Town of Southampton Eelgrass and Bay Scallop Restoration Planning Project

C006469 - Planning for Eelgrass and Bay Scallop Restoration in South Shore Estuary Reserve Bays

FINAL REPORT

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Background

Much of Southampton Town's rich maritime heritage stems from the large quantities of fish and shellfish that have been harvested from its bays and nearby waters throughout history. Commercial and recreational harvest of shellfish, including hard and soft clams (*Mercenaria mercenaria, Mya arenaria*), mussels (*Mytilus edulis*) bay scallops (*Argopecten irradians*), and, more recently, razor clams (*Ensis directus*) continue to support the local economy, yet declines in shellfish populations and landings have been reported in recent years (NYSDEC 2008). Declining populations may be the result of overharvesting, pollution, habitat destruction, poor natural recruitment, increased predation, harmful algal blooms (HAB's) and/or climate change, but further research is necessary in order to effectively manage and, where possible, restore these populations (Southampton MRPMP 2001).

Healthy populations of filter feeding bivalves contribute to good water quality by reducing suspended algae, bacteria, and other particulates from the water column. This can help to improve the clarity of the water and potentially helps to prevent harmful algal blooms such as brown tides, which have repeatedly disturbed the SSER (Cerrato et al. 2004). Shellfish also provide a forage base for a multitude of fish and invertebrate species, including commercially valuable species such as the blue-claw crab (*Callinectes sapidus*), whelks (*Busycon carica, Busycotypus canaliculatus*) and the northern puffer*(Sphoeroides maculatus*) (Tettlebach 1986; Carriker 1951; Garcia-Esquivel & Bricelj 1993). Healthy and sustainable populations of shellfish ensure that commercial and recreational harvest will continue, supporting the local economy and these important maritime traditions for future generations.

Figure 1. Aerial view overlooking the channel facing the Coast Guard Station in Shinnecock Bay.

Submerged aquatic vegetation (SAV) provides essential habitat for marine finfish and shellfish and also provides important ecosystem services. Eelgrass (*Zostera marina* L.), our local seagrass, is considered the most ecologically important species of SAV in Southampton waters due to its high habitat value as well as its sediment stabilization and nutrient cycling capabilities (Southampton MRPMP 2001, Hemminga & Duarte 2000). Eelgrass meadows often support more abundant and diverse assemblages of fauna than do unvegetated areas (Orth 1973, Heck et al. 1989, Bostrom and Bonsdorff 1997). The higher value of seagrass when compared to unvegetated bottom or even macroalgae beds relates to structural complexity, persistance and

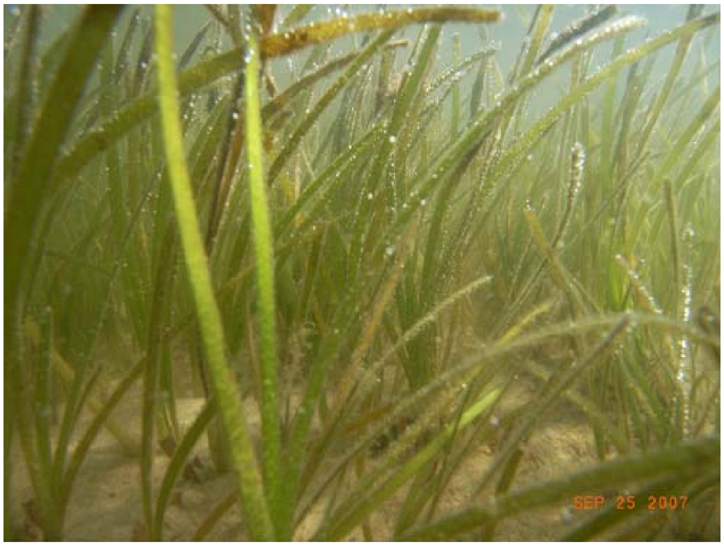

Figure 2. Natural eelgrass meadow in Shinnecock Bay.

ability to provide food and refuge for various life history stages for numerous marine species (Larkum et al. 2006).

