Ribbed Mussel
***Halichondria* spp.**	Bread-Crumb Sponges
Haliclona canaliculata	Sponge (Yellow/Tan)
Haliclona permollis	Sponge (Yellow/Tan)
Hemigrapsus sanguineus	Pacific Grapsid Shore Crab
Hippolyte zostericola	Zoster Shrimp
Holothuroidea	Sea Cucumber
Hydroides dianthus	Carnation Worm
Hydroids	
Ilyanassa obsoleta	Eastern Mudsnail
Ilyanassa trivittata	New England Dog Whelk
Isopods	
Libinia emarginata	Portly Spider Crab
Limulus polyphemus	Horseshoe Crab
Littorina littorea	Common Periwinkle
Mercenaria mercenaria	Hard Clam
Microciona prolifera	Red Beard Sponge
Molgula manhattensis	Sea Grape (Squirt)
Mytilus edulis	Blue Mussel
***Nereis* spp.**	Clam Worms
Ovalipes ocellatus	Lady Crab
Pagurus longicarpus	Longwrist Hermit Crab
Pagurus pollicaris	Flatclaw Hermit Crab
Palaemonetes vulgaris	Grass Shrimp
Panopeus herbstii	Atlantic Mud Crab
Pinnotheres maculatus	Squatter Pea Crab
Polychaetes	
Sclerodactyla briareus	Hairy Sea Cucumber
***Spirorbis spirillum* worm tubes**	Coiled Worms
Sponges	
Tunicates	
Urosalpinx cinerea	Atlantic Oyster Drill

Sources: Weiss. 1995. Marine Animals of Southern New England and New York
Gosner. 1978. Peterson Field Guides: Atlantic Seashore
AFS Spec. Pub. 17. 1989.Common and Scientific Names of Aquatic Invertebrates from the Unites States and Canada

APPENDIX A TABLE 3

Floral Species List

Algae:

Scientific Name	Common Name
Ahnfeltia plicata	Wire Weed
Antithamnion cruciatum	Unnamed Red Algae
***Ceramium* sp.**	Banded Weeds
***Chaetomorpha* sp.**	Filamentous Green Algae
Champia parvula	Barrel Weed
***Chondria* sp.**	Pod Weed
Chondria tenuissima	Pod Weed
Chondrus crispus	Irish Moss
Codium fragile	Dead Man's Fingers
***Ectocarpus* sp.**	Filamentous Brown Algae
***Enteromorpha* sp.**	Hollow Green Weeds
***Fucus* sp.**	Rockweed
***Gracilaria* sp.**	Red Weed
Stilophora rhizodes	Rough Tangle Weed
Ulva lactuca	Sea Lettuce

Plants:

Scientific Name	Common Name
Ruppia maritima	Widgeongrass
Zostera marina	Eelgrass

Sources: Abbott. 1994. How to Know the Seaweeds
Gosner. 1978. Peterson Field Guides: Atlantic Seashore
Lee. 1986. The Seaweed Handbook
Hillson. 1977. Seaweeds
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APPENDIX A TABLE 4

Algal Species Present in Study Area (Great South Bay, Moriches Bay, and Shinnecock Bay) by Month and Station

Monthly Distributions:

	June	July	August	September	October	Number of Months Present
Ahnfeltia plicata		x	x			2
Antithamnion cruciatum				x	x	2
Ceramium sp.	x	x	x	x	x	5
Chaetomorpha sp.				x	x	2
Champia parvula			x	x	x	3
Chondria sp.			x	x	x	3
Chondrus crispus			x			1
Codium fragile	x	x	x	x	x	5
Ectocarpus sp.	x	x	x			3
Enteromorpha sp.	x	x	x	x	x	5
Fucus sp.	x		x			1
Gracilaria sp.		x	x	x	x	4
Stilophora rhizodes			x	x		2
Ulva lactuca	x	x	x	x		4
Total Number of Species	*6*	*7*	*12*	*10*	*8*	

Station Distributions:

	GSB East Fire Island	GSB Bellport	MOR Great Gun	MOR Cupsogue	SH Tiana	SH Ponquogue East	Number of Stations Present
Ahnfeltia plicata		x					1
Antithamnion cruciatum		x	x	x	x	x	5
Ceramium sp.	x	x	x	x	x	x	6
Chaetomorpha sp.		x	x	x			3
Champia parvula		x			x	x	3
Chondria sp.	x	x	x				3
Chondrus crispus		x	x		x	x	4
Codium fragile	x			x	x	x	4
Ectocarpus sp.	x				x	x	3
Enteromorpha sp.		x	x		x	x	4
Fucus sp.					x	x	2
Gracilaria sp.	x	x	x	x	x	x	6
Stilophora rhizodes	x		x			x	3
Ulva lactuca	x	x	x	x	x	x	6
Total Number of Species	*7*	*10*	*9*	*6*	*10*	*11*	

