PECONIC ESTUARY PROGRAM
EELGRASS HABITAT CRITERIA STUDY

VOLUME I

Prepared For:
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EXECUTIVE SUMMARY

The main objective of this study is to develop criteria for eelgrass habitat establishment and persistence within the Peconic Estuary utilizing various environmental analyses.

The Program evaluated water and sediment quality data to characterize existing conditions within the estuary where eelgrass *(Zostera marina)* density is highest, lowest, transitional, stressed, and non-existent based on previous studies of eelgrass distribution within the estuary (Cashin, 1996). Also analyzed, were general hydrodynamic trends at selected eelgrass monitoring stations within the estuary. The collected data were then compared to criteria from the Connecticut-Long Island Sound Study (LISS) and the Chesapeake Bay Study (CBS).

While not a primary study goal, eelgrass test plots were established utilizing various methods for harvesting and transplanting eelgrass to determine the most successful methodology for this geographic area.

EEA, Inc. in cooperation with the Suffolk County Department of Health Services, East Hampton Town Natural Resources Department, and Cornell Cooperative Extension chose 14 fixed sampling locations (Figure 1) within the estuary. These locations were chosen in part, based upon historical eelgrass bed density, surrounding land use, as well as information provided in the 1996 SAV study by Cashin Associates. Site reconnaissance and aerial photography at 1:1,200 (1996) were used to characterize the stations.

Water quality monitoring was conducted by SCDHS as in-kind services for this project. Water quality collection data has been on-going throughout the estuary by the SCDHS since 1976. Collection and analysis associated with this project was conducted one time per month at each station for the months of June, July August, and September, 1997 and May 1998. All collections and analyses conform to ASTM Standards.

General physical chemistry parameters were measured each time water collections were conducted by SCDHS. Those parameters include salinity, temperature, conductivity, pH, secchi disc, dissolved oxygen, depth and light extinction coefficient. Water samples collected for laboratory analysis include total suspended solids, chlorophyll-a, dissolved inorganic phosphorous (orthophosphate) and dissolved inorganic nitrogen (NOX and NH_3).

During each water quality run conducted by SCDHS, EEA, Inc. collected sediment samples. Sediment collections were conducted from the boat utilizing a 0.025 meter-square petite bottom grab sampler. Often, multiple grabs were composited to acquire a suitable sample size Additionally, weather data and global position (GPS) were recorded.

Sediment was collected for total organic carbon (TOC) and grain size analysis. Grain size collections were conducted one time during the Project Term to obtain general grain size distribution data for each sampling location. Samples were sent to Chemtech, Inc. for analysis within 30 days from collection.

A Falmouth Scientific 3D-ACM acoustical flow meter was deployed at several locations to get a general picture of hydrodynamic conditions existing where eelgrass beds are non-existing, transitional, stressed and lush. Vector, velocity and temperature of near-bed conditions were recorded for the following locations:

Lake Montauk (135), Napeague Harbor (134), Accabonac Harbor (133), Three-Mile Harbor (132), Northwest Creek (131), Cornelius Point (144), Coecles Harbor (122), Flanders Bay (170), and Great Peconic Bay (130).

A Seapoint Turbidity Sensor was added to the flow meter in May, 1998. Three-Mile Harbor and Napeague Harbor were monitored prior to the addition of the turbidity sensor and therefore, are lacking turbidity data:

Using water quality data provided by SCDHS, monthly and seasonal arithmetic means were calculated using Microsoft Excel 97. The arithmetic means were used to generate tables and graphs for analysis of data and are located in the Appendices of this report. The data were organized by station and by season (growing vs. summer) for eelgrass *(Zostera marina)*. For this study the growing season is assumed to be March through November and the summer season is assumed to be June through August.

Flow meter data were converted to ASCII format. Excel 97 was used to generate graphs for turbidity (where applicable), temperature, vector and velocity for analysis.

Analysis of the synthesized and graphically represented data were conducted for water quality, sediment quality and hydrodynamics. Arithmetic means were computated for all appropriate water quality data associated with this study. Sediment data were analyzed by the raw data provided from the laboratory regarding TOC. Grain size has been graphically represented in pie charts and shown in Figure 2 to illustrate percentage of particle size distribution at the various locations for this study. Vector, velocity, temperature and turbidity (where applicable) have been graphically presented in Appendix D to illustrate cyclic ongoing events within the estuary.

Eelgrass test plots were conducted by EHTNRD, CCE and EEA, Inc. as in-kind services for this project. Spring harvest and transplantation of eelgrass was conducted in Napeague Harbor for both 1997 and 1998. Fall harvest and transplantation were conducted by CCE at Cedar Beach Point and Cutchogue Harbor in 1997. Initially, monitoring consisted of trying to locate the transplanted bed and determine whether the eelgrass blades looked healthy, whether wasting disease was suspected, whether grazing had occurred or whether the eelgrass was dying or had died off.

By 1998, the monitoring program had become better developed because the goals for transplantation were defined more clearly. The objective was to observe each of the eight transplant locations to determine the general health of the plants using a relative scale of good, poor or excellent. Additional observations regarding die back, wildlife utilization, and epiphytic growth were also noted. Each monitoring event included an underwater photograph and a measurement of water temperature.

There has never been any follow-up monitoring conducted at the Cutchogue Harbor transplant location by CCE. The conditions of those transplants within Cutchogue Harbor are presently unknown. It is presumed that due to the conditions in which they were transplanted and the observations made at Cedar Beach Point, that the likelihood for survival is minimal.

Water quality data collected specifically for this study was limited, especially for light extinction measurements for the areas supporting thick beds of eelgrass. The areas supporting the densest beds, averaged 0.3 m^{-1} Kd, 3.1 $\mu g/l$ chlorophyll-a, 0.01mg/l DIP, 0.02 mg/l DIN, and summer DO of 7.1 mg/l. Except for chlorophyll-a, the observed parameters throughout the Peconics fall on average, lower than the estuary averages recommended for the Criteria Requirements for the Chesapeake Bay and the Long Island Sound.

The '97/'98 water data collected in conjunction with this study were compared to water quality data analyzed by SCDHS (1998) for SAV habitat criteria. In general, water quality conditions are suitable for re-establishment of eelgrass at a two-meter depth only in the eastern portion of the estuary. The data for 1994-1996 is quite comparable to the data collected for 1997 and 1998 and there are no monumental variations between water years.

As described in Section 3.0, sand accretion and scour are obvious from aerial photography. In general, sand accretion occurs on the eastern portions of land masses such as peninsulas and islands. Scour occurs mostly on the western portion of these same land masses. EEA, Inc. evaluated the mapping produced by Cashin Associates (1996), which clearly indicates that the thickest eelgrass beds occur in the eastern portion of the estuary and on the eastern portions of these same land masses. EEA, Inc. has correlated our field observations during the Eelgrass Transplant Monitoring Program, with the suspected importance that periodic burial may facilitate re-colonization of eelgrass to the regional picture of shifting sands and probable burial along the eastern sections of these estuarine land masses. This premise should be investigated further, as the original scope of work for this study does not provide for further investigation and analysis of this concept.

Additionally, substrate TOC is fairly low within the estuary. Grain size analysis correlates with previous studies conducted within the estuary and grain size trends already established.

The hydrodynamic data, although rated as baseline, indicates typical tidal and wind-influenced occurrences for an estuary within the main bays, peripheral bays and tidal creeks. The larger bays show significant evidence of wind forces predominating with many diurnal pulses. The peripheral bays and large tidal creeks, depending on size and location, fall between wind-driven and tidally influenced. Most of the small tidal creeks indicate predictable ebb/flood cycles over a 24-hour period.

As there are many variables considered when determining the overall health of a system where eelgrass re-establishment is a primary goal, most variables measured fall within the recommended criteria established for other major estuaries along the east coast. As observed from reviewing many years of data, the Peconic Estuary is a very dynamic system and shows variation and pulsing from year to year.

As observed in the catastrophic events of the 1930's when wasting disease impacted nearly 90% of the eelgrass beds along the eastern coastline of the United States, nearly 35 years passed before modest recovery was observed. Between 35 and 40 years after the initial event, eelgrass had reached thick densities and had become a nuisance to boaters. The Peconic Estuary may, in fact, be in a state of recovery now, and we may not see the desired results by natural recolonization anticipated for another 25 to 30 years. Recovery may be prolonged due to the periodic recurrences of brown tide which disrupts the balance of the ecosystem. Continued observations and measurements of water and sediment quality will provide invaluable data over the next several decades.

EEA, Inc. also conducted a brief overview of historical eelgrass bed locations within the estuary through both a literature review and by speaking with local long-term residents and baymen during the sampling program. EEA, Inc. discovered that at certain areas, such as Cornelius Point and Napeague Harbor, the near shore shallow water zone of less than one-meter was historically dominated by eelgrass. Presently, these areas are dominated by *C. fragile* and *Grassilaria sp.*

EEA, Inc., in conjunction with SCDHS has established baseline conditions within the Peconic Estuary for water and sediment quality. This study was not an exhaustive collection program and did not generate enough data to conduct sound statistical and regression analyses. The information provided should be considered carefully and should not be used as a sole source for overall management decisions within the estuary. Based on the studies conducted to date, we recommend the following Eelgrass Habitat Criteria for the Peconic Estuary (Table 5) expressed as mean summer water quality values. These values are expected to optimize conditions and guide researchers and regulators in identifying potentially successful eelgrass restoration areas within the Peconic Estuary. In the next section (9.2), we also recommend additional studies to be considered in the near future.

Proposed Eelgrass Habitat Requirements Within the Peconic Estuary

Parameter	Peconic Estuary (proposed)	Chesapeake (2-meter restoration)	LISS (Draft)	LISS (revised)
Kd (m^{-1})	*0.75 +/- 0.05*	< 0.8	< 1.0	<0.7
DIN (mg/l)	*0.02*	<0.15	< 0.15	< 0.15
DIP (mg/l)	*0.02*	<0.03	<0.02	<0.02
Chlorophyll -a (ug/l)	*5.5 +/-0.5*	<10	<15	<5.5
TSS (mg/l)	**None at this time*	<15	<30	<30
Substrate TOC	** None at this time*	N/A	N/A	< 3%

* Additional data required

Statement of Difficulties:

1. EEA, Inc. and SCDHS were unable to coordinate wet-weather sampling events in a timely fashion. It was not possible to mobilize boat crews and staff from both groups to collect first flush samples.
2. Periodic problems with flow meter due to chip and battery issues caused a loss of some data. All stations where data were lost were re-measured during the period of study.
3. Gardiners island was too remote for sampling, transplantation and monitoring.
4. Due to initial technical problems with the underwater camera and turbidity in Napeague Harbor, most pictures for monitoring of transplanted beds were not helpful for the analytical portion of this study.

1.0 INTRODUCTION

The Eelgrass Habitat Criteria Study has been funded by the U.S. Environmental Protection Agency through the Peconic Estuary Program and managed by the Suffolk County Department of Health Services.

EEA, Inc. would like to thank the following Agency's and staff members for their support and in-kind services during the duration of this study. Without their assistance, this project would not have been possible.

United States Environmental Protection Agency (USEPA)	Rick Balla
Suffolk County Department of Health Services (SCDHS)	Vito Minei Walter Dawydiak Dr. Robert Nuzzi Robert Waters Boat Crews Laboratory Staff
East Hampton Town Natural Resources Department (EHTNRD)	Larry Penny Barnaby Friedman
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Natural Resources Conservation Service (NRCS)	Allan Connell
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University of Washington	Mr. Sandy Weilly Echeverria
Adelphi University	Dr. Jerry Churchill

1.1 Study Objectives

The main objective of this study is to develop criteria for eelgrass habitat establishment and persistence within the Peconic Estuary utilizing various environmental analyses.

The Program evaluated water and sediment quality data to characterize existing conditions within the estuary where eelgrass *(Zostera marina)* density is highest, lowest, transitional, stressed, and non-existent based on previous studies of eelgrass distribution within the estuary (Cashin, 1996). Also analyzed, were general hydrodynamic trends at selected eelgrass monitoring stations within the estuary. The collected data were then compared to criteria from the Connecticut-Long Island Sound Study (LISS) and the Chesapeake Bay Study (CBS).

While not a primary study goal, eelgrass test plots were established utilizing various methods for harvesting and transplanting eelgrass to determine the most successful methodology for this geographic area.

1.2 Geographic Description

The Peconic Estuary system is situated between the northern and southern forks of Long Island comprised of a series of connected bays and tidal creeks. The Peconic River empties into the head of the estuary at Flanders Bay, the western most portion of the system. From Flanders Bay, the estuary stretches eastward to Great Peconic Bay, Little Peconic Bay, and Gardiners Bay (Hardy, 1976). Islands within the estuary include Robins, Shelter and Gardiners.

Approximately 128,000 acres drain to the estuary, 30,000 of which are protected by public and private agencies and organizations (draft CCMP, 1998). The non-point source runoff and groundwater seepage account for the largest freshwater inputs to the system.

The bays which make up the Peconic Estuary are relatively shallow. The deepest areas are at the races and range from approximately six-meters to 31-meters (draft CCMP, 1998).

1.3 Historical Distribution of Eelgrass in the Peconic Estuary

Eelgrass historically was well-established within the Estuary. In the 1930's an epidemic of wasting disease *(Labyrinthula zosterae)* almost completely wiped out the eelgrass on the Atlantic coast of Europe and North America. According to Burdick, *et. al.* (1993), the actual cause of the wasting disease was never determined. However, *L. zosterae* has recently been identified as the organisms causing the present form of wasting disease. Muehlstein (1989) has concluded in her work that *L. zosterae* is the pathogen that was responsible for the 1930's wasting disease events.

During the late 1960's eelgrass made such a remarkable recovery that it was considered a nuisance because it fouled motor boat propellers, and it washed up large wrack lines along bathing beaches. During the severe Brown Tide Years 1985 and 1986, eelgrass beds disappeared at alarming rates due to the density of brown tide (*(Aureococcus anophagefferens)* cells which inhibited light penetration necessary for photosynthesis.

2.0 REVIEW OF EXISTING DATA AND LITERATURE

2.1 Biology of Eelgrass

A technical description of *Zostera marina* is described after Gleason's (1991) treatment of the species as follows: Common. Stems freely branched, to 2.5 m lvs to 1m with 3-7 strong veins and many minute ones on sterile stems to 1cm wide; on fertile stems 2-5 mm wide. Spadix 2-8 cm, lacking retinacula. The beak 1-2mm; seed strongly ribbed, the ribs visible through the pericarp. 2n=12. Shallow water in sheltered bays and coves, usually wholly submersed, circumboreal, on the Atlantic coast from Greenland to Florida *(Z. Stenophylla)*.