Eelgrass and shellfish have a mutually beneficial relationship (i.e., the presence of one favors some life stage of the other). Larvae, including those of clams and scallops, settle into eelgrass meadows due to the dampening effect the eelgrass blades have on water movement (tidal currents and waves), and these bivalves benefit not only from reduced predation pressure but often higher concentrations of particulate food leading to higher growth rates (Peterson et al. 1984, Peterson et al. 2001). The association between bay scallops and eelgrass has been long understood (Belding 1910, Gustell 1930, Thayer and Stewart 1974). For instance, eelgrass is a favored substrate for larval scallop attachment (Eckman 1987) and juvenile scallops that attach (via byssal threads) to the eelgrass canopy can often escape predation (Prescott, 1990, Pohle et al. 1991, Ambrose & Irlandi 1992, Garcia-Esquivel & Bricelj 1993). For this reason, declines in bay scallop populations have been linked to losses of eelgrass habitat (Dennison et al. 1989, Valiela et al. 1992). Filter feeding bivalves living in eelgrass can help bring nutrients from the water column into the sediment, where eelgrass roots can most readily utilize these nutrients. This benthic-pelagic coupling can also help to maintain clear water, minimizing light attenuation, allowing the maximum amount of available light to reach the surface of the eelgrass blades. Both of these factors can lead to increased growth of the seagrass (Peterson & Heck 2001a, 2001b; Reusch et al. 1994).

Figure 3. Local broodstock on spawning table at the Suffolk County Marine Environmental Learning Center in Southold.

Maintaining healthy and sustainable finfish and shellfish populations is a major goal of both the South Shore Estuary Reserve Comprehensive Management Plan (CMP) and Southampton Town's Marine Resources Protection and Management Plan (MRPMP); the need for effective management strategies that avoid over fishing and limit habitat degradation are essential to achieve this goal. The council recommends protecting and restoring high quality SAV habitat in order to support the productivity of commercially and ecologically important species including shellfish. A better understanding of the current status of shellfish populations and SAV habitat as well as the potential for restoration of these important living marine resources will help managers make proper decisions in order to effectively sustain these resources while maintaining maritime-related economic activities. Because of regional variation within the SSER, the council recommends management efforts be region-specific (e.g. watershed).

The Town of Southampton has a long-standing program to improve water quality and natural resources in local waterways, including storm water abatement projects, wetland protection/enhancement/restoration projects, a vessel pump-out program and shellfish re-seeding projects. Continuing with these efforts, the Town sought funding to develop a comprehensive eelgrass and bay scallop restoration plan in order to facilitate future restoration and enhancement efforts in Southampton waters. Funding was attained through the New York State Environmental Protection Fund in cooperation with the NYS Department of State, The Town of Southampton, The Southampton Town Trustees and Suffolk County. Cornell Cooperative Extension of Suffolk County Marine Program was chosen to implement the project, with the aim of addressing local declines in eelgrass and bay scallop populations as well as the development of a comprehensive restoration blueprint for restoring eelgrass and bay scallop populations in Southampton Town waters in the SSER.