Abbreviations:

Great South Bay (GSB)
Moriches Bay (MOR)
Shinnecock Bay (SH)

SAV BED CHARACTERIZATION REPORT, SEPTEMBER 2004

TECHNICAL APPENDIX

US Army Corps
of Engineers ®

TECHNICAL APPENDIX TABLES

TECHNICAL APPENDIX FIGURES

TECHNICAL APPENDIX TABLE 1
Monthly Abundance of Finfish Collected in Seine Net

Scientific Name	2003 JUNE	JULY	AUG.	SEP.	OCT.	*SPECIES TOTALS*	*PERCENT of TOTAL*
Apeltes quadracus	692	1,208	1,077	743	1,500	***5,220***	***31.80***
Menidia menidia	35	686	645	380	917	***2,663***	***16.22***
Tautoga onitis		2	1,046	1,071	352	***2,471***	***15.06***
Myoxocephalus aenaeus	104	107	712	524	193	***1,640***	***9.99***
Tautogolabrus adspersus	6	24	430	703	284	***1,447***	***8.82***
Syngnathus fuscus	101	324	426	106	48	***1,005***	***6.12***
Pseudopleuronectes americanus	27	158	333	356	130	***1,004***	***6.12***
Pollachius virens	304					***304***	***1.85***
Fundulus heteroclitus		3	43	26	63	***135***	***0.82***
Sphoeroides maculatus		74	49	2		***125***	***0.76***
Opsanus tau		2	16	31	13	***62***	***0.38***
Chaetodon ocellatus			9	34	9	***52***	***0.32***
Anguilla rostrata	17	7	12	11	1	***48***	***0.29***
Gobiosoma bosc				18	28	***46***	***0.28***
Microgadus tomcod	11	4	23	8		***46***	***0.28***
Centropristes striata			2	15	3	***20***	***0.12***
Anchoa mitchilli	3		7	8		***18***	***0.11***
Pholis gunnellus	3	2	3	5	1	***14***	***0.09***
Prionotus evolans				10	1	***11***	***0.07***
Fistularia tabacaria			4	2	4	***10***	***0.06***
Micropogonias undulatus			8			***8***	***0.05***
Gasterosteus aculeatus	1		1	2	3	***7***	***0.04***
Chilomycterus schoepfi			4	1		***5***	***0.03***
Sphoeroides spengleri			5			***5***	***0.03***
Strongylura marina		1	3		1	***5***	***0.03***
Fundulus majalis				1	3	***4***	***0.02***
Lactophrys quadricornis			2	2		***4***	***0.02***
Alosa aestivalis				3		***3***	***0.02***
Enchelyopus cimbrius	3					***3***	***0.02***
Hippocampus erectus			1	1	1	***3***	***0.02***
Mullus auratus		3				***3***	***0.02***
Urophycis chuss		1	2			***3***	***0.02***
Cynoscion regalis		2				***2***	***0.01***
Epinephelus flavolimbatus			2			***2***	***0.01***
Acanthurus chirurgis			1			***1***	***0.01***
Alosa pseudoharengus			1			***1***	***0.01***
Caranx hippos					1	***1***	***0.01***
Chaetodon capistratus				1		***1***	***0.01***
Cyprinodon variegatus					1	***1***	***0.01***
Epinephelus nigritus			1			***1***	***0.01***
Menticirrhus saxatilis				1		***1***	***0.01***
Monacanthus hispidus			1			***1***	***0.01***
Mugil cephalus			1			***1***	***0.01***
Mycteroperca microlepis				1		***1***	***0.01***
Paralichthys dentatus	1					***1***	***0.01***
Pomatomus saltatrix			1			***1***	***0.01***
Prionotus carolinus				1		***1***	***0.01***
Pterois volitans				1		***1***	***0.01***
Urophycis regia	1					***1***	***0.01***
Monthly Total Abundances	***1,309***	***2,608***	***4,871***	***4,068***	***3,557***	***16,413***	
Total Number Species	***15***	***17***	***32***	***30***	***22***	***49***	