Botanists place *Zostera marina* in the monocotyledon family Potamogetonacea. *Zostera marina* produces roots, stems, flowers and seeds. The monoecious flowers of eelgrass are pollinated under water by the aid of water currents. The growth stages of eelgrass include vegetative and sexual reproduction (Setchell, 1929). According to Setchell, the activities of vegetative growth and sexual reproduction are confined chiefly to the period when the temperature of water is rising from 10 degrees Celsius to 20 degrees Celsius. The vegetative growth is carried on in the range of 10 - 15 degrees Celsius, while reproduction occurs solely in the range of 15-20 degrees Celsius. Therefore, according to Setchell's criteria, vegetative growth occurs during the months of March through May, and sexual reproduction during May and June for the Peconic Estuary. Dependent on local meteorology, vegetative growth may take place slowly through some of the winter months.

Heat rigor and cold rigor adversely impact the anatomy and physiology of eelgrass. It facilitates disintegration of the upper parts of the leaves and older portions of the rhizomes. Fruiting stems die rapidly. According to Doheny (1968), the influence of temperature upon vegetative growth and reproduction by seed appears to be very important for the geographic distribution of *Zostera marina.*

In the Peconic Estuary, the average depth that eelgrass is established for stations included in this study is approximately three-meters. The average depth of low density eelgrass beds is approximately three-meters and the average of dense eelgrass beds is approximately 2.7-meters. The height to which it can grow above low tide is limited by the type of sea bottom and by the resistance of the plant drying out. The maximum depth to which eelgrass may grow depends upon the transparency of the water (Ostenfield, 1905). In the Peconic Estuary, eelgrass has not been observed to grow above the low tide line for all stations included in this study. Typical substrate for eelgrass within the Peconic Estuary ranges from coarse sand-gravel to coarse medium sand where coarse sand-gravel is the predominant substrate. Eelgrass grows well in estuaries where the salinity falls as low as 26 parts per thousand (ppt). *Small* variations in salinity concentrations do not have an appreciable effect on eelgrass.

Tutin (1942) states that epiphytic diatoms, other small algae and hydroids, reduce the light availability for the plant to conduct photosynthesis. He concludes that light in general, if not always, is the limiting factor for growth of eelgrass, especially in deep water.

Generally, healthy eelgrass rhizomes are thick with short internodes, creeping and branching freely. In a mature plant, each section produces leaves and a terminal bud one year, and a flowering stem and leafy branches in the following year. The section of rhizome which bears the inflorescence (flower) dies, while the dead rhizome persists for a considerable time thereafter. The branches show similar behavior to the rhizomes. The adventitious roots are produced from the nodes and are bunched. They serve to anchor the rhizome in a suitable substrate. Rhizomes can survive burial during storm events.

2.2 Chesapeake Bay Study

The description of this study has been adopted from the Executive Summary for CBPTRS83/92 Report. The primary objective of the CBS is to establish the quantitative levels of relevant water quality parameters necessary to support continued survival, propagation, and restoration of sub-aquatic vegetation (SAV) in the Bay Complex. Presently, the study is focused on establishing regional SAV distribution, density, and species targets for the Chesapeake Bay and its tributaries. Empirical data are used to develop relationships between water quality characteristics and SAV distributions within the Chesapeake Bay Complex. SAV requirements are defined as the minimal water quality levels necessary for SAV survival. Field data were collected over several years in varying meteorologic and hydrologic conditions.

The diversity of SAV communities throughout the Chesapeake Bay, with its wide salinity range, led to the establishment of separate habitat requirements based on salinity regime. Water quality parameters sufficient to support survival, growth , and reproduction of SAV to water depths of one and two meters were established in the Chesapeake SAV Habitat Requirements.

For polyhaline water (> 18 ppt) SAV Habitat Requirements for One-Meter and Two-Meter Restorations are as follows:

One-Meter Restoration							Two-Meter Restoration	
Salinity Regime	**Light Attenuation Coefficient (m^{-1})**	**TSS (mg/l)**	**Chl-a (μg/l)**	**DIN (mg/l)**	**DIP (mg/l)**	**Critical Life Period**	**Light Attenuation Coefficient (m^{-1})**	**Critical Life Period**
Polyhaline	<1.5	<15	<15	<0.15	<0.02	March-Nov.	<0.8	March-Nov.

The Team determined that mid-channel water quality data can be used to characterize near shore areas over seasonal time frames but do not imply a predictive relationship between near shore and mid-channel observations. This habitat requirement approach provides testable hypotheses that can be explored for other estuaries.

2.3 Long Island Sound Study

The LISS ground-truthed the coastal zone from Little Naragansett Bay to Jordan Cove between August and October 1993 for seagrass beds. Three sites were chosen: (1) Bushy Point; (2) Niantic Bay; and (3) Clinton Harbor, for monthly sampling during the first two hours into the flood tide. Parameters measured include temperature, salinity, secchi depth, and light profile (Kd). Laboratory analysis include total and organic suspended load, No_2^-, NO_3-(DIN), NH_4^+, orthophosphate, chlorophyll, dissolved and particulate organic nitrogen. Additionally, grain size was determined via sediment cores and organic content of sediment within the seagrass canopy.

At the conclusion of the study, habitat requirements were established and compared to Chesapeake Bay Habitat Requirements. The Long Island Sound Study Habitat Requirements are as follows:

PARAMETER	LISS HABITAT REQUIREMENT (1998)	CBS HABITAT REQUIREMENT (2 meter restoration)
Kd (m^{-1})	< 0.7	<0.8
TSS (mg/l)	<30.0	<15.0
Chl (μg/l)	<5.5	<10.0
DIN (μmoles)	<0.15	<0.15
DIP (μmoles)	<0.02	<0.03
Sediment TOC	< 3 %	N/A

The more conservative values recommended by LISS are based on the finding that seagrasses of a regenerating bed of *Zostera marina* require "better" conditions than those needed for simply maintaining the bed (Okubo and Slater, 1989).

3.0 SITE SELECTION AND DESCRIPTION

EEA, Inc. in cooperation SCDHS, EHTNRD, and CCE chose 14 fixed sampling locations (Figure 1) within the estuary. These locations were chosen in part, based upon historical eelgrass bed density, surrounding land use, as well as information provided in the 1996 SAV study by Cashin Associates. Site reconnaissance and aerial photography at 1:1,200 (1996) were used to characterize the stations listed below:

3.1 Flanders Bay (Station 170)

Flanders Bay was chosen for four primary reasons; (1) known established widgeon grass population; (2) lack of eelgrass beds; (3) relatively low salinity (24 ppt); and (4) historical duck farm nutrient loading into the estuary.

The mouth of the Peconic River empties into Flanders Bay (Riverhead) and Reeves Bay (Southampton). Flanders Bay is approximately 2,346 acres. The Riverhead Golf Course is adjacent and to the north of the Peconic River, bounded on the north by Sawmill Creek. Indian County Park is bounded to the south by Sawmill Creek and Terry Creek to the north. Tidal creeks that empty into Flanders Bay include Meetinghouse Creek and Reeves Creek.

Meetinghouse Creek is located in the northwest corner of Flanders Bay within the Town of Riverhead. Meetinghouse Creek is a medium sized creek of approximately 30+ acres, and is the most developed of tidal creeks terminating into Flanders Bay. The Creek is approximately 1.1 kilometers long north to south and 123-meters wide east to west on average. The eastern boundary of the creek is the most heavily developed, while the western boundary supports a significant area of intertidal and high marsh. The dominant species include salt marsh cordgrass and groundsel tree. The headwaters of Meetinghouse Creek, a formerly connected tidal wetland, drains through the Corwin Duck Farm (active). Meetinghouse Creek is periodically dredged for the marina. These activities were initiated in 1948 and according to SCDPW, the creek was last dredged in the spring of 1998. Dredge spoil disposal areas include upland areas at Indian Island County Park. The majority of dredge material consists of duck sludge. Other dredge material consists primarily of sand and some mud (SCPD, 1985).

Reeves Creek has a relatively low land use supporting low density residential housing and approximately six docks.

A spit at Simmons Point is situated at the eastern-most portion of Flanders Bay. A review of recent aerial photography (1996) indicate that a scour area exists on the western portion of the spit, and deposition on the eastern portion.

Eelgrass Station Location Map

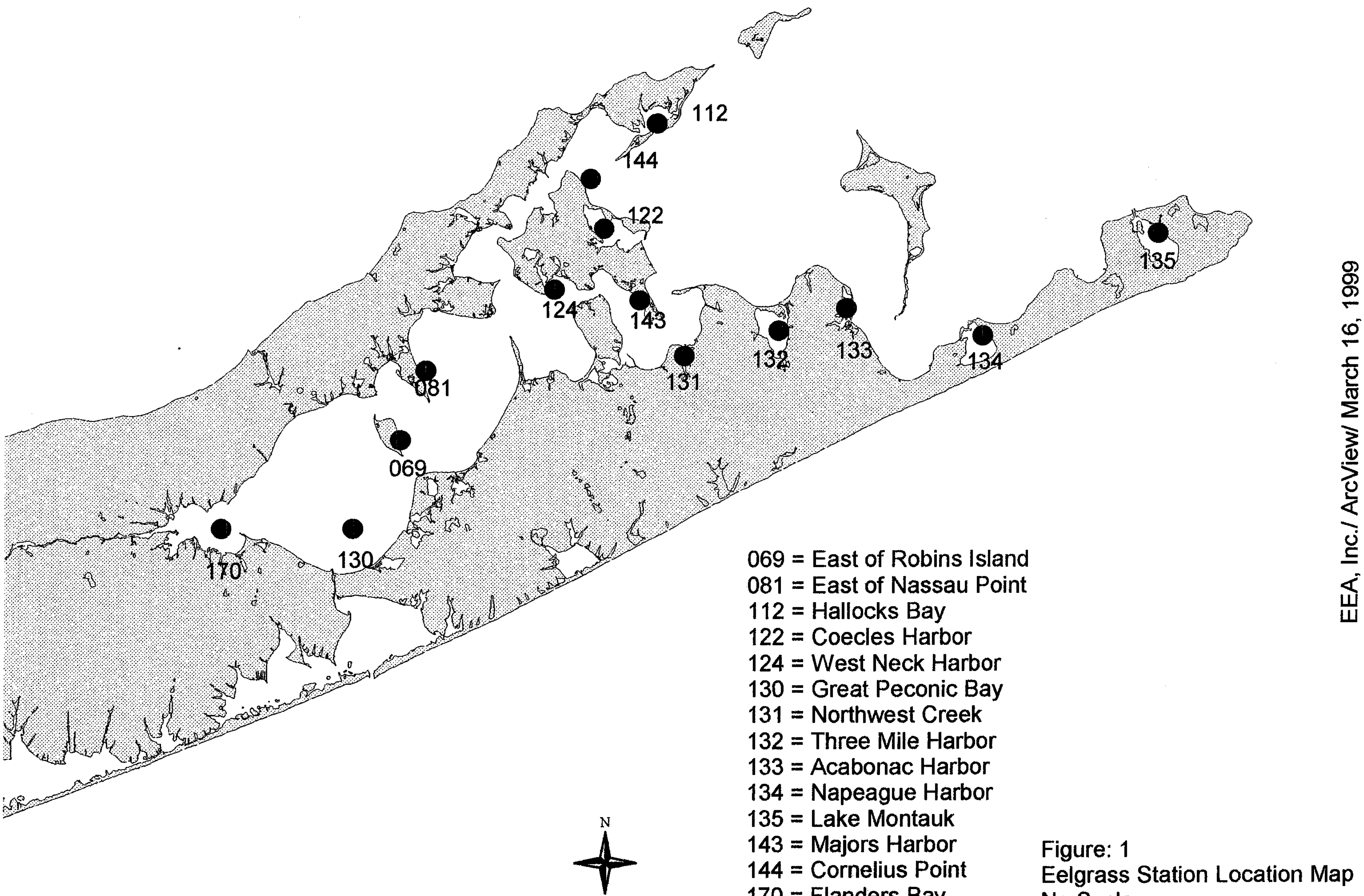


Figure: 1
Eelgrass Station Location Map
No Scale

EEA, Inc./ ArcView/ March 16, 1999

3.2 Great Peconic Bay (Station 130)

Great Peconic Bay was chosen because there are no SAV beds established. Data collected here is intended to provide negative baseline conditions to be compared with areas that support various densities of eelgrass populations further to the east within the estuary.

Great Peconic Bay is approximately 26,693 acres. The northern portion of the bay is situated in the Town of Southold and the southern portion in the Town of Southampton. Robins Island is located at the eastern portion of the Bay in the Town of Southold between the North Race and South Race. Tidal Creeks entering the bay from the Town of Southold include Brushs, Horton, James, Deep Hole, Downs, and West. Tidal creeks and ponds entering the bay from Southampton include Red Creek Pond, Squire Pond, Shinnecock Canal, Cold Spring Pond, Sebonac, Little Sebonac, North Sea Harbor Complex, and Wooley Pond.

The area examined under this study is located in the Town of Southampton, just northwest of the Shinnecock Canal. Surrounding land use is very low from Sebonac Neck east to Cow Neck. To the west of Sebonac Neck, there exists a relatively high density residential land use. The Shinnecock Indian Reservation is located to the west of the Shinnecock Canal, and Meschutt Park is located to the east. The National Golf Links of America is located to the west of Bullhead Bay and east of Sebonack Neck.

Aerial photographs (1996) reveal that there is considerable sand movement along the southeastern shorelines of Great Peconic Bay with many ripple marks extending approximately 262-meters off the shoreline to the center of bay. They also reveal a sand plume east of Cow Neck that radiates in an easterly direction. The Sebonac complex appears to be an area of accretion during the time period that the aerial photography was taken (April 1995). This complex has extensive ditching throughout. Cold Spring Pond also appears to be an area of accretion.

3.3 Eastern Robins Island (Station 069)

Eastern Robins Island is presently devoid of eelgrass, but has been identified by Cashin (1996) as an area likely to support eelgrass based on physical characteristics. The area is supported by a sandy substrate, salinity of approximately 30 parts per thousand, and visibility to two-meters.

Privately owned, there is a low density residence on the island. The main use of the island is to support a managed Game Preserve and private estate. Ring-necked pheasant are raised on the island for traditional English fowl hunts held annually on the island.

A review of the aerial photographs indicate that the shoreline is an area of accretion with shoals and bars extending approximately from 197-meters at the northeastern edge to 328-meters at the southeastern edge of the shoreline. A spit exists at the southerly portion of the island radiating to the west. Therefore, most of the sand accreting is likely being transported from the east.

3.4 Eastern Hog Neck Bay (Station 081)

Hog Neck Bay is located in the Town of Southold and is part of Little Peconic Bay. It is bordered on the west by Nassau Point and terminates in the east at Cedar Beach County Point (Cedar Beach Point). It is approximately 4,333 acres in size from Nassau Point to Cedar Beach Point. Two Parks exist along the shoreline; Emerson Park to the east of Richmond Creek, and Cedar Beach County Park at the eastern extent of the bay. A launching ramp exists on Cedar Beach Road into Shelter Island Sound. Tidal Creeks terminating into the bay include Richmond Creek and Corey Creek. The area analyzed for this study is located at the southeastern portion of Nassau Point. This is a very shallow area with a mean water depth of approximately 1.1-meters and a salinity of 30 ppt (Cashin, 1996). This area supports a patchy coverage of green fleece *(Codium fragile)* and lacks eelgrass entirely (Cashin, 1996).