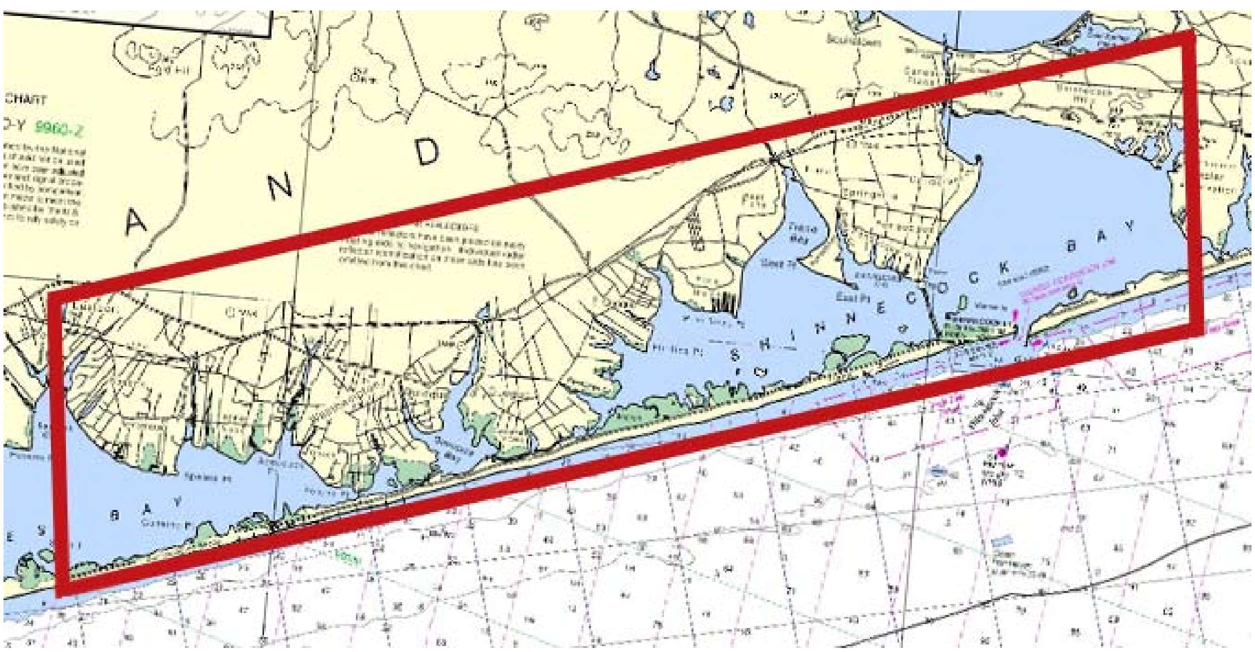

Figure 4. The project area: Southampton Town waters in the South Shore Estuary Reserve.

For over 25 years, Cornell Cooperative Extension's Marine Program has been involved in fishery management as well as educational outreach. CCE staff also has over 15 years experience working with the restoration, monitoring and management of eelgrass. The Suffolk County Marine Environmental Learning Center (SCMELC) in Southold has a fully functional shellfish hatchery and nursery as well as the region's only eelgrass nursery and research facility.

The Project

Objectives:

1. To assess the current condition of extant eelgrass meadows throughout Town waters (in the SSER) using standard monitoring protocols currently in use in the Peconic Estuary.
2. To assess the potential seed yield for use in future restoration efforts.
3. To identify potential restoration sites within Shinnecock, Tiana, Quantuck, and Moriches Bays using a GIS-based planting suitability index model developed and refined for the Peconic Estuary.
4. To conduct small scale seeding of eelgrass and adult shoot plantings to refine and test planting model.
5. To identify potential bay scallop planting sites based on existing conditions and historic occurrence.
6. To conduct test plantings of scallops in and outside of existing eelgrass meadows to test assumptions of the site identification methodology.
7. To measure bay scallop recruitment from planted brood stock using spat collectors deployed near scallop seeding areas.

Methods / Work Plan

Listed below are the original tasks presented in the proposal for this project. It is important to note that due to experience gained since originally proposing this plan as well as the need to gather additional data, we chose to amend Task 4 to include the use of adult shoot transplants. Although eelgrass restoration by seed is often considered the most ideal method of restoration due to time and cost efficiency, genetic diversity, low impact on the donor meadow and relative ease in planting, unfortunately, we have had difficulty in achieving prolonged success when using this technique as the sole method. Also, because seeding efforts require a lengthy amount of time to evaluate, in order to assess our results over the duration of this project we felt the use of adult shoot transplants would give us more timely and tangible results. Nonetheless, data and observations on seed yield, maturation and seed donor sites were incorporated in this plan for possible future use.

Because the Town of Southampton expressed concern over the use of transplants as propagules for restoration in their MRPMP recommendations, it is important to note that all shoots collected from natural meadows were collected in a sustainable fashion and only from areas deemed the most productive and healthy enough to support such harvest. The minimal amount necessary was collected in order for us to effectively assess the ability of the eelgrass in this region to recover from disturbance and the potential for restoration. The town recommended using only cultivated specimens, but eelgrass cultivation is not practical at a large scale and therefore these plants are not readily available.