TECHNICAL APPENDIX TABLE 2

Monthly Weight (in grams) of Finfish Collected in Seine Net

Scientific Name	2003 JUNE	JULY	AUG.	SEP.	OCT.	*SPECIES TOTALS*	*PERCENT of TOTAL*
Tautoga onitis		94	4,359	3,288	1,259	***9,000***	***22.30***
Apeltes quadracus	344	886	1,568	2,457	1,239	***6,494***	***16.09***
Myoxocephalus aenaeus	157	328	3,152	1,552	695	***5,884***	***14.58***
Menidia menidia	1	619	1,444	881	1,469	***4,414***	***10.94***
Tautogolabrus adspersus	19	247	1,430	1,955	548	***4,199***	***10.41***
Pseudopleuronectes americanus	20	453	1,296	1,325	479	***3,573***	***8.85***
Anguilla rostrata	108	12	1,720	91	7	***1,938***	***4.80***
Syngnathus fuscus	137	456	729	222	94	***1,638***	***4.06***
Sphoeroides maculatus		113	618			***731***	***1.81***
Microgadus tomcod	19	31	275	136		***461***	***1.14***
Opsanus tau		<1	184	97	44	***325***	***0.81***
Fundulus heteroclitus		12	76	50	139	***277***	***0.69***
Pollachius virens	201					***201***	***0.50***
Urophycis chuss		176	14			***190***	***0.47***
Fistularia tabacaria			18	39	65	***122***	***0.30***
Alosa pseudoharengus			117			***117***	***0.29***
Prionotus evolans				108	4	***112***	***0.28***
Paralichthys dentatus	95					***95***	***0.24***
Chilomycterus schoepfi			36	50		***86***	***0.21***
Gobiosoma bosc				47	35	***82***	***0.20***
Centropristes striata			1	61	18	***80***	***0.20***
Chaetodon ocellatus			4	33	19	***56***	***0.14***
Pholis gunnellus	3	7	10	13	15	***48***	***0.12***
Hippocampus erectus			13	15	6	***34***	***0.08***
Anchoa mitchilli	7		2	20		***29***	***0.07***
Sphoeroides spengleri			28			***28***	***0.07***
Pomatomus saltatrix			25			***25***	***0.06***
Fundulus majalis				2	22	***24***	***0.06***
Mullus auratus		17				***17***	***0.04***
Strongylura marina		<1	10		2	***12***	***0.03***
Gasterosteus aculeatus	<1		1	3	5	***9***	***0.02***
Monacanthus hispidus			7			***7***	***0.02***
Epinephelus nigritus			5			***5***	***0.01***
Menticirrhus saxatilis				5		***5***	***0.01***
Micropogonias undulatus			5			***5***	***0.01***
Urophycis regia	5					***5***	***0.01***
Enchelyopus cimbrius	3					***3***	***0.01***
Lactophrys quadricornis			1	2		***3***	***0.01***
Mycteroperca microlepis				3		***3***	***0.01***
Pterois volitans				3		***3***	***0.01***
Acanthurus chirurgis			2			***2***	***<0.01***
Chaetodon capistratus				2		***2***	***<0.01***
Epinephelus flavolimbatus			2			***2***	***<0.01***
Alosa aestivalis				1		***1***	***<0.01***
Caranx hippos					1	***1***	***<0.01***
Cyprinodon variegatus					1	***1***	***<0.01***
Mugil cephalus			1			***1***	***<0.01***
Prionotus carolinus				1		***1***	***<0.01***
Cynoscion regalis		<1				***0***	***<0.01***
Monthly Total Weight (g)	***1,119***	***3,451***	***17,153***	***12,462***	***6,166***	***40,351***	