Surrounding land use supports a relatively high density of residential homes. Aerial photographs indicate the eastern shoreline supports a sand bar approximately 328-meters wide. Cedar Beach has been periodically dredged since 1979. All of the material dredged is sand and/or gravel and is used for beach nourishment to the west (SCPD, 1985).

3.5 West Neck Harbor (Station 124)

West Neck Harbor is located on the southwestern portion of Shelter Island and terminates in Shelter Island Sound. West Neck Harbor is part of the West Neck Complex composed of West Neck Bay to the north, West Neck Creek, and West Neck Harbor to the south. A long peninsula exists at the southern portion of the harbor called Shell Beach where mooring is available. The sampling station for West Neck Harbor is located immediately south of the southeastern shoreline of West Neck Creek near Montclair Avenue. Cashin (1996) reports a mean water depth of 1.7-meters, visibility to 1.3-meters and salinity at 31.5 ppt. Cashin (1996) observed widely scattered green fleece (1 %) at this location.

West Neck Harbor is surrounded by low density residential housing. Menantic Yacht Club is located to the northeast of the harbor. Twenty four docks exist in West Neck Creek and a ramp exists at the end of Daniel Lord Road.

West Neck Harbor has been periodically dredged since 1955 and was last dredged November 1998 A dredged channel can be clearly observed from the aerial photography. The spoil material is principally sand and includes some mud. All of the spoil is used for beach nourishment (SCPD, 1985).

3.6 Coecles Harbor (Station 122)

Coecles Harbor is located along the northeastern shoreline of Shelter Island. It is approximately 1,485 acres in size. According to the Cashin study (1996), average depth within the harbor is approximately 2.6-meters. Salinity within the harbor fluctuate between 31 and 32 ppt. Visibility appears good to about 2.1-meters. Although historically eelgrass was plentiful, there are no beds presently located within Coecles Harbor.

The southern portion of Coecles Harbor is bordered by Mashomack Preserve and further north by a New York State Conservation Area. Congdons and Foxen Creeks are the only two tidal creeks entering the harbor. The northwestern shoreline of the harbor is moderately developed. From the north, a long peninsula runs in a southeasterly direction. It is comprised of Little Ram Island and Ram Island. There is low density residential housing on Little Ram Island. Ram Island is well-developed on the western shoreline supporting 27 docks. Ram Island Yacht Club is located along the southwestern tip of Ram Island near Reel Point. All undeveloped areas are supported by natural vegetation. Both anchorage and moorings are present within the harbor.

A review of the aerial photography (1996) indicate shifting sands moving in the northern portion of the harbor radiating from the south. In the lower portion of the harbor, some shoaling is evident. Coecles inlet has been periodically dredged since 1966. It was last dredged April 1996 primarily for boat access to the Coecles Harbor Marina. The spoil material is principally sand with some mud. All spoil material is used for beach nourishment (SCPD, 1985).

The 1996 report by Cashin Associates indicates that moderately dense eelgrass beds are located immediately to the north and outside of the inlet. The salinity range in this area fluctuates between 31 and 32 ppt, visibility to 5.2-meters (higher than in harbor) and water depth from 1.9-3.2-meters.

3.7 Hallocks Bay (Station 112)

Hallocks Bay is located within Orient Bay north of Orient Point State Park. It is approximately 444 acres in size. The western shoreline of Hallocks Bay supports low density eelgrass beds. Salinity is approximately 32 ppt, depth approximately 2.0-meters and visibility to 2.6-meters (Cashin, 1996). Substrate is gravelly sand.

Hallocks Bay is surrounded predominantly by farmland (70%) and natural vegetation (28 %) north to Route 25. At King Street along the south west portion of the bay, a few structures and docks exist. Aerial photographs (1996) indicates that Peters Neck Point is an area of sand deposition.

3.8 Cornelius Point (Station 144)

Cornelius Point is located at the northeastern portion of Shelter Island. Large, thick beds of eelgrass exist around Cornelius Point. The beds are stunted in height and have very narrow leaves. Historically, eelgrass existed approximately 5-6.6-meters off the shoreline (personal conversation with local residents). This area is presently dominated by *C. fragile* and attached sargassum weed *(Sargassum filipendula)*. Eelgrass beds are presently located approximately 20-meters from the shoreline.

Depth of water in this area ranges from approximately 1.8-2.9-meters. Salinity is approximately 31 ppt and visibility is very good. There is an area with large glacial erratics immediately to the north of the established eelgrass beds. Surrounding land use is very low density residential. The Gardiners Bay Country Club is located to the west of Gardiners Bay Drive. From aerial photographs, the area immediately north of the point appears to be an area of deposition, and the shoreline immediately south of the point is an area of scour. Aerial photographs indicate that sand movement radiates from the northwestern portion of the point.

3.9 Majors Harbor (Station 143)

Majors Harbor is located at the southwestern portion of Mashomack Preserve on Shelter Island and is approximately 83.2 acres in size. The interior of Majors Harbor supports eelgrass beds with signs of extreme stress (Cashin, 1996). The station is located at Majors Point just north of the harbor.

Surrounding land use is entirely protected as part of Mashomack Preserve with no development. It is an open inlet, likely to have good flushing. Anchorage is available within the harbor. Aerial photography did not indicate any shoaling near the harbor.

3.10 Three-Mile Harbor (Station 132)

Three-Mile Harbor is located in the Town of East Hampton. The inlet opens to Gardiners Bay to the north bounded by Sammy's Beach to the west and Maidstone Town Park to the east. This area is presently devoid of eelgrass. EHTNRD conducted an eelgrass transplant at Sammy's Beach in 1996. It was successful initially, but as of the summer of 1997 only a few plugs could be found during the annual monitoring event by EHTNRD. The shoreline surrounding the harbor is moderately developed by residential housing. Anchorage and mooring exist within the harbor. There are 10 marinas, a town commercial fishing dock, three town boat ramp sites, and slips at the Town/County facility.

Aerial photographs indicate that immediately adjacent to the cut channel at the mouth exists a large sand plume. According to Suffolk County Department of Public Works (SCDPW) records, dredging began at the mouth in 1958 for boat access to marinas. This area is scheduled to be dredged in April 1999. The dredge spoil material is all sand and is readily used for beach nourishment on both sides of the inlet and at an upland area on Marina Lane.

3.11 Napeague Harbor (Station 134)

Napeague Harbor is located in the Town of East Hampton between Napeague State Park (west) and Heather Hills State Park (east). The railroad tracks run east/west immediately to the south of the harbor. Napeague Harbor is approximately 1,086 acres in size. Although mostly surrounded by parkland, a small section along the northwest portion of the harbor supports low density residential housing.

Napeague Harbor supports thick beds of eelgrass on the southerly side of the shoal along the eastern shoreline. Although patchy from clam rakers, the eelgrass beds appear very healthy. Cashin reported high salinity of 33 ppt, shallow depth of approximately 1.1-meters and good visibility. There are two inlets to Napeague Harbor. A review of aerial photographs indicate a sand plume immediately inside the western-most entrance and immediately along the inner western edge of the eastern inlet. Dredging of a modified inlet began in 1967. Dredge spoil is entirely of sand and historically was deposited on the Hicks property. The area was last dredged January 1989. Napeague Harbor provides anchorage and has a boat launching ramp at Lazy Point (northwest of western inlet).

3.12 Lake Montauk (Station 135)

Lake Montauk is located in the Town of East Hampton and is approximately 1,102 acres in size. It is situated at the eastern end of the south fork of Long Island. It is surrounded by moderately dense residential housing to the west and south and low density residential housing and the Montauk Airport to the east. The inlet has been periodically dredged since 1949 and was last dredged in 1974. The dredge spoil material is all sand and is used for beach nourishment. Immediately to the south of the inlet is the U.S. Coast Guard Station and Montauk Yacht Club located on Star Island.

The sampling station is located at the northeastern portion of the Lake near the Airport. This area supports a mixed bed of eelgrass with 5 % *C. fragile* at a depth of 2.6-meters. This area is known for high boat traffic which may be related to the moderate density of the eelgrass, and mixed bed conditions within the harbor.

3.13 Accabonac Harbor (Station 133)

Accabonac Harbor is located in the Town of East Hampton and is approximately 304 acres in size. It is situated to the west of Gardiners Island. There is relatively low density residential housing around the harbor. There are three sanctuary's; Kaplan Meadows, Merrill Lake and Edwards Island within and/or surrounding the harbor. C. Gerard Town Park is located along the eastern shoreline on Gerard Drive. Additionally, a New York State Conservation area is situated at the lower portion of the harbor (East Harbor).

Historically, eelgrass was abundant in Accabonac Harbor and even harvested as insulation for houses before the turn of the century. Presently there are no eelgrass beds within the harbor. The inlet has been periodically dredged since 1959 and was last dredged February 1996. All dredge spoil consists of sand and some mud and is used for beach nourishment on both sides of the inlet. This is evident on the aerial photographs (1996) where thick sand plumes exist on both sides of the inlet. There are two boat launching ramps; one on Shipyard Lane and one on Landing Lane. Anchorage is present within the harbor.

3.14 Northwest Creek (Station 131)

Northwest Creek is located within the Town of East Hampton. Northwest Creek is immediately adjacent to Northwest Harbor which drains into Gardiners Bay. It is a relatively long (approximately 2.3 kilometers) and narrow (an average 410-meters) estuary occupying approximately 140 acres. The inlet connecting Northwest Creek to Northwest Harbor is extremely narrow (less than 33-meters across). Although Northwest Creek historically supported eelgrass beds, none are present today.

The vast majority of the shoreline is boarded by an expansive intertidal marsh dominated by saltmarsh cordgrass. Beyond the marsh is an oak/pine forest. The eastern portion of the creek is bordered by New York State Environmental Conservation Area and the Northwest Harbor County Park. The western shoreline is bordered by the Sag Harbor Golf Club at Barcelona Neck. A boat launching ramp is located at the County Dock and anchorage exists within the creek. Salinity within the creek system averages 26.5 ppt, ranging from 24.1 to 28.8 ppt with little variation between the mouth and head.

In general, the entire system is extremely shallow, with an average depth of 1.0-meter. The deepest areas are at the mouth and northeast corner where a mooring field is located. The substrate consists of silty fine grain material with the exception of the mouth and mooring area which is mostly medium sands. Northwest Harbor has been dredged since 1961 to modify the inlet and was last dredged January 1999. Dredge spoil material is all sand and can readily be used for beach nourishment. Presently, the spoil is placed on the barrier spit at the entrance to Northwest Creek.

4.0 METHODOLOGIES

4.1 Water Quality Monitoring

Water quality monitoring was conducted by SCDHS as in-kind services for this project. Water quality collection data has been on-going throughout the estuary by the SCDHS since 1976. Collection and analysis associated with this project was conducted one time per month at each station for the months of June, July August, and September, 1997 and May 1998 All collections and analyses conform to ASTM Standards.

General physical chemistry parameters were measured each time water collections were conducted by SCDHS. Those parameters include salinity, temperature, conductivity, pH, secchi disc, dissolved oxygen, depth and light extinction coefficient. Water samples collected for laboratory analysis include total suspended solids, chlorophyll-a, dissolved inorganic phosphorous (orthophosphate) and dissolved inorganic nitrogen (NOX and NH_3).

4.2 Sediment Quality Monitoring

During each water quality run conducted by SCDHS, EEA, Inc. collected sediment samples. Sediment collections were conducted from the boat utilizing a 0.025 meter-square petite bottom grab sampler. Often, multiple grabs were composited to acquire a suitable sample size. Observations of biotic and abiotic material were recorded on data log sheets for each station (Appendix A). These observations included the presence or lack of: vegetation, nematodes, crustacea, sediment size and color. Additionally, weather data and global position (GPS) were recorded.

Sediment was collected for total organic carbon (TOC) and grain size analysis. Grain size collections were conducted one time during the Project Term to obtain general grain size distribution data for each sampling location. Samples were sent to Chemtech, Inc. for analysis within 30 days from collection. All analytical sheets provided to EEA, Inc. from Chemtech are located in Appendix B. Grain Size and TOC Protocols for Laboratory Analysis are located following the analytical sheets in Appendix B.

4.3 Hydrodynamic Monitoring

A Falmouth Scientific 3D-ACM acoustical flow meter was deployed at several locations to get a general picture of hydrodynamic conditions existing where eelgrass beds are non-existing, transitional, stressed and thick. Vector, velocity and temperature of near-bed conditions were recorded for the following locations:

Lake Montauk (135), Napeague Harbor (134), Accabonac Harbor (133), Three-Mile Harbor (132), Northwest Creek (131), Cornelius Point (144), Coecles Harbor (122), Flanders Bay (170), and Great Peconic Bay (130).

A Seapoint Turbidity Sensor was added to the flow meter in May, 1998. Three-Mile Harbor and Napeague Harbor were monitored prior to the addition of the turbidity sensor and therefore, are lacking turbidity data:

<u>Equipment</u>

The 3D-ACM flow meter offers the ability to interface optional sensors such as temperature and turbidity as adopted for this study. The basic instrument measures velocity along four acoustic paths, three orthogonal magnetic vectors and two orthogonal gravity vectors (tilt) from which it calculates velocity relative to the earth. The velocity interface uses a single transmitter and receiver, which are multiplex to the eight acoustic transducers mounted on the sensor head. Using the acoustic transmission of sound from one transducer to another, the 3D-ACM can calculate water flow along each of the four acoustical paths. The computaion is based on the acoustic phase shift of the sound, which occurs due to the advance of sound traveling in the same direction as the water flow and the corresponding retardation of sound traveling against the water flow. The compass uses a fixed (no gimbals) three-axis magnetometer along with the two-axis tilt sensor to determine the instrument orientation relative to the earth's magnetic and gravity vectors.

For this study, recordings were generally made with an "on time" (time collecting data during each interval) of 15 seconds, an "interval time" (time stored) of 30 seconds, and an "AVGI"(length of time) every 15 minutes. Detailed Specifications are located in Appendix C.

The Seapoint Turbidity Sensor was added for the 1998 summer sampling season. The Seapoint Meter is a sensor that measures turbidity by detecting scattered light from suspended particles in water. The sensor is insensitive to ambient light when under water and has a very low temperature coefficient.

The Meter senses scattered light from a small volume within 5 centimeters of the sensor windows. Confining the sensing volume allows the sensor to be calibrated in relatively small water containers without errors from surface and wall reflections.

Two control lines allow the user to externally set the sensitivity of the Meter by choosing one of four gains. This provides an easy means to set the sensitivity to provide the range and resolution required for a particular application. Sensitivities of 2, 10, 40 and 200 mV/FTU (Formazin Turbidity Units) are possible. The gain was fixed at 10 (100X) for this study. Detailed Specifications are located in Appendix C.