Although our study site encompassed both Shinnecock and Moriches Bays, most of our work focused on Shinnecock. This larger water body presented a broad range of environmental and *physical conditions, including those found in Moriches, and had populations of both eelgrass and bay scallops that were readily studied. Moriches Bay also had the unfortunate circumstance of being the site of a major brown tide (*Aureococcus anophagefferens*) bloom during the study making work there problematic. Despite these facts, much of what has been learned in Shinnecock can be applied to parts of Moriches Bay and indeed the rest of the South Shore Estuary Reserve.*

TASK 1 - *Monitoring of existing eelgrass meadows (Year 1 & 2)*
Prior to initiating any work it will be necessary to monitor existing eelgrass meadows for relative health and restoration potential. Scheduling of field work is based on the phenology of eelgrass in the region. Since temperature is one of the most significant factors controlling plant growth, development and flowering, monitoring will begin (~April) with deployment of automatic bottom temperature loggers at all extant meadows. We would expect to monitor for natural seedling recruitment in existing meadows in the early spring April/May. Counts of flower and seed yield will take place in late June. Monitoring of other growth parameters would take place in July/August. Overall, monitoring would include measurement of stem density, shoot length, epiphyte biomass, co-occurrence of macroalgae, above and below ground biomass, sediment texture and organic matter analysis.

TASK 2 – Monitoring for existing scallops and planting site selection (Year 1 - early spring)
Before a bay scallop seeding program can be developed it is necessary to determine location and extent of existing populations. This data along with observations regarding bottom type, presence of SAV/macroalgae (to be completed in TASK 1), predator counts and other characteristics will be used to determine the most suitable sites for future seeding efforts. Planting sites will be selected based on the combination of factors that is most favorable to the growth and survival of the bay scallop.

TASK 3 – Planting Suitability Index Model (Year 1)
Conduct field reconnaissance to collect data necessary to complete the planting suitability index model. This data would include measurement of sediment texture, and organic matter content, depth range of existing meadows, deployment of epiphyte monitoring arrays at existing meadows and potential planting sites. Additional data to be gathered from various sources includes, but is not limited to areas closed to shellfishing, current shellfishing activity, nutrient levels, light attenuation, mooring and boating activities.

TASK 4 – Seed collection, handling and planting (Year 1 & 2) **Now to include all propagule collection, handling and planting*
In order to develop a comprehensive restoration plan seeds are the most likely propagule source. Before seeds can be utilized it is necessary to assess the potential for seed yield for each meadow. This work would involve measuring flowering shoot occurrence per unit area, spathe number per flowering shoot and seed number per spathe in existing meadows. This information would be used to develop a theoretical seed yield number that would be necessary if large-scale seeding is to be used for restoration purposes. We propose to collect ~500,000 seeds from several extant meadows in the SSER for use in test plantings at three to four

locations selected as part of the site selection work (above). Seed collection would occur in late June/early July. Most of the flowers would be transferred to Cornell's eelgrass nursery facility for processing and storage until planting in September or October. A small number of flowers may also be deployed immediately upon collection using Cornell's Buoy Deployed Seeding System that was developed for use in the Peconic Estuary.

TASK 5 – Bay scallop plantings (Year 1 & 2)

Based on the results of the field observations and site selection work several sites will be chosen for small-scale plantings of bay scallops. During late spring approximately 10,000 brood stock with an average shell height of 35 mm will be released in a defined area at each of 3 to 5 sites.

TASK 6 - Monitoring of test eelgrass plantings (Year 2)

In order to assess the effectiveness of the previous-years plantings it is necessary to conduct field monitoring of the planting sites. Monitoring of seeded sites begins in April with initial observations of seedling emergence. Later in the season (June) when the plants are larger and easier to observe seedling counts will be conducted at each planting site. Following this, seedling plots will be observed in late summer/early fall to determine the effect of peak water temperatures on the long term survival.

TASK 7 - Monitoring of bay scallop seeding (Year 1 & 2)

In order to assess the effectiveness of the each year's plantings it is necessary to conduct field monitoring of the planting sites. Monitoring will consist of deployment of numerous spat collectors located in proximity to the seeding areas. Depending on gonadal development and anticipated spawning time collectors will likely be deployed in early July. Following deployment each collector will be checked weekly for signs of spat fall. Monitoring of spat will also take place in beds where brood stock were deployed, as well as nearby adjacent beds.

Summary of Field Work / Field Notes, Observations, and Methods

Table 1. Summary of Field Work by Year. The following table contains a brief summary of the field work conducted according to the tasks listed above on a seasonal basis. For a detailed field schedule including field notes and observations, please see **Appendix II**.