TECHNICAL APPENDIX TABLE 3

Total Number of Finfish by Station

	GSB	GSB	MOR	MOR	SH	SH		
	East Fire Island	Bellport	Great Gun	Cupsogue	Tiana	Ponquogue East	***Species Totals***	***Percent of Total***
Apeltes quadracus	286	800	1,629	1,067	1,403	35	***5,220***	***31.80***
Menidia menidia	247	363	539	831	421	262	***2,663***	***16.22***
Tautoga onitis	65	8	608	137	732	921	***2,471***	***15.06***
Myoxocephalus aenaeus			607	12	45	976	***1,640***	***9.99***
Tautogolabrus adspersus	15	1	155	6	285	985	***1,447***	***8.82***
Syngnathus fuscus	191	91	197	383	97	46	***1,005***	***6.12***
Pseudopleuronectes americanus	44	40	159	29	225	507	***1,004***	***6.12***
Pollachius virens			56			248	***304***	***1.85***
Fundulus heteroclitus		55	4	39	37		***135***	***0.82***
Sphoeroides maculatus	44	11	54	12	4		***125***	***0.76***
Opsanus tau	6	3		51	2		***62***	***0.38***
Chaetodon ocellatus			8		3	41	***52***	***0.32***
Anguilla rostrata	3	8	12	4	12	9	***48***	***0.29***
Gobiosoma bosc		1		38	5	2	***46***	***0.28***
Microgadus tomcod			10		3	33	***46***	***0.28***
Centropristis striata	4		1		10	5	***20***	***0.12***
Anchoa mitchilli	2		13	3			***18***	***0.11***
Pholis gunnellus			2			12	***14***	***0.09***
Prionotus evolans		1	1		7	2	***11***	***0.07***
Fistularia tabacaria	1		3		1	5	***10***	***0.06***
Micropogonias undulatus						8	***8***	***0.05***
Gasterosteus aculeatus				1		6	***7***	***0.04***
Chilomycterus schoepfi	3	2					***5***	***0.03***
Sphoeroides spengleri			2		1	2	***5***	***0.03***
Strongylura marina		1	1		1	2	***5***	***0.03***
Fundulus majalis					1	3	***4***	***0.02***
Lactophrys quadricornis		1	1		1	1	***4***	***0.02***
Alosa aestivalis			2		1		***3***	***0.02***
Enchelyopus cimbrius						3	***3***	***0.02***
Hippocampus erectus	1				2		***3***	***0.02***
Mullus auratus						3	***3***	***0.02***
Urophycis chuss						3	***3***	***0.02***
Cynoscion regalis			2				***2***	***0.01***
Epinephelus flavolimbatus			1			1	***2***	***0.01***
Acanthurus chirurgis						1	***1***	***0.01***
Alosa pseudoharengus			1				***1***	***0.01***
Caranx hippos						1	***1***	***0.01***
Chaetodon capistratus					1		***1***	***0.01***
Cyprinodon variegatus		1					***1***	***0.01***
Epinephelus nigritus						1	***1***	***0.01***
Menticirrhus saxatilis					1		***1***	***0.01***
Monacanthus hispidus	1						***1***	***0.01***
Mugil cephalus				1			***1***	***0.01***
Mycteroperca microlepis						1	***1***	***0.01***
Paralichthys dentatus		1					***1***	***0.01***
Pomatomus saltatrix				1			***1***	***0.01***
Prionotus carolinus					1		***1***	***0.01***
Pterois volitans						1	***1***	***0.01***
Urophycis regia						1	***1***	***0.01***
Station Total Abundances	***913***	***1,388***	***4,068***	***2,615***	***3,302***	***4,127***	***16,413***	
Total Number of Species	***15***	***17***	***25***	***16***	***26***	***32***	***49***	