4.4 Data Reduction

Using water quality data provided by SCDHS, monthly and seasonal arithmetic means were calculated using Microsoft Excel 97. The arithmetic means were used to generate tables and graphs for analysis of data. The data were organized by station and by season (growing vs, summer) for *Zostera marina*. For this study the growing season is assumed to be March through November and the summer season is assumed to be June through August.

Laboratory data for sediment analyses including grain size and TOC were transferred to Excel format and tables and graphs were generated for analysis. Grain size data were graphed in pie chart format. The grain size classification for substrates was adopted from the Wentworth Scale based on the U.S. Standard Sieves.

Flow meter data were converted to ASCII format. Excel 97 was used to generate graphs for turbidity (where applicable), temperature, vector and velocity for analysis.

5.0 ANALYSIS

Analysis of the synthesized and graphically represented data were conducted for water quality, sediment quality and hydrodynamics. Arithmetic means were computated for all appropriate water quality data associated with this study. Sediment data were analyzed by the raw data provided from the laboratory regarding TOC. Grain size has been graphically represented in pie charts and shown in Figure 2 to illustrate percentage of particle size distribution at the various locations for this study. Vector, velocity, temperature and turbidity (where applicable) have been graphically presented in Appendix D to illustrate cyclic ongoing events within the estuary.

5.1 Water Quality

The water quality analysis is intended to provide preliminary quantitative baseline data for guidance on the establishment of Eelgrass Habitat Criteria. This analysis is not intended to be an exhaustive statistical study as limited new data were collected in association with this study.

Water quality parameters collected for this study include salinity, temperature, DO, chlorophyll-a, secchi disk, dissolved inorganic nitrogen, dissolved inorganic phosphate, total suspended solids, and light extinction. Additional water quality information has been provided by SCDHS and has been included where applicable for this study.

A transect delineating water quality stations and SAV (western/central and eastern) follows the delineation outlined in SCDHS' draft report "Peconic Estuary Surface Water Quality" (October, 1998). Water data has been reduced and analyzed for water sampling years 1997 and 1998. These data are compared with older water quality reports produced for the Peconic Estuary Program in the Discussion Section of this report.

For this analysis, areas lacking eelgrass have been labeled "NO SAV" in the tables and represent data from stations 069, 124, 130, 131, 132, 133, and 170. "Thick beds" represent areas supporting thick eelgrass or mixed beds and represent data from stations 134, 135 and 144.

<u>Overview:</u>

The Peconic Estuary is classified as a polyhaline environment, where salinity is typically greater than 18 ppt. Table 1 below summarizes water quality data collected and analyzed for 1997-1998 All synthesized data and associated graphs related to Table 1 are located in Appendix D

Table 1 Summary of Water Quality Parameters (1997 & 1998)

Location	Temp (C)	DO (mg/l)	Salinity (ppt)	DIN (mg/l)	DIP (mg/l)	Chl-a (μg/l)	TSS (mg/l)	Kd = 1.45/ secchi	Kd = $\frac{-\ln(I_z/I_o)}{Z}$
Western/ Central									
'97 GS	15.82	7.79	27.76	0.019	0.013	4.05		0.8	1.3
'97 SS	22.41	6.50	27.65	0.013	0.014	4.90		0.9	1.8
'98 GS	16.96	7.9	26.19	0.022	0.011	2.78	6.08	0.7	0.7
'98 SS	23.34	6.5	26.26	0.026	0.020	3.15		0.8	0.8
Eastern									
'97 GS	15.29	7.94	28.37	0.020	0.012	3.44		0.8	0.8
'97 SS	20.25	6.82	28.36	0.017	0.014	3.81		0.6	0.8
'98 GS	15.98	8.4	27.35	0.016	0.018	2.21		0.5	0.4
'98 SS	23.07	6.8	27.4	0.016	0.010	1.98	5.58	0.7	0.4
No SAV									
GS	15.54	8.189	28.58	0.023	0.013	3.717		0.6	0.85
SS	20.0	6.967	28.64	0.019	0.016	3.638		0.7	1.2
Thick Beds									
GS	14.4	8.9		0.018	0.012	3.1		0.65	0.2
SS	21.45	7.1		0.018	0.016	3.1		0.5	0.4

GS = Growing Season
SS = Summer Season
Western/Central = Stations 069, 081, 124, 130, 170
Eastern Stations = 112, 122, 131, 132, 133, 134, 135, 143, 144
No SAV (no eelgrass) = Stations 170, 130, 069, 124, 132, 133, 131
Thick Beds (eelgrass) = Stations 134, 135, 144

The data analysis for No SAV and Thick Bed stations is extremely limited and should be considered as a variable lacking statistical representation. In some cases only one or two data sets were available for analyses.

Salinity (ppt)

Salinity measurements averaged for all stations examined under this program are 27.4 (ppt). The western/central portion of the estuary averages 27.0 ppt and the eastern portion averages 27.9. Water becomes less saline at the inner portion of the estuary near the mouth of the Peconic River. Salinity measurements from Flanders Bay support this and have been observed at 24.0 ppt near the river's mouth.

Temperature (C)

Water temperature within the estuary increases from the east to the west. There are no significant differences between geographic locations during any particular season. Table 2 below, indicates the arithmetic mean for 1997 and 1998 for all stations evaluated under this study.

Table 2 Temperature Data

LOCATION	SEASON	TEMPERATURE (C)
Western/Central	growing season	16.4
Western/Central	summer season	22.9
Eastern	growing season	15.6
Eastern	summer season	21.7
No SAV	growing season	15.5
No SAV	summer season	20.0
Thick beds	growing season	14.4
Thick beds	summer season	21.4

Dissolved Oxygen (mg/l)

In salt water, the solubility of oxygen decreases as water temperature and salinity increase. DO tends to be slightly higher in the eastern portion of the estuary when compared to the western portion. Summer minimum values were lowest in the western/central portion and highest in the eastern portion where *Zostera marina* beds are thickest. The same trend follows for the growing season throughout the estuary.

Summer DO for the western/central region averaged 6.5 mg/l, while the eastern region averaged 6.8 mg/l. There were relatively no differences in averaged summer DO levels when areas lacking eelgrass beds (7.0 mg/l) were compared to areas supporting thick beds of eelgrass (7.1 mg/l).

Based on the long-term mean (1988-1996) for chlorophyll-a (SCDHS, October, 1998) for summer conditions of 6.6 ug/l for Great Peconic Bay and 8.7 ug/l for Flanders Bay, all stations observed under this study fall well below this range for optimal water quality against violations of the DO standard.

Chlorophyll-a (μ/l)

Chlorophyll-a levels ranged from a maximum of 27.80 μg/l at Station 240 (Peconic River) to a low of 1.2 μg/l at Station 143 (Majors Harbor). The arithmetic mean for chlorophyll-a concentrations for water sampling years 1997 and 1998 at stations associated with this study were 3.85 μg/l. All stations reported peak concentrations during January with a steady decline until all stations bottomed out during the April through May period. Chlorophyll-a levels only rose slightly throughout the summer before increasing again in December. For both the summer and growing seasons, the western portion of the estuary maintains higher mean chlorophyll-a concentrations than the eastern portion. Mean values are presented in Table 3 below:

Table 3 Chlorophyll-a Data

LOCATION	SEASON	ARITHMETIC MEAN (μg/l)
Western/Central	summer	4.0
Western/Central	growing	3.4
Eastern	summer	2.9
Eastern	growing	2.8
No SAV	summer	3.6
No SAV	growing	3.7
Thick beds	summer	3.1
Thick beds	growing	3.1

Additionally, the areas that do not support eelgrass (No SAV), when averaged, indicate higher chlorophyll-a values for both the summer and growing seasons than the stations that support thick beds of eelgrass.

Dissolved Inorganic Nitrogen (DIN) (mg/l)

Data provided by SCDHS was synthesized for the computation and determination of arithmetic means for DIN by combining NOX and NH_3^+. The arithmetic mean for all stations regarding DIN is 0.02 mg/l. There are no lateral changes in concentration from east to west within the estuary, nor are there any differences between the growing season and the summer season for DIN.

Orthophosphate (DIP) (mg/l)

Orthophosphate levels ranged from a maximum of 0.076 mg/l at Station 122 (Coecles Harbor) to a low of 0.005 mg/l which occurred at all stations, with the exception of 135 (Lake Montauk), 143 (Majors Harbor), and 144 (Cornelius Point). In general, orthophosphate levels averaged 0.016 mg/l for all study stations combined over the sampling season, with the exception of a single spike of 0.065 mg/l at Station 135 (Lake Montauk) during February of 1997. The data for orthophosphate indicate that the levels begin to rise in June and peak in September with levels declining by October. In January, orthophosphate levels return to their lowest values. There are no significant lateral changes within the estuary from east to west.

Total Suspended Solids (TSS) (mg/l)

The only TSS data analyzed for this report is for water year 1998. Data collections were minimal for 1998 and are presented here, with little weight in the overall analysis for generating Habitat Criteria associated with this study. TSS varied slightly between the western/central portion of the estuary at 6.075 (mg/l) and the eastern portion of the estuary at 5.58 (mg/l) for the summer season.

Light Extinction ($Kd\ m^{-1}$)

Light attenuation was calculated by using the standard coefficient of 1.45/secchi depth = Kd for polyhaline waters (Chesapeake Bay). Minimum light requirements for SAV can be determined where the maximum depth limit and light attenuation coefficients are simultaneously measured. Incident light that corresponds to maximum depth penetration for marine SAV was calculated using the equation $kd = \frac{-\ln(I_z/I_o)}{Z}$ [Lambert's Law]. Table 4 presents these values.

Table 4 Light Extinction Data

LOCATION	SEASON	$Kd = \frac{\ln(I_z/I_o)}{Z}$	$Kd = \frac{1.45}{\text{Secchi depth}}$
Western/Central	growing season	1.0	0.8
Western/Central	summer season	1.3	0.9
Eastern	growing season	0.6	0.7
Eastern	summer season	0.6	0.7
Arithmetic Mean	ALL	0.9	0.8

Kd values varied slightly between the Chesapeake Bay coefficient/secchi depth and Lambert's Law. Overall, the western/central portion of the estuary maintains higher Kd values than the eastern portion. The lower the Kd value, the deeper light is attenuated. A Kd value of $0.8m^{-1}$ will support SAV to a two-meter depth, while a Kd value of $1.5m^{-1}$ will support SAV to a depth of 1.1 meters. This analysis indicates that the western/central portion of the estuary could not support eelgrass to a depth slightly greater than one-meter.

Total Kjeldahl Nitrogen (TKN) (ppm)

TKN levels ranged from a maximum of 1.057 and 1.055 ppm at Station 133 (Accabonac Harbor) and Station 112 (Hallocks Bay), respectively, to a low of 0.14 ppm at Station 081 (Nassau Point). In general, TKN averaged 0.40 ppm for all stations associated with this study combined. Peak occurrences of TKN occurred at irregular intervals, with spikes occurring during January, July, August, and September at Stations 112, 132 (Three Mile Harbor) and 133, respectively. Trends showed the lowest average values reported during April and May, with only a slight increase to peak levels during August and September.

Total Coliforms (mpn/100ml)

Total coliform levels ranged from a maximum of 1,600 (mpn/100ml) at Stations 170 and 122 (Flanders Bay and Coecles Harbor) to a low of less than 2.0 (mpn/100ml) at Stations 069, 081, 112, 122, 124, 131, 130, 132, 133, 134, 135, 143, and 144, in general, with the exceptions of Stations 131, 122, 240 and 170, which had elevated spikes primarily from June through September. Total coliform levels remained low at all the other stations throughout the year. The mean for total coliform levels for all stations associated with this study for 1997 and 1998 is 20.65 (mpn/100ml). The total coliform data averaged for all study stations was 16.0 (mpn/100ml) for 1997 and 25.3 (mpn/100 ml) for 1998.

Urea (mg/l)

Urea levels ranged from a maximum of 0.4380 mg/l at Station 122 (Coecles Harbor) to a low of 0.005 mg/l which occurred at most stations, except for Stations 069, 122, 144, 170 and 240. The average concentration for urea at all stations was 0.014 mg/l for the sampling year 1997. The spike at Station 122 occurred during July (1997) and during June (1997) at Station 135, although remaining low urea levels were highest during the summer (June through August sampling period).

$NO_2 + NO_3$ (NOX) (mg/l)

NOX levels ranged from a maximum of 0.552 mg/l at Station 135 (Lake Montauk) to a minimum of less than 0.005 mg/l which occurred at all stations sampled. NOX levels of 0.50 mg/l, just below the maximum, were reported from Station 170 (Flanders Bay), with additional spikes occurring at Station 130 (Great Peconic Bay) and Station 069 (East Side Robbins Island). All of the spikes occurred during February of 1997. In general, the average NOX levels were extremely low at 0.012 mg/l for the entire sampling season.

Silicate (mg/l)

Silicate levels ranged from a maximum of 20.7 mg/l at Station 122 (Coecles Harbor) to a minimum of 0.028 mg/l at all stations, with the exception of 131, 143, 144, 170, and 240. In general, the average silicate levels for all stations combined was 0.33 mg/l. The only three occurrences of silicates over 1.0 mg/l was the peak at Station 122; a second spike of 11.83 mg/l at Station 240 (Peconic River), and two observations of silicate of 1.09 and 1.08 at Station 170 (Flanders Bay). The occurrence of silicate for all stations was greatest during July and lowest during the winter and spring months of January through April.

Total Organic Carbon (TOC) (mg/l)

Total organic carbon levels ranged from a maximum of 3.97 mg/l at Station 170 (Flanders Bay) to a minimum of 1.15 mg/l at Station 135 (Lake Montauk). The average TOC level for all stations combined over the study period was 1.92 mg/l. TOC levels dropped during March and April, then slowly rose to peak in July.

5.2 Substrate Quality

Total Organic Carbon (mg/kg)

The results of the substrate TOC analysis ranged from a maximum of 41,975 mg/kg at Station 133 (Accabonac Harbor) to a minimum of 52.6 mg/kg at Station 112 (Hallocks Bay). Peak levels at Station 133 occurred during June, while average TOC levels for all stations combined occurred during July. The single lowest level of 52.6 mg/kg at Station 112 occurred during October (1997). The arithmetic mean for TOC is higher in the eastern portion of the estuary (10,132.02 mg/kg) when compared to the western portion (7,673.2 mg/kg). The average TOC levels for all stations combined was 8,902.61 mg/kg for the entire sampling season.

The presence of eelgrass is not encountered until TOC levels drop below 1.75 mg/kg. It is possible that embayments that historically supported eelgrass may have had TOC levels in excess of 1.75 mg/kg.

Grain Size

Of the 14 stations evaluated for grain size, six stations (43 percent) contained mostly gravel (Figure 2). These included Stations 112, 124, 130, 133, 135, and 144. Three stations, 112, 131, and 170, were mostly coarse sand to gravel (21 percent). Stations 069, 081, and 132 (21 percent) were comprised mostly of medium to coarse sands. Only one sample (Station 134) consisted mostly of coarse to medium sand; one station (132) was mostly medium to fine grain. Overall, the sediments at the sampling stations consist primarily of coarse to gravelly material with very few fines.