Year	Summary of Work Accomplished
2005	Tasks 1-3 were initiated in Fall 2005. Efforts included the creation of digitized aerial photographs for both Shinnecock and Moriches bays as well as the mapping and ground-truthing of suspected eelgrass locations. Other eelgrass monitoring efforts included observations and sample collections at several locations within Shinnecock Bay. Data on scallop presence/absence and size were collected at a number of locations. Sample specimens were also collected.
2006	Tasks 1-5 and 7 were conducted in 2006. Spring and summer eelgrass work included the establishment of reference meadows for site characterization and monitoring which included gathering information on plant phenology, algal cover, and sediment composition. Eelgrass test plantings occurred at two potential restoration sites, one east and one west of the Ponquogue Bridge in Shinnecock Bay. Clearance plots were also created in December in order to determine the recovery potential of Shinnecock eelgrass following disturbance. Bay scallops were planted in May on a test plot with existing eelgrass of approximately 400 square meters, and reconnaissance of this site occurred in September. Survival and growth was assessed by divers performing 20 random square meter counts.
2007	All Tasks were conducted in 2007. Eelgrass monitoring work included reconnaissance of the test plantings and clearance plots in the Spring and Fall as well as observations of patchy meadows to be included in a patch dynamics study. An additional test planting was conducted in October near the mouth of Far Pond. Bay scallop spat collectors were deployed in June and were replaced every three weeks until November in order to estimate the times and magnitude of bay scallop sets in the bay. Bay scallop spawner sanctuaries were also established at three sites; two in Shinnecock Bay and one in Tiana Bay. Each sanctuary plot was approximately 400 square meters in area and differed in terms of depth and bottom type.
2008	Tasks 1, 2, 4, 6 and 7 were completed in 2008. Monitoring efforts evaluated and finalized work accomplished in previous years. This included reconnaissance of all eelgrass test plantings, bay scallop plantings and clearance plots. Observations of seed development and seed collection occurred at the "Shinnecock Ave" reference site in June and July. Potential scallop planting sites for future plantings were also surveyed in the summer of 2008.