TECHNICAL APPENDIX TABLE 4

Total Weight (in grams) of Finfish by Station

	East Fire Island	Bellport	Great Gun	Cupsogue	Tiana	Ponquogue East	*Species Totals*	*Percent of Total*
Tautoga onitis	459	393	1,574	544	3,163	2,867	***9,000***	***22.30***
Apeltes quadracus	195	667	1,923	503	3,133	73	***6,494***	***16.09***
Myoxocephalus aenaeus			2,254	48	130	3,452	***5,884***	***14.58***
Menidia menidia	349	383	780	1,694	718	489	***4,413***	***10.94***
Tautogolabrus adspersus	22	<1	500	12	622	3,043	***4,199***	***10.41***
Pseudopleuronectes americanus	172	120	466	133	665	2,017	***3,573***	***8.86***
Anguilla rostrata	16	53	1,072	717	20	60	***1,938***	***4.80***
Syngnathus fuscus	140	123	422	609	227	117	***1,638***	***4.06***
Sphoeroides maculatus	66	69	409	165	22		***731***	***1.81***
Microgadus tomcod			83		32	346	***461***	***1.14***
Opsanus tau	80	11		232	2		***325***	***0.81***
Fundulus heteroclitus		123	7	62	85		***277***	***0.69***
Pollachius virens			36			165	***201***	***0.50***
Urophycis chuss						190	***190***	***0.47***
Fistularia tabacaria	15		17		3	87	***122***	***0.30***
Alosa pseudoharengus			117				***117***	***0.29***
Prionotus evolans		4	<1		88	20	***112***	***0.28***
Paralichthys dentatus		95					***95***	***0.24***
Chilomycterus schoepfi	66	20					***86***	***0.21***
Gobiosoma bosc		1		68	8	5	***82***	***0.20***
Centropristis striata	14		1		43	22	***80***	***0.20***
Chaetodon ocellatus			9		5	42	***56***	***0.14***
Pholis gunnellus			9			39	***48***	***0.12***
Hippocampus erectus	13				21		***34***	***0.08***
Anchoa mitchilli	<1		22	7			***29***	***0.07***
Sphoeroides spengleri			20		1	7	***28***	***0.07***
Pomatomus saltatrix				25			***25***	***0.06***
Fundulus majalis					10	14	***24***	***0.06***
Mullus auratus						17	***17***	***0.04***
Strongylura marina		<1	5		2	5	***12***	***0.03***
Gasterosteus aculeatus				<1		9	***9***	***0.02***
Monacanthus hispidus	7						***7***	***0.02***
Epinephelus nigritus						5	***5***	***0.01***
Menticirrhus saxatilis					5		***5***	***0.01***
Micropogonias undulatus						5	***5***	***0.01***
Urophycis regia						5	***5***	***0.01***
Enchelyopus cimbrius						3	***3***	***0.01***
Lactophrys quadricornis		2	<1		<1	1	***3***	***0.01***
Mycteroperca microlepis						3	***3***	***0.01***
Pterois volitans						3	***3***	***0.01***
Acanthurus chirurgis						2	***2***	***<0.01***
Chaetodon capistratus					2		***2***	***<0.01***
Epinephelus flavolimbatus			n/a			2	***2***	***<0.01***
Alosa aestivalis			<1		1		***1***	***<0.01***
Caranx hippos						1	***1***	***<0.01***
Cyprinodon variegatus		1					***1***	***<0.01***
Mugil cephalus				1			***1***	***<0.01***
Prionotus carolinus					1		***1***	***<0.01***
Cynoscion regalis			<1				***<1***	***<0.01***
Total Weight by Station	***1,614***	***2,065***	***9,726***	***4,820***	***9,009***	***13,116***	***40,350***	

n/a = not available

TECHNICAL APPENDIX TABLE 5

Monthly Totals for Invertebrates Collected in Seine Net

	June	July	August	September	October	*Monthly Totals*	*Percent of Total*
Carcinus maenas	297	395	810	506	80	***2,088***	***88.47***
Callinectes sapidus	2	23	55	29	6	***115***	***4.87***
Ovalipes ocellatus			6	33	10	***49***	***2.08***
Cancer irroratus	9		16	9	12	***46***	***1.95***
Libinia emarginata	8	3	2	13	13	***39***	***1.65***
Limulus polyphemus	4	3	1			***8***	***0.34***
Pinnotheres maculatus		1	5	1		***7***	***0.30***
Argopecten irradians					2	***2***	***0.08***
Hemigrapsus sanguineus		2				***2***	***0.08***
Sclerodactyla briareus		2				***2***	***0.08***
Calappa flammea					1	***1***	***0.04***
Pagurus pollicaris			1			***1***	***0.04***
Amphipods	Rank=1	Rank=1	Rank=1	Rank=2			
Anachis spp.				Rank=1			
Anemones	Rank=1						
Asterias forbesi	Rank=1	Rank=1	Rank=1	Rank=1	Rank=1		
Aurelia aurita		Rank=1					
Caprellid Amphipods	Rank=1	Rank=1					
Crangon septemspinosa	Rank=2	Rank=1	Rank=1	Rank=1	Rank=1		
Crepidula fornicata			Rank=1	Rank=1	Rank=1		
Ctenophores	Rank=1	Rank=2	Rank=2	Rank=2	Rank=2		
Cyanea capillata	Rank=1						
Diopatra cuprea					Rank=1		
Dyspanopeus sayi	Rank=1	Rank=1	Rank=1	Rank=1	Rank=1		
Eupleura caudata		Rank=1					
Hippolyte spp.	Rank=1	Rank=1	Rank=1	Rank=1	Rank=1		
Holothuroidea	Rank=1						
Ilyanassa obsoleta	Rank=2	Rank=3	Rank=2	Rank=1	Rank=1		
Ilyanassa trivittata	Rank=1	Rank=1	Rank=1				
Isopods	Rank=1	Rank=1	Rank=2	Rank=1	Rank=1		
Littorina littorea				Rank=1			
Mytilus edulis	Rank=2		Rank=1	Rank=1	Rank=2		
Nereid	Rank=1	Rank=1					
Pagurus longicarpus	Rank=1	Rank=1	Rank=1	Rank=1	Rank=1		
Palaemonetes vulgaris	Rank=2	Rank=2	Rank=2	Rank=2	Rank=2		
Paneopeus herbstii	Rank=2	Rank=3	Rank=2	Rank=2	Rank=1		
Polychaetes	Rank=1	Rank=1			Rank=1		
Urosalpinx cinerea	Rank=1			Rank=1	Rank=1		
Botrylloides diegensis	Present		Present		Present		
Botryllus schlosseri	Present	Present	Present	Present			
Cerebratulus lacteus Egg Cases	Present		Present				
Halichondria spp.			Present				
Haliclona spp.			Present	Present	Present		
Hydroids	Present	Present		Present			
Mercenaria mercenaria			Present				
Microciona prolifera	Present	Present	Present	Present			
Molgula manhattensis			Present				
Spirorbis spirillum on eelgrass		Present	Present	Present	Present		
Monthly Total Abundances	***320***	***429***	***896***	***591***	***124***	***2,360***	
Total Number of Species	***30***	***28***	***31***	***27***	***25***	***50***	