5.3 Hydrodynamic Analysis

The western/central stations monitored with the 3D-ACM include 170, 130 and 124. Within this region hydrodynamic data collected in conjunction with the Peconic Estuary Program's Tidal Creek Study has been included for Meetinghouse Creek and West Neck Creek as additional information within the study area for stations 170 and 124.

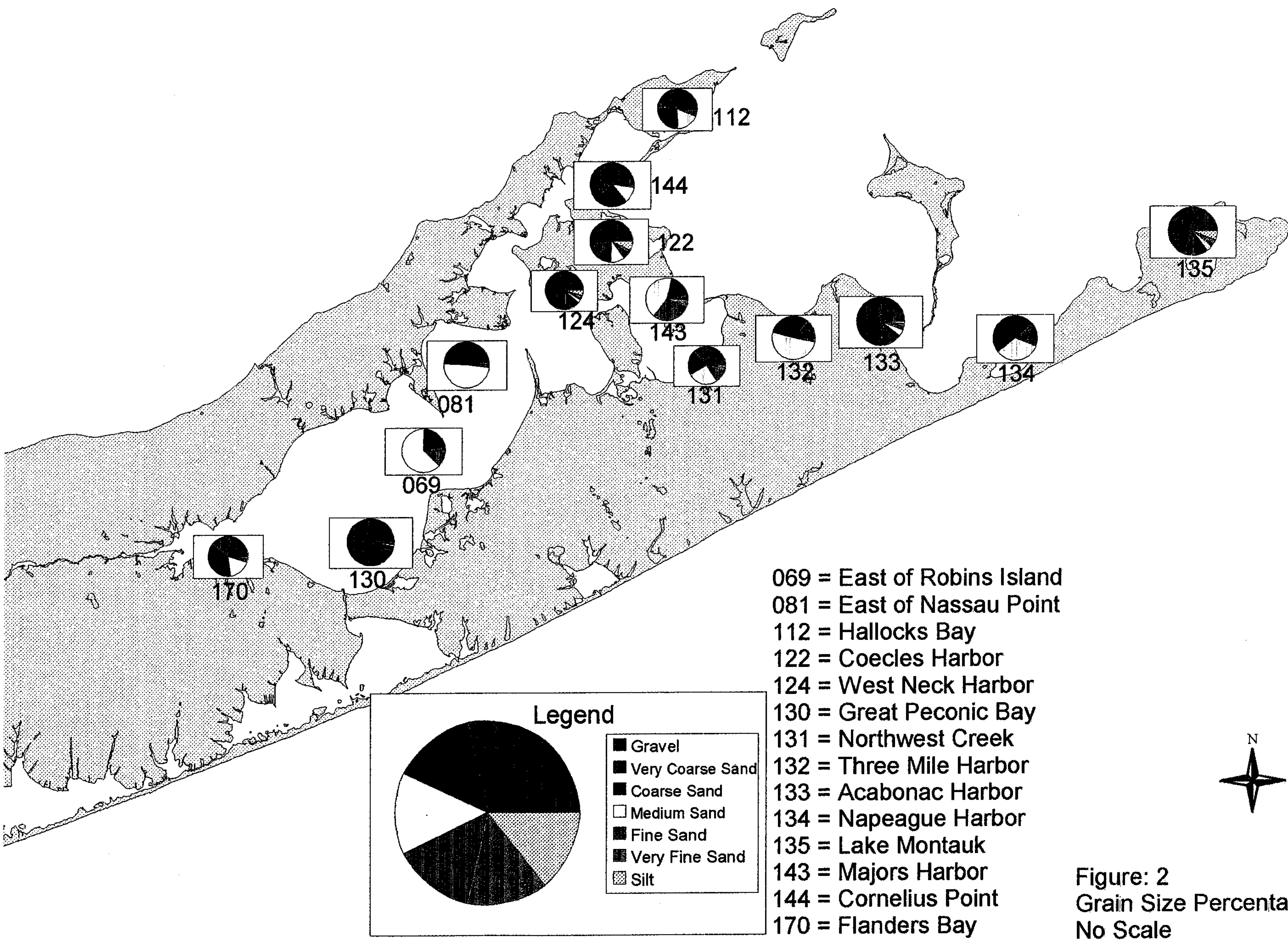
The Eastern Stations monitored with the 3D-ACM include 112, 121, 132, 131, 133, 134, 135, 143, and 144. Additionally, Bass Creek data has been included as additional information as it is so close to the Majors Harbor station (143). All graphs associated with this analysis are located in Appendix E.

5.3.1 Western/Central

Flanders Bay (170)

The hydrographic survey was conducted from August 11-17, 1998 The flow meter was deployed east of the terminus of Bay Harbor Road. Neap tide conditions occurred August 13 through 15 from the third quarter moon appearing on the 14th. A general ebb/flood current pattern exists within the harbor with minor pulsing suspected as wind-derived. Average velocity within the Bay is 2.3 cm/sec with a maximum velocity of 9.55cm/sec during the period of measurement. The average vector for the harbor is 154 degrees northwest. Turbidity noticeably increased during the weekend

Grain Size Percentage Map



069 = East of Robins Island
081 = East of Nassau Point
112 = Hallocks Bay
122 = Coecles Harbor
124 = West Neck Harbor
130 = Great Peconic Bay
131 = Northwest Creek
132 = Three Mile Harbor
133 = Acabonac Harbor
134 = Napeague Harbor
135 = Lake Montauk
143 = Majors Harbor
144 = Cornelius Point
170 = Flanders Bay

Figure: 2
Grain Size Percentage Map
No Scale

EEA, Inc./ ArcView/ March 16, 1999

recreational period. The maximum turbidity reading was approximately 14 FTU. This reading rose steadily form less than 5 FTU with a spike mid-week to approximately 10 FTU until it reached its peak at a little over 14 FTU and then declined to approximately 3 FTU by Monday.

Meetinghouse Creek

Data for Meetinghouse Creek was collected during the Tidal Creek Study and was measured between August 17-18, 1998. The current meter was deployed at the terminus of Harbor Road, along Beach Avenue, northward in the creek. Based upon the results of EEA's current meter deployment and hydrological studies conducted by the Suffolk County Department of Health Services, it becomes apparent that Meetinghouse Creek is receiving fresh water influx from a large drainage area. This was confirmed by low salinity readings collected during various surveys. Given the larger size and narrow corridor associated with Meetinghouse Creek, the likelihood of wind influences is lessened within the creek. Based on the data collected, the typical tidal regime consists of two floods and two ebbs over a twenty-four-hour period. The average velocity was recorded as 4.34 cm/sec, with a maximum of 12.2 cm/sec. The average vector of the current was determined to be 90.8 degrees, east southeast. The hydrographic survey ended 3 days prior to the new moon.

Great Peconic Bay (130)

The hydrographic survey was conducted from August 18-24, 1998. The current meter was deployed west of the terminus of Hampton Place. The new moon appeared on August 21st causing spring tide conditions from the 20th through the 22nd. A general ebb/flood current pattern exists within the harbor with minor pulsing suspected as wind-derived. The average velocity for Peconic Bay was 4 cm/sec with a maximum velocity of 21.9 cm/sec. The average vector was 172 degrees northwest during the period of measurement. Turbidity data indicate a moderate increase during the weekend recreational period within Great Peconic Bay. Turbidity measurements rose from, a low of 0.0 FTU to a high of 25 FTU.

West Neck Harbor (124)

The hydrographic survey was conducted from August 4-10, 1998. The flow meter was deployed approximately half way down the Peninsula of Shell Beach. There was a full moon event (Spring Tide) on August 8, 1998. This was responsible for spring tide conditions to exist within the harbor from August 6-8, 1998. A general ebb/flood current pattern exists within the harbor with minor pulsing suspected as wind-derived. Average velocity within the harbor is 6.4 cm/sec with a maximum velocity of 12 cm/sec during the period of measurement. The average vector for the harbor is 35 degrees northeast. Turbidity noticeably increased during the weekend recreational period. The maximum turbidity reading was approximately 25 FTU. This reading rose steadily form less than 5 FTU with a spike mid-week to approximately 18 FTU until it reached its peak at

25 FTU and then declined to approximately 7 FTU by Monday. Average velocity within the harbor was 6.4 cm/sec with a maximum velocity of 12 cm/sec during the period of measurement. The average vector for the harbor was 35 degrees northeast. Turbidity noticeably increased during the weekend recreational period.

West Neck Creek

The current meter was deployed at the terminus of Montclair Avenue. The results of the hydrographic survey conducted by EEA show that a clear ebb/flood current pattern exists at the mouth of West Creek. The average velocity of the current was 3.67 cm/sec, with a maximum of 7.4 cm/sec. The average direction was 305.5 degrees, west north-west. Turbidity for Sunday August 3 was considerably higher and peaked at approximately 5.5 FTU and decreased steadily to 0.0 FTU by Monday morning.

5.3.2 Eastern

Hallocks Bay (112)

The hydrographic survey was conducted from March 27 through April 2, 1998. The current meter was deployed at the mouth of Little Bay tributary in Orient Point State Park. The typical tidal regime consists of two floods and two ebbs over a twenty-four hour period. Spring tides occurred during the period of March 27 - 28 due to the new moon on the 27th. Neap tide conditions occurred on April 2nd due to the upcoming first quarter moon on the 3rd. The average velocity was 19.7 cm/sec. For the period of measurement with a maximum velocity of 50.1 cm/sec., Hallocks Bay rated second highest for average velocity for all stations measured under this Program. The average vector was 179 degrees west. No turbidity measurements were taken.

Cornelius Point (144)

The hydrographic survey was conducted from July 28 - August 3, 1998. The flow meter was deployed at the terminus of Menhadden Lane, northward along the shoreline near the southern tip of the point. Neap tides occurred during the period of July 30-August 1, 1998 due to the appearance of the first quarter moon on the 31st. The data reveal that a clear ebb/flood current pattern exists. The average velocity was 6.72 cm/sec. for the period of measurement with a maximum velocity of 24 cm/sec. The average vector was 82 degrees northeast. Turbidity measurements increased by pulsing from approximately 3 FTU to a high of 25 FTU until the weekend. The turbidity then slowly rose from approximately 3 FTU to a high of 25 FTU with slower pulsing events (from high and low peaks) until it declined to 0.0 FTU.

Coecles Harbor (122)

The hydrographic survey was conducted from July 21 - July 27, 1998. The flow meter was deployed at the terminus of Hudson Avenue. Spring tides occurred during the period of July 22-24, 1998 due to the appearance of the new moon on the 23rd. A general ebb/flood current pattern existed within the harbor with minor pulsing suspected as wind-derived. The average velocity was 3.88 cm/sec. for the period of measurement with a maximum velocity of 6.65 cm/sec. The average vector was 304 degrees southeast. Turbidity measurements increased by pulsing steadily from approximately 4 FTU to a high of 16 FTU as the new moon approached.

Bass Creek

The hydrographic survey was conducted from July 27 - July 28, 1998. The flow meter was deployed at the mouth of the tidal creek near the footbridge in Mashomack Preserve. The typical tidal regime consisted of two floods and two ebbs over a twenty-four hour period. The average velocity was 22.2 cm/sec. for the period of measurement with a maximum velocity of 51.9 cm/sec. The average vector was 123 degrees northwest. Turbidity measurements remained on average at approximately 5 FTU with a few spikes around 10 FTU and one spike near 20 FTU over the 24-hour period of measurement. Given the circular and somewhat irregular shape of the main body of the creek, it is likely that current patterns might not be as clearly defined, and are probably both wind and tidally derived.

Three-Mile Harbor (132)

The hydrographic survey was conducted from August 29 - September 30, 1997. The flow meter was deployed across from the intersection of Three-Mile Harbor Road and Discovery Lane. Spring tides occurred during the periods of August 31-September 2, September 15-17, and again on September 30th. New moons occurred on September 1st and 30th. Full moon occurred on September 16th. Neap tides occurred during the periods of September 8th-10th due to the first quarter moon appearance on the 9th and again during the period of the 22nd - 24th due to the appearance of the third quarter moon on the 23rd. A general ebb/flood current pattern existed within the harbor with minor pulsing suspected as wind-derived. The average velocity was 2.09 cm/sec. for the period of measurement with a maximum velocity of 10.2 cm/sec. The average vector was 123 degrees northeast. No turbidity measurements were taken.

Accabonac Harbor (133)

The hydrographic survey was conducted from September 2 - 9, 1998. The flow meter was deployed at the terminus of Gerard Avenue. Spring tides occurred during the period of September 5th - 7th, 1998 due to the appearance of the full moon on the 6th. A general ebb/flood current pattern existed within the harbor with minor pulsing suspected as wind-derived. The average velocity was

16.1 cm/sec. for the period of measurement with a maximum velocity of 59 cm/sec. Accabonac Harbor ranked as 3rd highest for average velocity readings during this study (when Bass Creek is included). Turbidity measurements indicated daily pulsing from lows of 0.0 FTU to highs of 25 FTU.

Northwest Creek

The flow meter was deployed at the terminus of Northwest Landing Road. Based on the results of the hydrographic survey, as well as regular observations conducted by EEA and numerous tidal studies conducted by the East Hampton Town Natural Resources Department, the tidal cycle was relatively normal with two ebb tides and two flood tides in a twenty-four hour period. The tidal height in North West Creek on average was approximately one-meter above mean low water. This is reported by the computer program "Tides and Currents for Windows 1995" and confirmed by field sampling conducted by EHTNRD.

The current pattern within the creek appear to be variable, possibly more influenced by the wind direction than a predictable ebb and flood current pattern. The average direction of the current was recorded as 130 degrees, east south-east. Velocities within the creek were fairly weak with a maximum velocity of 9.9 cm/sec. The average velocity was 2.42 cm/sec. As expected, velocities dropped out to near zero on the slack water. The hydrographic survey was studied from a first quarter moon to a full moon.

Northwest Harbor

EEA, Inc. monitored this station for three days to obtain baseline data for an area immediately outside the creek that supports healthy eelgrass beds. This station was monitored from September 16th through the 18th, 1998. The flow meter was deployed at the terminus of Mile Hill Road, approximately 30 feet into the harbor. A general ebb/flood current pattern existed within the harbor with minor pulsing suspected as wind-derived. The average velocity was 2.3 cm/sec. for the period of measurement with a maximum velocity of 5.1 cm/sec. Turbidity measurements remained fairly constant at approximately 2.14 FTU with one spike to 24.8 FTU.

Napeague Harbor (134)

The hydrographic survey was conducted once in 1997 from August 12th through August 29th and again in 1998 from September 18th through September 29th. The flow meter was deployed on the eastern portion of the harbor at the 1997 eelgrass harvest location and the 1998 eelgrass transplant location. A general ebb/flood current pattern existed within the harbor with minor pulsing suspected as wind-derived. The average velocity was 4.4 cm/sec. for the two periods of measurement with a maximum velocity of 47 cm/sec reached in 1997. The average vector was 162 degrees northwest. Turbidity measurements averaged 4.4 FTU with a maximum of 25 FTU.