Methods and Results

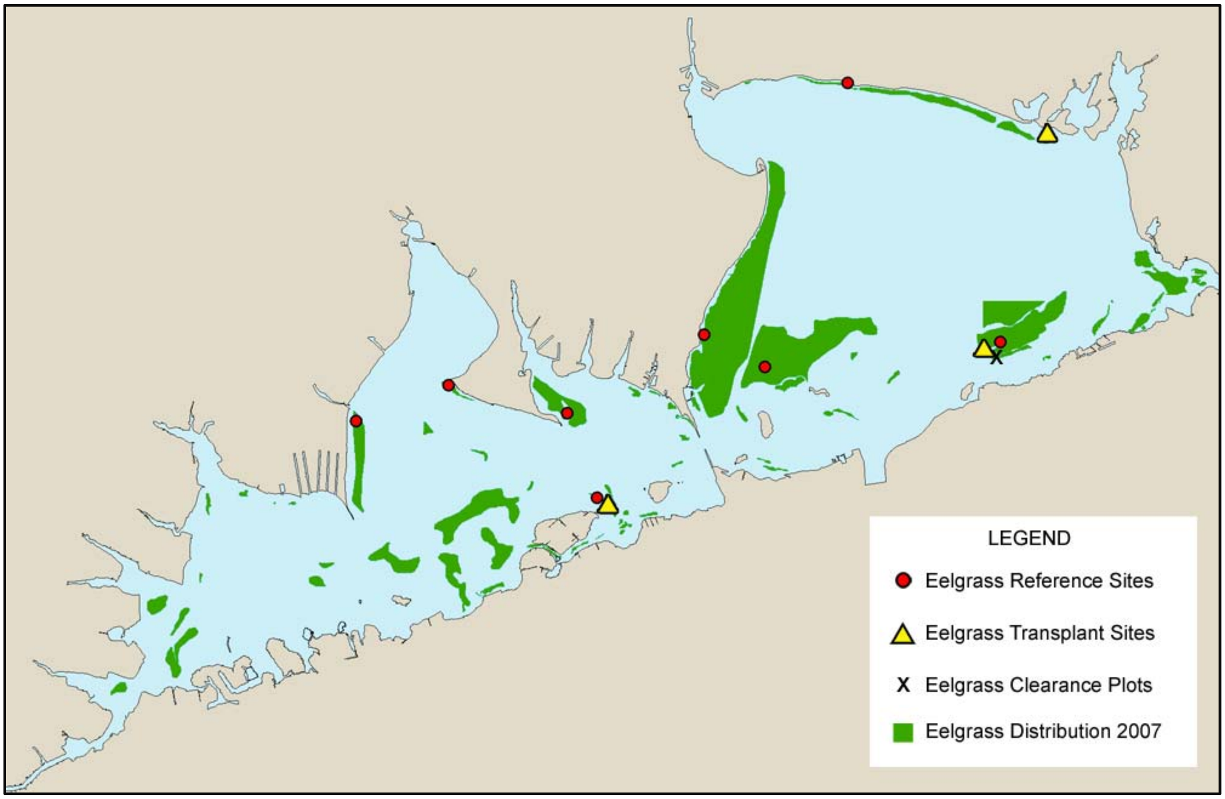

Figure 5. Eelgrass Project Locations in Shinnecock Bay.

All Eelgrass Monitoring and Restoration Work

(includes Tasks 1, 4 and 6) TASK 1 - *Monitoring of existing eelgrass meadows; TASK 4 – Propagule collection, handling and planting ; TASK 6 - Monitoring of test eelgrass plantings*

TASK 1 - *Monitoring of existing eelgrass meadows*

Establishment of Eelgrass Reference Sites:

In order to track the health of eelgrass, routine monitoring is necessary to identify ecological trends and any potential threats to a meadow. Long-term eelgrass monitoring on Long Island began in 1997 in the Peconic Estuary to establish baseline data for eelgrass and monitor trends in eelgrass parameters for management and restoration purposes. In order to assess the current status of existing eelgrass in Southampton Town waters, eight permanent reference sites were established in Shinnecock Bay within existing eelgrass meadows during June 2007 (Figure 4). For each site, measured parameters included average shoot density, canopy height, percent cover macroalgae and sediment grain size/organic content (see Table 2). Density counts were measured by a diver randomly tossing a $0.10m^2$ quadrat within a 5 meter radius of a marked DGPS point. This was repeated ten times at each site, and an average was determined. This number was then back-calculated to represent a $1m^2$ density. Canopy heights were determined by a diver using measuring tape, swimming around the marked GPS point, randomly selecting ten locations to measure the height of the canopy, and an average was determined for each site.

Sediment type/texture is one of the most important characteristics of an eelgrass meadow. Sediment samples were collected by a diver using a 5 cm PVC core which was driven 10 cm into the sediment, capped at both ends, and once at the surface, the water decanted from the top and the remaining sediment was placed into a labeled Ziplock© bag. Samples were stored in coolers with ice packs until arrival at the lab where they were transferred to the freezer until analysis. Percent organic matter was assessed by combusting samples in a muffle furnace at 450 ˚C for 4 hours, and the loss after combustion indicated the amount of organic matter present in that sample. Percent grain size was assessed by wet sieving the course fractions (gravel and sand) and fine fractions were determined using the pipette method described by Folk (1974). For both analyses, three subsamples were taken from each sample and the average of the three subsamples represented the resulting percentage. Tables 2 and 3 present the resulting data for all parameters measured.