Refer to SAV Seine Survey Methodology (Section IV.A) of text for explanation of Present and Rank Values.

TECHNICAL APPENDIX TABLE 6
Total Number of Invertebrates per Station

	GSB East Fire	GSB Bellport	MOR Great Gun	MOR Cupsogue	SH Tiana	SH Ponquogue East	*Station Totals*
Carcinus maenas	1	2	541	8	201	1,335	***2,088***
Callinectes sapidus	18	83	1	3	9	1	***115***
Ovalipes ocellatus			2	3	11	33	***49***
Cancer irroratus			16	1	12	17	***46***
Libinia emarginata	8		7	2	12	10	***39***
Limulus polyphemus			3		5		***8***
Pinnotheres maculatus			6	1			***7***
Sclerodactyla briareus					1	1	***2***
Argopecten irradians					2		***2***
Hemigrapsus sanguineus				2			***2***
Calappa flammea					1		***1***
Pagurus pollicaris			1				***1***
Dyspanopeus sayi	Rank=1	Rank=1	Rank=1	Rank=1	Rank=1	Rank=1	
Pagurus longicarpus		Rank=1	Rank=1	Rank=1	Rank=1	Rank=1	
Asterias forbesi			Rank=1		Rank=1	Rank=1	
Crepidula fornicata					Rank=1	Rank=1	
Amphipods	Rank=1	Rank=2	Rank=1	Rank=1	Rank=2	Rank=1	
Anachis spp.						Rank=1	
Anemones		Rank=1					
Aurelia aurita						Rank=1	
Caprellidae	Rank=1	Rank=1			Rank=1	Rank=1	
Crangon septemspinosa	Rank=1	Rank=1	Rank=1	Rank=1	Rank=2	Rank=1	
Ctenophores	Rank=1	Rank=1	Rank=2	Rank=2	Rank=2	Rank=2	
Cyanea capillata	Rank=1	Rank=1	Rank=1				
Diopatra cuprea					Rank=1		
Eupleura caudata				Rank=1			
Hippolyte sp.	Rank=1	Rank=1	Rank=1	Rank=1	Rank=1		
Holothuroidea					Rank=1		
Hydroids	Present	Rank=1				Rank=1	
Ilyanassa obsoleta	Rank=4	Rank=1	Rank=2	Rank=1	Rank=1	Rank=2	
Ilyanassa trivittata					Rank=1	Rank=1	
Isopods	Rank=1	Rank=1	Rank=1	Rank=1	Rank=2	Rank=1	
Littorina littorea						Rank=1	
Mytilus edulis	Rank=3	Rank=1	Rank=2		Rank=2	Rank=2	
Nereids	Rank=1	Rank=2	Rank=1		Rank=1		
Palaemonetes vulgaris	Rank=2	Rank=2	Rank=2	Rank=2	Rank=2	Rank=1	
Panopeus herbstii	Rank=1	Rank=1	Rank=1	Rank=1	Rank=2	Rank=1	
Polychaetes		Rank=1					
Urosalpinx cinerea	Rank=1	Rank=1			Rank=1	Rank=1	
Cerebratulus lacteus Egg Cases				Present	Present		
Botrylloides diegensis	Present	Present	Present				
Botryllus schlosseri	Present	Present	Present	Present		Present	
Halichondria spp.		Present					
Haliclona spp.	Present						
Mercenaria mercenaria				Present			
Microciona prolifera	Present	Present					
Molgula manhattensis				Present	Present		
Spirorbis spirillum on eelgrass	Present	Present		Present			
Station Totals*	***27***	***85***	***577***	***20***	***254***	***1,397***	***2,360***
Total Number of Species at each Station	***23***	***25***	***25***	***23***	***30***	***26***	***49***

Refer to SAV Seine Survey Methodology (Section IV.A) of text for explanation of Present and Rank Values.
*Station totals reflect only species that were counted.