Lake Montauk (135)

The hydrographic survey was conducted August 26th through September 2nd, 1998. The flow meter was deployed from East Lake Drive, south of Montauk Airport and north of Little Reed Pond. A general ebb/flood current pattern existed within the harbor with minor pulsing suspected as wind-derived. The average velocity was 3.57 cm/sec. for the period of measurement with a maximum velocity of 17.7 cm/sec. The average vector was 265 degrees southwest. Turbidity measurements progressively increased as both neap tide and weekend recreational conditions approached. They steadily rose from less than 5 FTU to a maximum of 25 FTU with evidence of pulsing periods.

5.4 Wind Trend

The main hypothesis for conducting a wind analysis was to determine if wind velocity and/or vector have changed significantly over the past thirty years. If an increase had occurred, turbulence could be expected to elevate the total suspended solids locally, thus decreasing the amount of light available for eelgrass growth.

Wind velocity and vector (direction) data were obtained from Brookhaven National Laboratory (BNL) from 1960 through 1993, except for 1966 where no data were provided from BNL. BNL provide twice-daily weather forecasts. A suite of meteorological measurements are maintained on exposed towers and monitored in real time. The measurements are suitable for accurate real-time and historical assessments of weather and atmospheric advection and dispersion. Although this report includes analysis for a 33 year period, BNL maintains data from 1949 to provide a climatological history of the local area.

6.0 Eelgrass Transplantation and Monitoring Program

Eelgrass test plots were conducted by EHTNRD, CCE and EEA, Inc. as in-kind services for this project. Spring harvest and transplantation of eelgrass was conducted in Napeague Harbor for both 1997 and 1998. Fall harvest and transplantation were conducted by CCE at Cedar Beach Point and Cutchogue Harbor in 1997.

6.1 Napeague Harbor (1997)

The first eelgrass harvest was conducted on June 26, 1997 along the eastern shoreline of Napeague Harbor. EHTNRD and CCE selected the donor bed location. Harvesting and transplantation techniques were modeled after Fonseca, (1982). Eelgrass was harvested as sods using a rounded, long-handled spade. Sods were removed at approximately one-meter and 1.6 meter on center from the central portion of the existing bed. Physical chemistry measurements for water quality were collected and two sediment samples were collected for grain size and total organic carbon content.

Eelgrass plugs were washed and bundled, containing three to four eelgrass shoots per bundle and then wrapped with paper and biodegradable twist ties to 15-centimeter (cm) metal staples to create a planting unit. Planting units and sods were separated and set one-meter below the water surface (mean low water) in fruit baskets, polypropylene trays, and bread trays until transported to the transplantation location. Sods remained covered in wet burlap and were out of the water for no longer than ten minute intervals. Harvested planting units were placed in cold water coolers to prevent them from shock and dessication during transportation. Prior to transplantation, the new location was delineated by four flagged steel posts marked with buoys. The transplantation site was approximately 3.3 square meters.

Transplantation occurred during the first two hours of the flood tide. EHTNRD and CCE provided a diving team. Each diver was aided by an assistant. Planting units were placed in the diagonal corners of the new bed. Fifty planting units were planted in a northwesterly position and 43 planting units were placed in a southeasterly position. Eelgrass planting units were installed 30-cm on center. Eelgrass sods ranged from 10 to 15-cm in diameter and were placed at the remaining diagonal corners of the test plot area. Smaller sods (11 pieces) were planted 30-cm on center

6.2 Cutchogue Harbor and Cedar Beach (1997)

CCE harvested sods in November 1997 from a donor site in Southold Bay. These sods were quickly transplanted in an area of Cutchogue Harbor and at Cedar Beach Point near the CCE Marine Laboratory. This occurred during the morning hours at the onset of a northeaster storm. This attempt was made in good faith by CCE to try and complete a fall transplant for 1997.

6.3 Napeague Harbor (1998)

Prior to the 1998 season for transplantation, many discussions between CCE, EHTNRD and EEA were held to improve a previously failed attempt to transplant eelgrass in Napeague Harbor. EHTNRD, in conjunction with Sandy Wyllie-Echeverria, proposed to plant within a fairly healthy bed, but one that had areas impacted due to clamming activities or storm erosion. A new way of marking the site and each transplant location was devised to enhance the monitoring program for that year and future years to follow.

Harvesting and transplantation took place on two dates, May 19 and June 4, 1998. The eelgrass bed located along the eastern portion of Napeague Harbor was used as both a donor and a restoration area (Figure 3). This bed was chosen because it was in good health and it had random patchy holes throughout the bed.

Eight plots were marked for restoration; four within these patchy holes inside the main eelgrass bed and four immediately adjoining the existing eelgrass bed along the outer edge. These areas were all marked with 30-cm PVC and buoys held in place by cement blocks.

Eelgrass Harvest & Transplantation Location Map

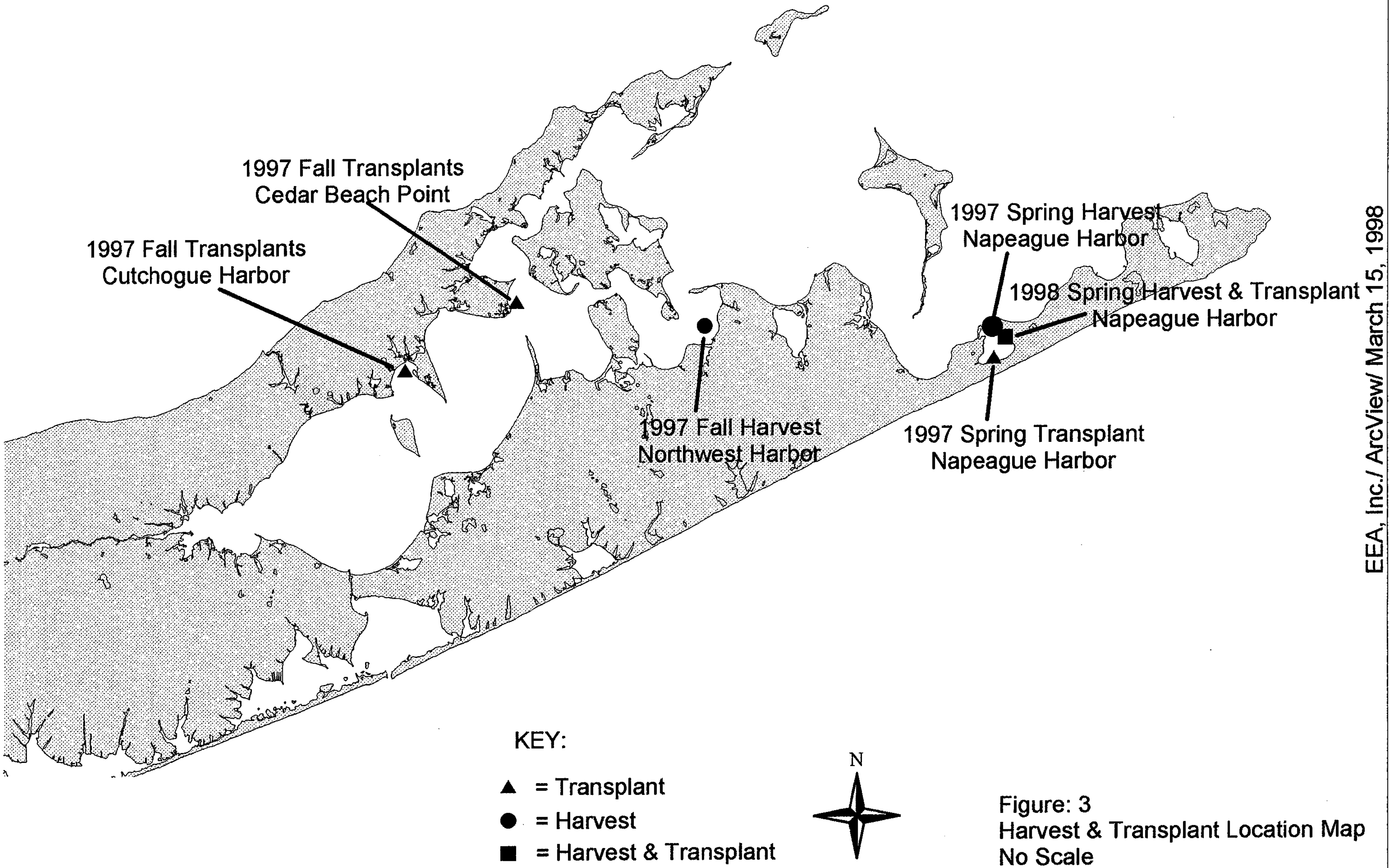


Figure: 3
Harvest & Transplant Location Map
No Scale

A .25 meter square quadrat was constructed from PVC piping. This was used to guide the placement of transplants at each of the eight locations. A 30-cm PVC pipe was placed in the center of the square and labeled P-1 through P-8 (Figure 4). Each square would be planted with four planting units at each of the four corners of the square while aligned along a north-south axis. Each square would contain 1/2 of the eelgrass harvested from within the bed and 1/2 of the eelgrass harvested from the outer edge. The planting units from within the bed were transplanted on the landward side of each square and the leading edge planting units were placed along the seaward edge. This was designed so that we could compare whether transplantation success is limited by transplanting outer edge plants or inner bed plants.

Eelgrass was harvested using a 20-cm coring device to dig each sod the same size. A diver identified where the coring tool should be placed. An assistant twisted the coring tool into the substrate while the diver guided the tool so that each sod were cut cleanly through rhizomes and substrate. The diver worked his/her hands under the sod carefully so as not to damage the rhizomes and pull the sod free. Sods were then placed into a holding tray under water and carried to the transplant location. The same coring tool was used to create the holes for sod transplantation. Four of the eight sites were completed on May 19, 1998 and the remaining four were completed on June 4, 1998.

The harvest locations were staked with PVC piping buoyed to a cement block for future monitoring of the bare holes.

6.4 Eelgrass Monitoring Program

This task was mostly conducted by EHTNRD as an in-kind service. Monitoring consisted of trying to locate the transplanted bed and determine whether the eelgrass blades looked healthy, whether wasting disease was suspected, whether grazing had occurred or whether the eelgrass was dying or had died off.

By 1998, the monitoring program had become better developed because the goals for transplantation were defined more clearly. The objective was to observe each of the eight transplant locations to determine the general health of the plants using a relative scale of good, poor or excellent. Additional observations regarding die back, wildlife utilization, and epiphytic growth were also noted. Each monitoring event included an underwater photograph and a measurement of water temperature. Due to initial technical problems with the underwater camera and turbidity in Napeague Harbor, most pictures were not helpful for the analytical portion of this study.

6.4.1 Napeague Harbor (1997)

Monitoring began within two week of the initial transplant. On July 29, 1997, EHTNRD noticed that some of the blades on both sods and planting units were turning black. Coincidentally, within

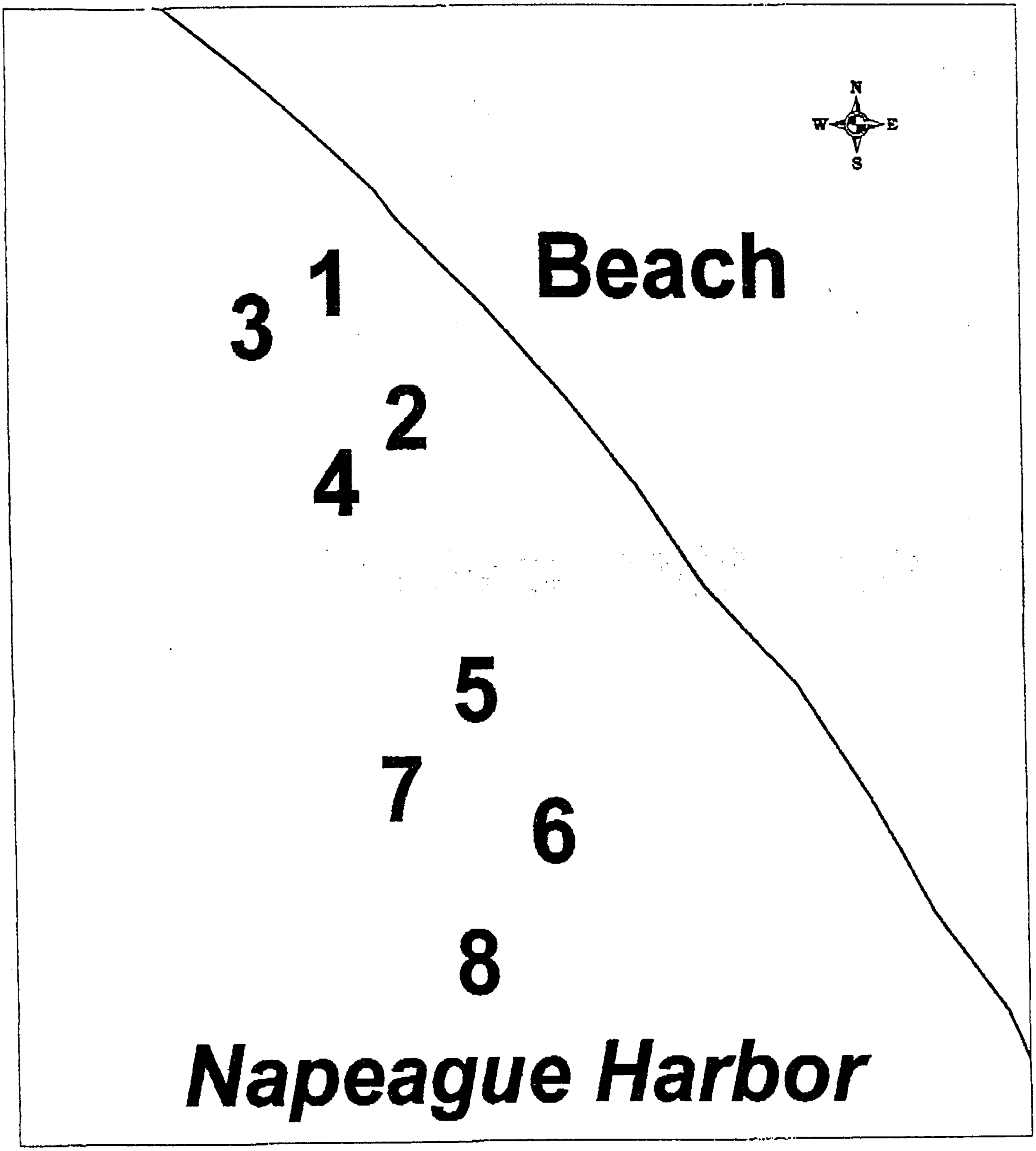


Figure 4

* - Map not to scale

Napeague Harbor
1998 Transplantation
Index Map

the time frame from transplantation to this monitoring event, the water temperature rose above the 20 degree Celsius mark in Napeague Harbor. By the following week, all transplants had died off.