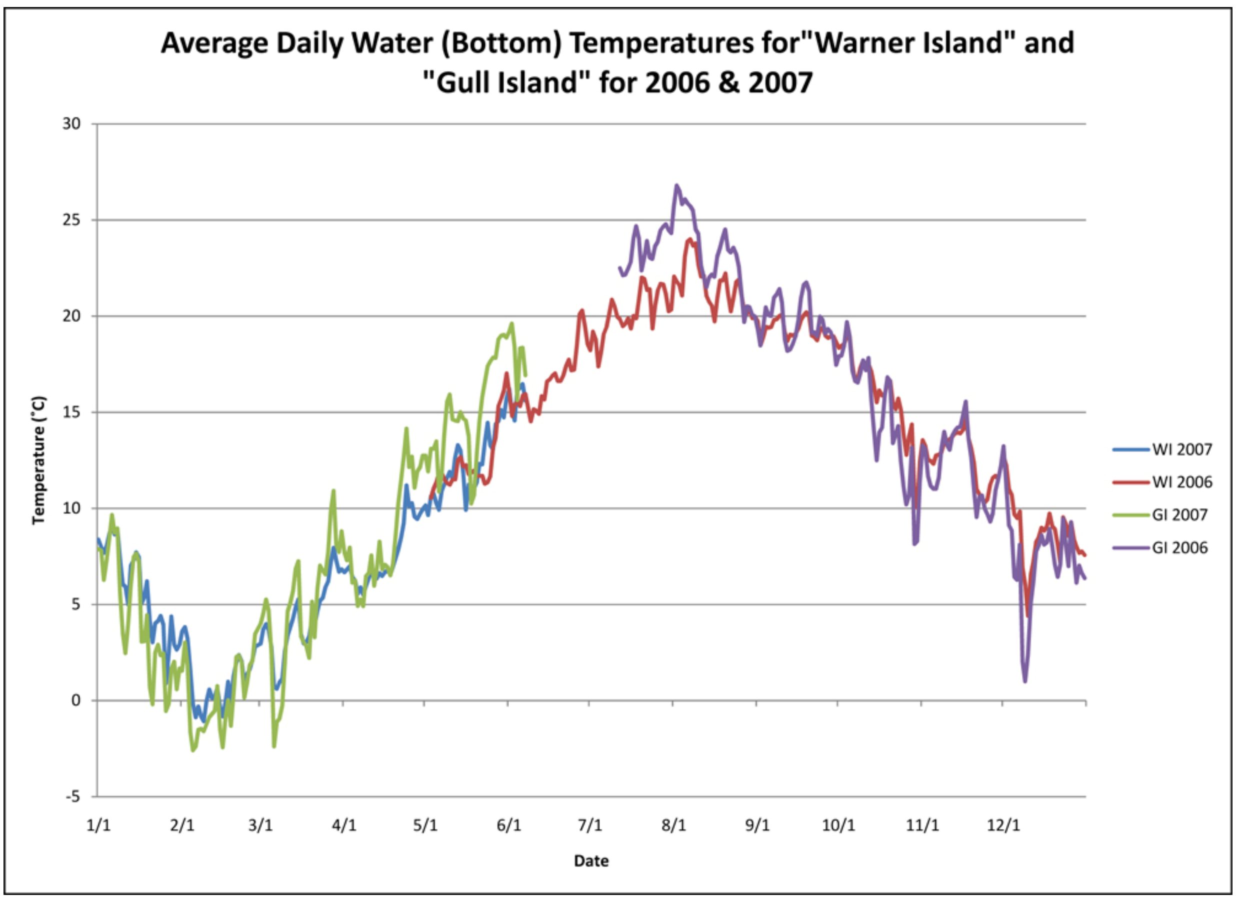

Figure 6. Average Daily Temperature at "Warner Island" and "Gull Island" Reference Sites.

Water temperature is a primary factor controlling eelgrass growth and survival. Because bays and creeks in New York can reach summer peaks that exceed the tolerance of eelgrass, it is important that daily water temperature is logged, especially during the late summer to identify any of these potentially detrimental spikes in temperature. Although much of Shinnecock Bay receives cool ocean water with every incoming tide, water temperatures of shallow flats and inland bays can quickly spike on hot summer days. Bottom temperatures at two sites in Shinnecock Bay were logged in 2006 and 2007: Warner Island (reference site) and Gull Island (Reference site and planting site). Figure 5 compares these two sites for both years. All temperature data can be found in Appendix IV of this report.

Table 2. Eelgrass Reference Site Parameters. Because plant phenology can vary greatly between seasons, it is important to note the dates at which any plant metrics were taken: Density counts were conducted on 30 June 2006 and canopy height measurements were taken on 11 July 2006. To determine average density of vegetative and flowering (reproductive) shoots, divers collected 10 random quadrat counts at each site.