TECHNICAL APPENDIX TABLE 7

Mean Eelgrass Height and Density by Month for Each Station

Great South Bay

Station	Month	Height (in)	Density (%)
East Fire Island	June	***7.0***	***50.0***
	July	***16.4***	***50.0***
	Aug.	12.2	60.0
	Sep.	10.2	62.5
	Oct.	9.2	***80.0***
Mean		***11.0***	***60.5***

Shinnecock Bay

Station	Month	Height (in)	Density (%)
Tiana	June	14.0	***62.5***
	July	***19.6***	***62.5***
	Aug.	15.9	47.5
	Sep.	***9.8***	35.0
	Oct.	14.3	***27.5***
Mean		***14.7***	***47.0***

Great South Bay

Station	Month	Height (in)	Density (%)
Bellport	June	***3.0***	37.5
	July	***7.7***	***27.5***
	Aug.	7.2	40.0
	Sep.	5.2	***57.5***
	Oct.	6.8	52.5
Mean		***6.0***	***43.0***

Shinnecock Bay

Station	Month	Height (in)	Density (%)
Pon-quogue East	June	***6.3***	***25.0***
	July	14.5	37.5
	Aug.	***15.3***	35.0
	Sep.	10.8	***60.0***
	Oct.	13.1	40.0
Mean		***12.0***	***39.5***

Moriches Bay

Station	Month	Height (in)	Density (%)
Great Gun	June	15.0	56.3
	July	15.1	***47.5***
	Aug.	***18.9***	***67.5***
	Sep.	***14.0***	57.5
	Oct.	**16.9**	***67.5***
Mean		***16.0***	***59.3***

Bay Averages:

	Height (in)	Density (%)
GSB	**8.9**	**51.8**
MOR	**16.2**	**58.5**
SH	**13.3**	**43.3**

Moriches Bay

Station	Month	Height (in)	Density (%)
Cup-sogue	June	15.1	56.3
	July	***21.2***	72.5
	Aug.	21.0	***82.5***
	Sep.	14.7	***35.0***
	Oct.	***10.5***	42.5
Mean		***16.5***	***57.8***

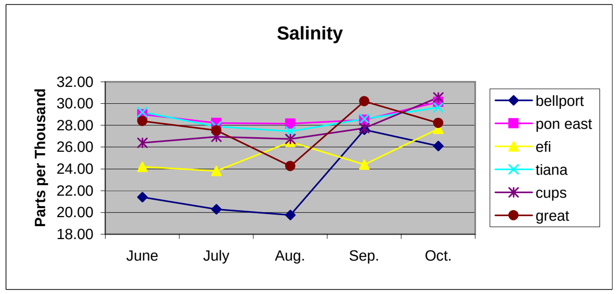
Minimum and maximum values are denoted in bold and italics.

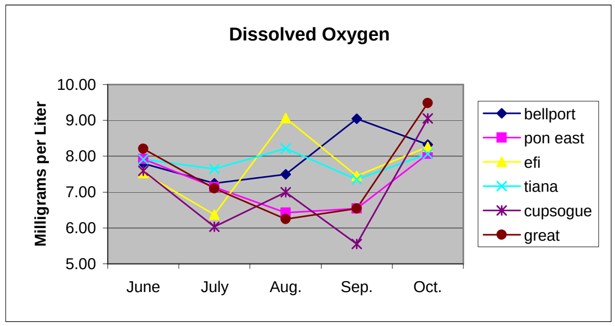
TECHNICAL APPENDIX TABLE 8
Mean Monthly Water Quality Data by Month and Station

Great South Bay

Station	Month	Temp. (^{0}C)	D.O. (mg/L)	Salinity (ppt)	Turbid. (ntu)
East Fire Island	June	15.50	7.53	24.20	1.92
	July	24.20	***6.38***	***23.80***	***2.50***
	Aug.	***26.15***	***9.07***	26.48	2.05
	Sep.	20.95	7.45	24.40	***2.50***
	Oct.	***13.45***	8.27	***27.70***	***1.22***
	Mean	20.05	7.74	25.32	2.03