6.4.2 Cedar Beach & Cutchogue Harbor (1997)

CCE monitored the Cedar Beach transplant location for eight months. Although initially the transplants remained viable through the winter and spring, by July of 1998 nearly all sods had died off. No further monitoring was conducted by CCE.

There has never been any follow-up monitoring conducted at the Cutchogue Harbor transplant location by CCE. The conditions of those transplants within Cutchogue Harbor are presently unknown. It is presumed that due to the conditions in which they were transplanted and the observations made at Cedar Beach Point, that the likelihood for survival is minimal.

6.4.3 Napeague Harbor (1998)

On June 4, 1998, the four transplant locations previously planted on May 19th were observed. All planting units appeared extremely healthy, and were rated as "excellent", except for two outer units within plot 4. The stressed units appeared to be dying back because there were not as many shoots present as when it had been planted. Water temperature was not measured.

All eight plots were monitored again on June 24, 1998. Plots 1,2,5,6,7, and 8 were all rated as "excellent". The northwest planting unit in plot 3 appeared as "good" on our scale. Plot 3 was noticeably thinner than when initially planted. Additionally, there were signs of scallop rakes within the vicinity of the transplanted area around Plot 4. Plants within Plot 4 did not appear stressed or damaged. Water temperature measured 18.7 degrees Celsius.

On July 14,1998, Plots 2, 3, 4, 7, and 8 were rated as "excellent" with thick growth continuing. Plot 1 appeared thinner than the previous monitoring event. Plots 5 and 6 appeared to show some brown and yellow shoots. Water temperature was not recorded.

On August 20, and October 29,1998, Plots 1, 2, 4, 6, 7, and 8 were still rated as "excellent". Notable was the northwest planting unit in Plot 3, which was a little thin, but still appeared healthy. Therefore, the Plot received a rating of "excellent" . Plot 5 was rated as "good" because the northwest planting unit appeared severely stressed. There was an abundance of epiphytic growth covering all plots, as well as the natural eelgrass beds. The presence of epiphytes did not appear to have a negative impact to the transplanted bed or natural bed. Water temperature was recorded at 24.8 degrees Celsius on August 20, 1998.

7.0 DISCUSSION

7.1 Water Quality

Salinity

The Western/Central portion of the estuary is less saline then the eastern portion of the estuary on average by approximately 3 ppt. The Peconic River empties into Flanders Bay in the western portion of the estuary creating the lateral salinity gradient observed.

Temperature

Temperature increases only marginally from east to west within the estuary. As the heat content is derived mainly from solar radiation, these waters are directly heated *in situ* as they occupy the estuary basin. The temperature of the estuary is a primary function of the temperature of the entering tidal creeks and the ocean water combined with various tidal stages. As seen in the analysis by Tetra Tech, Inc (1998) a density stratification exists only in Flanders Bay where the mouth of the Peconic River delivers fresh, less dense water over the more dense salt water.

Dissolved Oxygen

In salt water, the solubility of oxygen decreases as water temperature and salinity increases where water temperature is the most important factor in determining oxygen solubility. Less oxygen can be dissolved in seawater than in fresh water. Dissolved oxygen was studied by both SCDHS and EEA, Inc.(1998). Overall, the main bays and monitored embayments generally have excellent water quality with respect to DO. Dissolved oxygen characteristically varies diurnally and seasonally as was observed in the Peconic Estuary. The ranges of such variations differ, depending upon the nature of the freshwater sources, the morphology of the estuary, and effects from tides.

Surface water DO in the Peconic Estuary tends to be slightly lower in the western portion of the estuary when compared to the eastern portion. Tetra Tech, Inc. (1998) reported periods of low DO and high chlorophyll-a concentrations in Peconic River and Flanders Bay during summer periods. They noted that there is a recurring phenomenon of summer phytoplankton algal blooms commencing in June and ending in August. These algal blooms and chlorophyll-a concentrations have been observed to occur in especially large magnitudes during brown tide years. As the algae in the water column settles to the bottom it is deposited as organic matter and decays within the bottom sediments. During the natural processes of sediment flux, oxygen demand increases in the western portion of the estuary resulting in lowered DO concentrations. The oxygen-depleted bottom water layer enhances sediment nutrient release, especially ammonia. This nutrient release facilitates the cycle of benthic release, algal production, and oxygen consumption until water temperature decreases enough to halt this cycle.

For all stations monitored, DO standards are higher than those set for the CBS, 2-meter Restoration Criteria value of <10, and the LISS Restoration Criteria value of <5.5. Worst case summer average for all stations was 7.05 mg/l. (97/98).

Chlorophyll-a

In general, the average chlorophyll-a level for all stations combined over the study was 3.29 μg/l which falls below the standard of 5.5 μg/l established for Long Island Sound, and is also below the 15.0μg/l standard established for Chesapeake Bay. The vast majority of the incidents of elevated chlorophyll-a levels (> 5.5 μg/l) occurred during the winter season (December through March) and presumably did not impact the eelgrass during the growing season. SCDHS (1998) established a threshold for chlorophyll-a of approximately 7.0 μg/l in non-Brown Tide years and 12.5 μg/l in Brown-Tide years. 1997 and 1998 were both considered non-Brown Tide years. The mean for chlorophyll-a concentrations fell well below this rough threshold value of 7.0 μg/l.

Comparatively, EEA, Inc. conducted a nutrient sampling program in Jamaica Bay, New York during 1995-96 as part of the Jamaica Bay Eutrophication Study (in progress) conducted by the New York City Department of Environmental Protection (NYCDEP). Chlorophyll-a levels in Jamaica Bay, a nutrient rich system, averaged 31.99 μg/l for the study period. Chlorophyll-a levels peaked in March and April, reaching 105.59 μg/l. It is believed that the spring bloom is the result of the spring runoff which provides an influx of nutrients, primarily NO_3 (Gilbert, 1995). It should be noted that the amount of chlorophyll-a increases in response to the addition of growth limiting nutrients, such as NO_3 , NH_4, and PO_4. Long-term trends in chlorophyll-a abundances, provided by the Suffolk County Department of Health Services (1977-97), show a decreasing trend in chlorophyll-a levels.

Dissolved Inorganic Nitrogen (DIN)

Nitrogen occurs in the biosphere in a variety of forms ranging in oxidation state from +5 to -3. Inorganic nitrogen is present primarily as highly oxidized nitrite and nitrate, as reduced ammonia, and as molecular nitrogen. In the nitrogen cycle, except for the ammonia exchange with sediments, all reactions are biologically mediated. By far the greatest influx of inorganic nitrogen into organisms results from ammonia and nitrate assimilation. These reactions predominate in surface waters.

Organisms using nitrite as their nitrogen source must reduce it to ammonia before incorporating it into organic forms, and this process requires a reduction system including the enzyme nitrate reductase. This inducible enzyme is present in algal cells only when nitrate is being used as the nitrogen source, which suggests a mechanism for determining the form of nitrogen an algal population is using. The reverse of assimilation is ammonification, whereby organic nitrogen is returned to the inorganic nitrogen pool as ammonia.

Tetra Tech, Inc. (1998) found that in the peripheral embayments of the estuary and in the six main bays, nitrogen is more of a limiting factor than phosphorous, typical for estuaries and coastal waters. Tetra Tech Inc., relates seasonal factors where nitrogen-rich runoff is pushed downstream from the Peconic River headwaters and comprise a large fraction of the surface water.

The arithmetic mean for all stations observed in 1997 and 1998, regarding DIN is 0.02 mg/l. There are no lateral changes in concentration observed form east to west within the estuary, nor are there any differences between the growing season and the summer season. When compared to the CBS and LISS recommended value of <0.15, the Peconic Estuary concentrations fall well below the recommended criteria. These low values likely indicate that the level of inorganic nitrogen is probably contributed by atmospheric conditions and that surface runoff or groundwater intrusion are playing a minor role. Nitrogen levels from rainfall are highly variable and typically nitrate and ammonia occur in significant amounts in areas such as New York with temperate climates (Hutchinson, 1957).

Orthophosphate (DIP)

Orthophosphate levels were uniformly low throughout the Peconic Estuary. The four stations with the highest average orthophosphate levels were 143 (Majors Harbor), 144 (Cornelius Point), 112 (Hallocks Bay), both from Shelter Island, and Station 135 (Lake Montauk). All had eelgrass beds as reported by Cashin (1996). Conversely, Station 134 (Napeague Harbor) with one of the lowest orthophosphate levels, also had a well established eelgrass community.

Orthophosphate can be precipitated or absorbed by elements such as aluminum and iron. Additionally, in alkaline soils, orthophosphate may react with calcium carbonate to form a relatively insoluble hydroxapatite.

Based on observations in the field, it would appear that at least some of the sediment in Napeague Harbor contains a fair amount of iron, based on rusty-staining observed. No samples were analyzed to support this assumption. If true, this may, in part, explain the slightly lower levels of orthophosphate from that station.

There does not appear to be a clear link between orthophosphate levels and eelgrass establishment in the Peconic Estuary, but it is clear from the literature review that relatively elevated levels do not hinder the development of eelgrass.

Total Suspended Solids

Due to the limited available data provided, the analysis for TSS should be considered with caution. From the data analyzed, levels generally fall below 15 mg/l established for Chesapeake Bay and below the 30 mg/l level established for Long Island Sound and Connecticut. An intensive TSS sampling program should be coupled with a light attenuation sampling program for both the eelgrass growing and summer seasons. This will allow for the establishment of baseline data where known eelgrass beds are relatively thick, stressed and absent from the estuary.

Light Attenuation

Table 1 (Section 5.1) indicates the variability throughout the estuary regarding light extinction for the eelgrass growing season vs. summer season when stress from local environmental factors is greatest. In general, the coefficient for calculating Kd may need some revision based on the differences obtained when compared to calculations based on Lambert's Law. In general, the western/central portion of the estuary exceeds the CBS criteria value of 0.8 for Kd and LISS criteria value of 0.7. The eastern portion of the estuary fell within the range of 0.6 and 0.7 for both the growing and summer seasons for two-meter Habitat Restoration requirements.

This analysis is intended to provide baseline conditions for further studies to refine Habitat Criteria for light attenuation within the estuary and should not be considered an exhaustive statistical analysis. Although the eastern portion of the estuary falls within the acceptable range for eelgrass establishment for a two-meter Habitat Restoration, the western/central portion of the estuary is marginal for a one-meter restorations based on the literature. It should be noted that water quality criteria may further be refined in the future, and that water quality criteria for the Peconic Estuary may still need to be better than the existing conditions.

TKN

Total Kjeldahl Nitrogen is analyzed separately from ammonia nitrogen in order to determine the concentration of organic nitrogen within the system. Organic nitrogen is determined by calculating the difference between ammonia nitrogen and TKN.

The levels of TKN observed in the Peconic Estuary are lower than those described earlier that EEA, Inc. had observed in the East River system. A study conducted by EEA, Inc. during 1989-90 field season indicated an average TKN value of 1.6 ppm in the East River, nearly three times higher than those observed throughout the Peconics. Additionally, the occurrence of elevated levels of chlorophyll coincided with peaks of TKN. This is expected as organic nitrogen is a primary nutrient source for photosynthetic plants. As expected, eelgrass is absent from the East River system.

In general, the levels of TKN in the Peconic Estuary were very consistent, ranging from a maximum of 0.63 ppm at Station 240 (Peconic River) to a minimum of 0.40 ppm at Station 144 (Cornelius Point). These observations indicate a spatial decrease in TKN concentrations progressing from west to east in the Peconic Estuary.

Total Coliform

In general, the levels of coliforms are extremely low throughout the Peconic Estuary. Incidences of spikes and elevated levels are chiefly due to localized impacts and are not widespread through the Estuary. The high levels of coliforms from Northwest Creek were confirmed by the NYSDEC (1998). The Bureau of Marine Resources Shell Fisheries reported levels as high as 2,501 mg/l in Northwest Creek. This, in part, was attributed to several leaching septic systems known to be situated in the water table adjacent to creek waters.

The somewhat elevated coliform levels at Station 240 (the mouth of the Peconic River) are expected as the Town of Riverhead Sewage Treatment facility discharges directly into the Peconic River. Additionally, the Peconic River passes through several towns and farm country before reaching Flanders Bay bringing supplementary nutrients with it. Total coliform levels immediate drop to 16.7 mg/l at the Flanders Bay station and continue to drop further to 2.3 mg/l in Great Peconic Bay. These observations lead us to infer that effluent from the Peconic River produce localized events that are not observed to travel throughout the entire estuary. Overall, it does not appear that coliforms contribute significantly to the nutrient loading of the Peconic Estuary.

Urea

Urea is a nitrogen-containing waste product generally associated with animals, in particular cattle and feed lots. This nitrogen is readily utilized by plants. Elevated concentrations of urea were observed at both Station 122 and 135. Although this type of land use does not exist within the confines of the estuary, both areas are heavily utilized by private and recreational commercial fishing vessels. Therefore, the possibility exists that illegal discharge of sanitary holding tanks may be causing these localized events. According to observations made by both EEA, Inc. and Cashin Associates, the persistence of eelgrass beds within Lake Montauk does not appear to be impacted. The Cashin (1996) SAV report documents the presence of dense eelgrass beds in the vicinity of Station 135 in Lake Montauk. During the deployment of the 3D-ACM flow meter, EEA, Inc. staff observed dense eelgrass beds in the same area. Conversely, Cashin Associates (1996) documented the absence of eelgrass beds within Coecles Harbor, and more specifically at Station 122. The presence of urea is uniformly low throughout the rest of the Peconic Estuary.

NO_2 +NO_3 (No_x)

Levels of NOX throughout the Peconic Estuary are extremely low, falling well below the standard of one ppm for nitrite and 10 ppm for nitrate established by NYSDEC for Class SA waters.

No discernable pattern is evident in the 1997-1998 data between NOX levels at each of the 14 stations. Additionally, the presence or absence of eelgrass does not correlate with NOX levels. The highest level of NOX was 0.078 ppm at Lake Montauk which has a well established population of eelgrass. Additionally, Station 112 (Hallocks Bay) and Station 144 (Cornelius Point) exhibit some of the lowest measured levels of NOX, and support eelgrass populations. Conversely, Station 132 (Three-Mile Harbor) has high concentrations of NOX, and Station 131 (Northwest Creek) has low concentrations of NOX, yet neither support any eelgrass populations. Therefore, NOX alone does not appear to have any bearing on whether eelgrass is present or absent from a given location.

Silicate

Silicon ranks next to oxygen in abundance in the earth's crust. Silicate can be found in natural water bodies at levels from 1 to 30 ppm and can be found in concentrations as high as 100 ppm. Although it is subject for debate, some proof exists that silicate controls the magnitude of diatom production during the spring bloom and causes the collapse as well (Conely and Maline, 1992). It is a constituent of the diatom cell wall, some radiolarians skeletons, and some sponge spicules.

With the exception of a few elevated levels reported from Stations 122, 170, and 240 that are well within the naturally occurring range for silicate, the silicate concentrations throughout the Peconic Estuary are extremely low. Although no eelgrass is present at the stations with the relatively high silicate levels, eelgrass is also not present at all stations with relatively low silicate levels.