Station	Month	Temp. (^{0}C)	D.O. (mg/L)	Salinity (ppt)	Turbid. (ntu)
Bellport	June	15.30	7.80	21.40	1.52
	July	24.65	***7.25***	20.30	2.83
	Aug.	***26.00***	7.50	***19.75***	***3.10***
	Sep.	20.80	***9.05***	***27.60***	1.98
	Oct.	***13.90***	8.32	26.10	***1.48***
	Mean	20.13	7.98	23.03	2.18

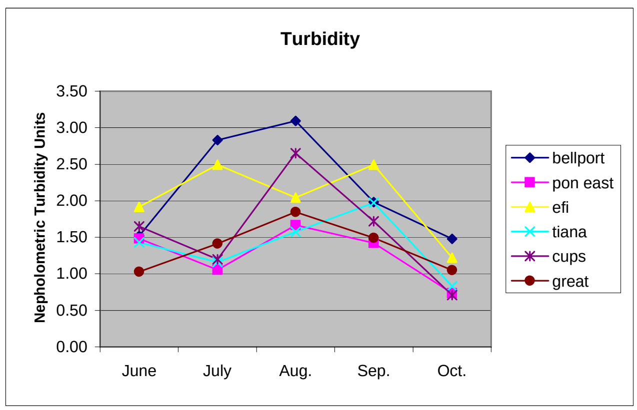




Moriches Bay

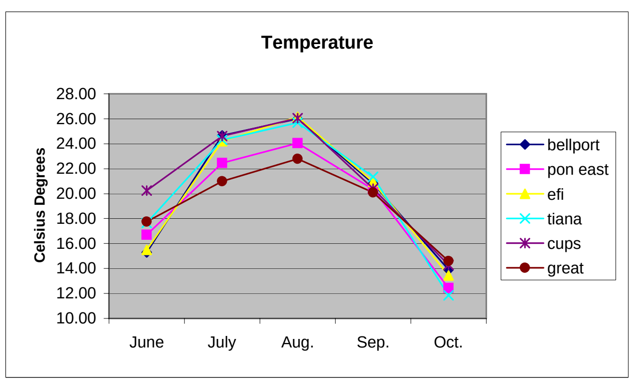
Station	Month	Temp. (^{0}C)	D.O. (mg/L)	Salinity (ppt)	Turbid. (ntu)
Great Gun	June	17.75	8.21	28.40	***1.03***
	July	21.00	7.11	27.55	1.42
	Aug.	***22.80***	***6.25***	***24.25***	***1.85***
	Sep.	20.10	6.55	***30.20***	1.49
	Oct.	***14.60***	***9.49***	28.20	1.05
	Mean	19.25	7.52	27.72	1.37

Station	Month	Temp. (^{0}C)	D.O. (mg/L)	Salinity (ppt)	Turbid. (ntu)
Cup- sogue	June	20.25	7.60	***26.40***	1.65
	July	24.60	6.03	26.95	1.20
	Aug.	***26.05***	7.00	26.75	***2.65***
	Sep.	20.40	***5.56***	27.75	1.72
	Oct.	***14.30***	***9.06***	***30.55***	***0.71***
	Mean	21.12	7.05	27.68	1.59



Shinnecock Bay

Station	Month	Temp. (^{0}C)	D.O. (mg/L)	Salinity (ppt)	Turbid. (ntu)
Tiana	June	17.65	7.91	29.20	1.43
	July	24.30	7.65	27.90	1.16
	Aug.	***25.70***	***8.22***	***27.45***	1.58
	Sep.	21.35	***7.35***	28.60	***1.98***
	Oct.	***11.85***	8.07	***29.65***	***0.83***
	Mean	20.17	7.84	28.56	1.39



Station	Month	Temp. (^{0}C)	D.O. (mg/L)	Salinity (ppt)	Turbid. (ntu)
Pon- quogue East	June	16.70	7.92	29.00	1.49
	July	22.45	7.14	28.20	1.06
	Aug.	***24.05***	***6.43***	***28.15***	***1.67***
	Sep.	20.35	6.54	28.50	1.42
	Oct.	***12.45***	***8.07***	***30.15***	***0.74***
	Mean	19.20	7.22	28.80	1.27

Maximum and minimum values denoted in bold and italics.

TECHNICAL APPENDIX FIGURE 1

Finfish and Invertebrates Plotted with Mean Monthly Temperature