Additionally, there does not appear to be a correlation between elevated silicate readings and elevated levels of chlorophyll-a. Although both silicate and chlorophyll-a levels are both consistently high at Station 240 at the mouth of the Peconic River, it does not carry over throughout the entire estuary.

7.2 Substrate Quality

TOC

TOC in the substrate appears to be extremely variable, fluctuating greatly between stations and from month to month, with no discernable pattern.

In general, TOC levels were lowest during the May and October sampling periods. The highest occurrences were observed at Accabonac Harbor (June'97), Northwest Creek (July '97), Great Peconic Bay (July '97) and West Neck Harbor (July '97). The trend observed for the months of data collection allows us to infer that between October and May, TOC levels in the substrate remain relatively low (below 5,000 mg/kg). For the sampling period of 1997 and 1998, the TOC concentrations began to rise in June, considerably in East Hampton and noticeably around Shelter Island. By July, TOC levels continued to rise specifically within Northwest Creek, Great Peconic Bay, West Neck Harbor, Cornelius Point and Coecles Harbor. By August and September, most stations revealed a decreasing trend in TOC's with minor localized events of increase.

Prior to this study, it was anticipated that substrate with high TOClues would consist primarily of silts or fine sands that would function to trap and hold organic matter. The two stations with the highest TOC levels are comprised of substrate made up of 75- 80 percent gravel. A closer look at this relationship reveals that not all stations with high percentages of gravel have high TOC levels.

The presence or absence of eelgrass did not correlate with the TOC levels. Of the stations where eelgrass is present. TOC levels ranged from 3,277 to 8,032 ppm, well below and above the average. Stations with similar TOC levels and substrate composition do not support eelgrass populations.

On average, the total organic carbon in the substrate falls below the <3 percent criteria established by the LISS. The result for TOC was 1.25 percent. Some stations did exceed this level. Therefore, it is concluded that substrate TOC does not solely contribute to the Habitat Criteria necessary to support or establish eelgrass populations within the Peconic Estuary.

Grain Size

The substrates of the Peconic Estuary generally consist of gravel, very coarse, and coarse sands. Only four of the stations are dominated by medium sands, and little or no fine sand and silts. These data indicate that in general, the estuary is a relatively high energy system with swift currents capable of scouring and transporting large particle sized substrates. Interestingly, this applies to both the larger open water bays as well as the smaller harbors.

Eelgrass beds are located in substrates that vary from 70 percent gravel to 50 percent coarse sand with a substantial medium sand component. Not all stations with similar grain size structure support eelgrass populations. Therefore, based on this preliminary data, we can propose that eelgrass may establish in substrates with a varied range of particle sizes, mostly of coarse sand and gravel. And, that substrate particle size is unlikely to be the limiting factor for establishment, persistence, and abundance of eelgrass.

7.3 Hydrodynamic Trends

The typical tidal regime consisting of two flood tides and two ebb tides over a twenty-four hour period was clearly defined in the data reviewed for Meetinghouse Creek, West Neck Creek, Hallocks Bay, and Cornelius Point.

Not as clearly defined as the stations above, a general ebb/flood current pattern exists with minor to moderate pulsing suspected as wind-derived for Flanders Bay, Great Peconic Bay, West Neck Harbor, Three-Mile Harbor, Accabonac Harbor, Northwest Creek, Northwest Harbor, Napeague Harbor, and Lake Montauk.

A turbidity sensor was added to the 3D-ACM flow meter in May 1998. Stations monitored prior to that date include Three-Mile Harbor, Hallocks Bay, and Northwest Creek. Therefore, no turbidity data was collected at these stations.

Turbidity trends fall between noticeable increases during holiday and weekend periods from increased recreational water use and noticeable increases due to moon events.

Areas with clearly defined turbidity increases resulting from increased weekend recreational water use include Flanders Bay, Meetinghouse Creek, West Neck Harbor and Lake Montauk. Areas with clearly defined turbidity spikes as neap or spring tide conditions approached include Cornelius Point, Coecles Harbor, Accabonac Harbor and Napeague Harbor.

7.4 Wind Trends

In general, the average wind speed for the entire study period was 2.31 meters/second. The maximum occurred in 1964 at 3.04 meters/second, and the minimum wind velocity occurred during 1989 at 1.79 meters/second. The average vector for the entire study period was 210.31° and was very consistent from year to year, ranging from 201.18° during 1989 to 223.77° in 1976.

The wind vector during 1971 radically differs for all other years (151.13°). Only four months of wind vector (January, July, August, and September) were recorded for 1971 with all being extremely atypical.

Peak wind velocity was reported to occur from November through May with the January through April period accounting for 82 percent of all peaks. March had the single greatest concentration of peak wind velocity.

The period representing the minimum wind velocity was from May through December, with most occurring (70 percent) from June through September. The month of September had the highest occurrence of minimum wind velocity events.

The main hypothesis for conducting a wind analysis was that wind velocity may have increased significantly and that the vector may have changed in such a manner that increased turbulence would elevate the total suspended solids, thus decreasing the amount of light penetration available for photosynthesis of SAV.

The opposite of what was originally expected occurred. Although the wind vector is extremely constant over the 33-year period, the overall wind velocity appears to have decreased. When broken down by decade, wind velocity between the 1960s and 1970s was nearly identical, averaging 2.50 meters/second and 2.47 meters/second, respectively. The most noticeable change occurred between the 1970s and 1980s, when average wind velocity dropped 0.39 meters/second or 15.8 percent. Wind velocity between the 1980s and 1990s were again nearly identical at 2.08 and 2.10 meters/second, respectively. It should be noted that data from the 1990s consisted of only four years (1990 to 1993).

This observation was collaborated (Wilson & Beltrami) who correlated meteorological data with blooms of brown tide (*Aureococcus anophagefferens*). Years with low wind velocity during the spring created favorable growth conditions for the brown tide.

Although some researchers at the time hypothesized that brown tide was responsible for the decline of eelgrass during the 1980s (e.g., Cosper, et al., 1987; Dennison, et al., 1989), by blocking light penetration, no definitive conclusion has been drawn.

A further review of the historical data by Cashin Associates (1996) allows us to conclude that a multitude of factors are more likely to explain the decline rather than a single event.

7.5 Eelgrass Transplantation Program

The Napeague Harbor Harvest and Transplantation Program provides valuable information for future programs within the estuary. The implementation of a Program for sod harvest and sod transplantation as opposed to planting units lacking substrate has proven to be a more successful technique for this geographic area. Additionally, working within a stressed bed as opposed to areas completely lacking eelgrass allows for re-establishment not only in the "gap" areas, but in the harvested areas where new gaps are created.

One of the most interesting observations made during the Monitoring Program is the natural re-colonization that occurred within the harvested areas that left small gaps between adjacent healthy beds. Partial burial of these holes, by natural environmental events, appears to be fundamental for re-colonization. Of the areas monitored, all holes created by harvesting re-colonized with healthy plants by mid to late summer.

Planting outer edge sods within the stressed eelgrass beds appears to have an overall better success rate than planting inner bed sods within the stressed bed. This inference is supported by the die off and stressed condition of the northwest planting units in plots 3 and 5 by late September 1998. This technique should be further monitored and implemented at different harbors within the estuary.

Lastly, the technique used to mark the site and each of the plots to be monitored had much greater success than the technique employed in 1997 whereby stakes and buoys were used. The cement blocks and PVC pipes are much more easily recognized, and when measured with a GPS in the field are quite easily navigated. Conversely, stakes with buoys can easily be removed by vandalists and/or strong current conditions.

8.0 CONCLUSIONS

Water quality data collected specifically for this study was limited, especially for light extinction measurements for the areas supporting thick beds of eelgrass. The areas supporting the densest beds, averaged 0.3 m^{-1} Kd, 3.1 μg/l chlorophyll-a, 0.01mg/l DIP, 0.02 mg/l DIN, and summer DO of 7.1 mg/l. Except for chlorophyll-a, the observed parameters throughout the Peconics fall on average, lower than the estuary averages recommended for the Criteria Requirements for the Chesapeake Bay and the Long Island Sound.

The '97/'98 water data collected in conjunction with this study were compared to water quality data analyzed by SCDHS (1998) for SAV habitat criteria. In general, water quality conditions are suitable for re-establishment of eelgrass at a two-meter depth only in the eastern portion of the estuary. The data for 1994-1996 is quite comparable to the data collected for 1997 and 1998 and there are no monumental variations between water years.

As described in Section 3.0, sand accretion and scour are obvious from aerial photography. In general, sand accretion occurs on the eastern portions of land masses such as peninsulas and islands. Scour occurs mostly on the western portion of these same land masses. EEA, Inc. evaluated the mapping produced by Cashin Associates (1996), which clearly indicates that the thickest eelgrass beds occur in the eastern portion of the estuary and on the eastern portions of these same land masses. EEA, Inc. has correlated our field observations during the Eelgrass Transplant Monitoring Program, with the suspected importance that periodic burial may facilitate re-colonization of eelgrass to the regional picture of shifting sands and probable burial along the eastern sections of these estuarine land masses. This premise should be investigated further, as the original scope of work for this study does not provide for further investigation and analysis of this concept.

Additionally, substrate TOC is fairly low within the estuary. Grain size analysis correlates with previous studies conducted within the estuary and grain size trends already established.

The hydrodynamic data, although rated as baseline, indicates typical tidal and wind-influenced occurrences for an estuary within the main bays, peripheral bays and tidal creeks. The larger bays show significant evidence of wind forces predominating with many diurnal pulses. The peripheral bays and large tidal creeks, depending on size and location, fall between wind-driven and tidally influenced. Most of the small tidal creeks indicate predictable ebb/flood cycles over a 24-hour period.

As there are many variables considered when determining the overall health of a system where eelgrass re-establishment is a primary goal, most variables measured fall within the recommended criteria established for other major estuaries along the east coast. As observed from reviewing many years of data, the Peconic Estuary is a very dynamic system and shows variation and pulsing from year to year.

As observed in the catastrophic events of the 1930's when wasting disease impacted nearly 90% of the eelgrass beds along the eastern coastline of the United States, nearly 35 years passed before modest recovery was observed. Between 35 and 40 years after the initial event, eelgrass had reached thick densities and had become a nuisance to boaters. The Peconic Estuary may, in fact, be in a state of recovery now, and we may not see the desired results by natural recolonization anticipated for another 25 to 30 years. Recovery may be prolonged due to the periodic recurrences of brown tide which disrupts the balance of the ecosystem. Continued observations and measurements of water and sediment quality will provide invaluable data over the next several decades.

EEA, Inc. also conducted a brief overview of historical eelgrass bed locations within the estuary through both a literature review and by speaking with local long-term residents and baymen during the sampling program. EEA, Inc. discovered that at certain areas, such as Cornelius Point and Napeague Harbor, the near shore shallow water zone of less than one-meter was historically dominated by eelgrass. Presently, these areas are dominated by *C. fragile* and *Grassilaria sp.*

In other areas such as Northwest Creek and Napeague Harbor where dredging of inlets has reconfigured the entrance and altered the inflow of water, historical eelgrass beds have disappeared.

Zonation shifts and to a lesser extent, future dredging programs should be investigated further. By studying the zonation shifts in the near shallow water environment, productivity and functionality of dominant algal species should be prioritized. These data should be compared with the historical productivity and functionality of eelgrass where enough information already exists.

9.0 RECOMMENDATIONS

9.1 Proposed Eelgrass Habitat Criteria for the Peconic Estuary

EEA, Inc., in conjunction with SCDHS has established baseline conditions within the Peconic Estuary for water and sediment quality. This study was not an exhaustive collection program and did not generate enough data to conduct sound statistical and regression analyses. The information provided should be considered carefully and should not be used as a sole source for overall management decisions within the estuary. Based on the studies conducted to date, we recommend the following Eelgrass Habitat Criteria for the Peconic Estuary (Table 5) expressed as mean summer water quality values. These values are expected to optimize conditions and guide researchers and regulators in identifying potentially successful eelgrass restoration areas within the Peconic Estuary. In the next section (9.2), we also recommend additional studies to be considered in the near future.

Table 5 Proposed Eelgrass Habitat Requirements Within the Peconic Estuary

Parameter	Peconic Estuary (proposed)	Chesapeake (2-meter restoration)	LISS (Draft)	LISS (revised)
Kd (m^{-1})	*0.75 +/- 0.05*	< 0.8	< 1.0	<0.7
DIN (mg/l)	*0.02*	<0.15	< 0.15	< 0.15
DIP (mg/l)	*0.02*	<0.03	<0.02	<0.02
Chlorophyll -a (ug/l)	*5.5 +/-0.5*	<10	<15	<5.5
TSS (mg/l)	**None at this time*	<15	<30	<30
Substrate TOC	** None at this time*	N/A	N/A	< 3%

* Additional data required

9.2 Proposed Additional Studies

EEA, Inc has identified numerous data gaps and additional studies that would provide invaluable insight into the conditions that favor eelgrass establishment and persistence within the estuary. Those studies are identified below.

1. Paired harbor/tidal creek study where eelgrass exists in harbor and is missing from tidal creek. i.e. Northwest Harbor/Northwest Creek; Coecles Harbor/outside of inlet. Intensive monitoring of criteria parameters;
2. Continued water quality collections for established eelgrass stations;
3. Additional TSS and early am chlorophyll - a sampling;
4. Additional substrate TOC sampling;
5. continued hydrodynamic measurements at key locations within the estuary such as those listed fro the paired harbor/creek study in item 1;
6 Laboratory modeling of burial dynamics for seed bank restoration vs. sod restoration under

various manipulated hydrodynamic conditions;

7. New transplantations within existing stressed beds incorporating and possibly modifying established techniques from this study (Hog Creek, Bullhead Bay, Napeague Harbor);
8. Continued monitoring of 1998 transplant at Napeague Harbor;
9. Continued evaluation of historical freshwater input vs. present day freshwater input to the Peconic Estuary system;
10. Intensive sampling/monitoring/restoration program at Bullhead Bay, the only eelgrass bed known west of Shelter Island;
11. Comparative study of Hog Creek vs. Lake Montauk - study of criteria parameters, land use and nitrogen cycling in these areas;
12. If/when results from studies become available for Great South Bay, compare data for both estuaries;
13. Regression analysis once statistical data sets exist for all criteria parameters. Concentrate on relationship between nitrogen and chlorophyl -a, as well as to DO sags.
14. Monitor summer season, bottom bed water temperatures in areas where eelgrass exists in the two-meter zone, macroalgae dominating the one-meter zone for areas where eelgrass historically occurred;
15. Sedimentary transport and burial analysis to determine rate of sand shifting within the estuary and its association with the success or failure at selected eelgrass locations.

These are important considerations for future studies within the estuary and if designed well, should all reveal important information for future management activities. They should provide relative and essential information to reach a practical and successful approach for the re-establishment of eelgrass within the estuary.

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