Reference Site	Mean Shoot Density (per m^2)	Mean Flowering Shoot Density (per m^2)	Mean Canopy Height (cm)	Mean % Cover Macro-algae	Sediment % Grain Size*	Sediment % Organics
Shinnecock Rd	428	27	57.42	100	0.06/97.07/2.86	0.41
East of Inlet	259	10	38.18	90	0/ 99.15/0.85	0.31
East Point	86	0	54.40	100	9.82/88.08/2.11	0.30
Gull Island	428	18	55.93	100	0/97.86/2.14	0.50
Montauk Hwy	322	4	25.4	4	0.06/98.62/1.33	0.37
Tiana Bay	53	0	n/a	15	0/24.54/75.47*	6.86
Warner Is.	200	5	67.49	84	0/91.11/8.89	1.76
West Point	113	6	42.90	90	4.65/94.21/1.14	0.33

% Grain Size is listed as % Gravel, % Sand, % Silt+Clay respectively
*The percent of fine sediments (silt and clay) for Tiana Bay is extremely high (avg. 75.47). Seagrasses usually tolerate less than 30% fine sediments. This may indicate that this meadow is in distress.

Table 3. Macroalgae Species Composition for Each Reference Site (Conducted 30 June 2006). Presence or absence of macroalgae was assessed at each of our reference sites.

	Chordaria sp.	*Cladophora sp.*	*Codium fragile*	*Dasya sp.*	*Ectocarpus sp.*	*Gracilaria sp.*	*Polysiphonia sp.*	*Spermothamnion sp.*	*Spyridia sp.*	*Ulva compressa*	*Ulva flexuosa*	*Ulva lactuca*	*Ulva prolifera*
Shinnecock Rd					X	X		X	X			X	
Warner Is.					X		X		X			X	
Montauk Hwy	X					X			X				
East of Inlet					X	X			X			X	
Gull Island		X	X		X	X			X	X	X	X	X
West Point		X			X	X		X	X	X		X	
East Pt		X	X	X	X						X	X	
Tiana Bay			X		X	X			X			X	

Establishment of Eelgrass Clearance Plots:

In order to determine the recovery potential (i.e., rate of spread) of natural eelgrass beds in Shinnecock after a disturbance (such as shellfishing) or transplanting, three clearance plots were created in the meadow near our “East of Inlet” reference site. Three $1m^2$ plots were marked off and cleared of all eelgrass which was counted to determine the pre-disturbance densities. Monitoring of these clearance plots was conducted regularly until they became indistinguishable from the undisturbed eelgrass surrounding them. This included estimated percent cover and photographs of each plot. The following table compiles the data collected during reconnaissance. Photos are included in Appendix V for comparison purposes.

After approximately 6 months, only a small number of shoots had encroached into the plot. After about 9 months, the eelgrass had recruited approximately 30 cm into the plot from most sides. After 18 months, the plots were indistinguishable from the neighboring natural eelgrass. According to these observations, the eelgrass in the flats east of Shinnecock Inlet will naturally re-vegetate after a disturbance within 18 months assuming the disturbance is about $1m^2$ in size.

Table 4. Reconnaissance of Eelgrass Clearance Plots/Rate of Natural Recruitment

Date	Plot 11 (1 m^2)	Plot 12 (1 m^2)	Plot 13 (1 m^2)
22 Dec 2006-preclearing	783 shoots/ 87.4% cover	1205 shoots/ 91.2% cover	601 shoots/ 86.0% cover
22 Dec 2006-post	0 shoots/ 0 % cover	0 shoots/ 0% cover	0 shoots/ 0% cover
7 June 2007	N/D	15.9%	25.9%
25 Sept 2007	56.5%	34.3%	35.1%
17 June 2008*	Est 90%	Est 90%	Est 80%

*Because of the low tide and poor visibility on 17 June 08, it was not possible to photograph each clearance plot entirely. Several close-up photos were taken, and a percent cover was estimated. All other percent cover figures were interpreted using GIS software (Map Info) to analyze the spatial relationship between the area of the quadrat and the area of regrowth.

TASKS 4 & 6– Eelgrass propagule collection, handling and planting; Monitoring of test eelgrass plantings

Establishment of Eelgrass Test Plantings

In order to determine the potential of using transplants to restore eelgrass in Shinnecock Bay, test plantings were conducted at three locations (shown in figure 4). Locations were chosen based on bottom type, proximity to healthy populations of existing eelgrass, and other physical and biological factors. A comprehensive list of these factors as well as other restoration parameters is included as Part 2 (The Restoration Blueprint) of this report. Tables 5 and 6 list the percent survival at two of the transplant locations “East of Inlet” and “Gull Island.”

<u>“East of Inlet” Test Planting Site</u>

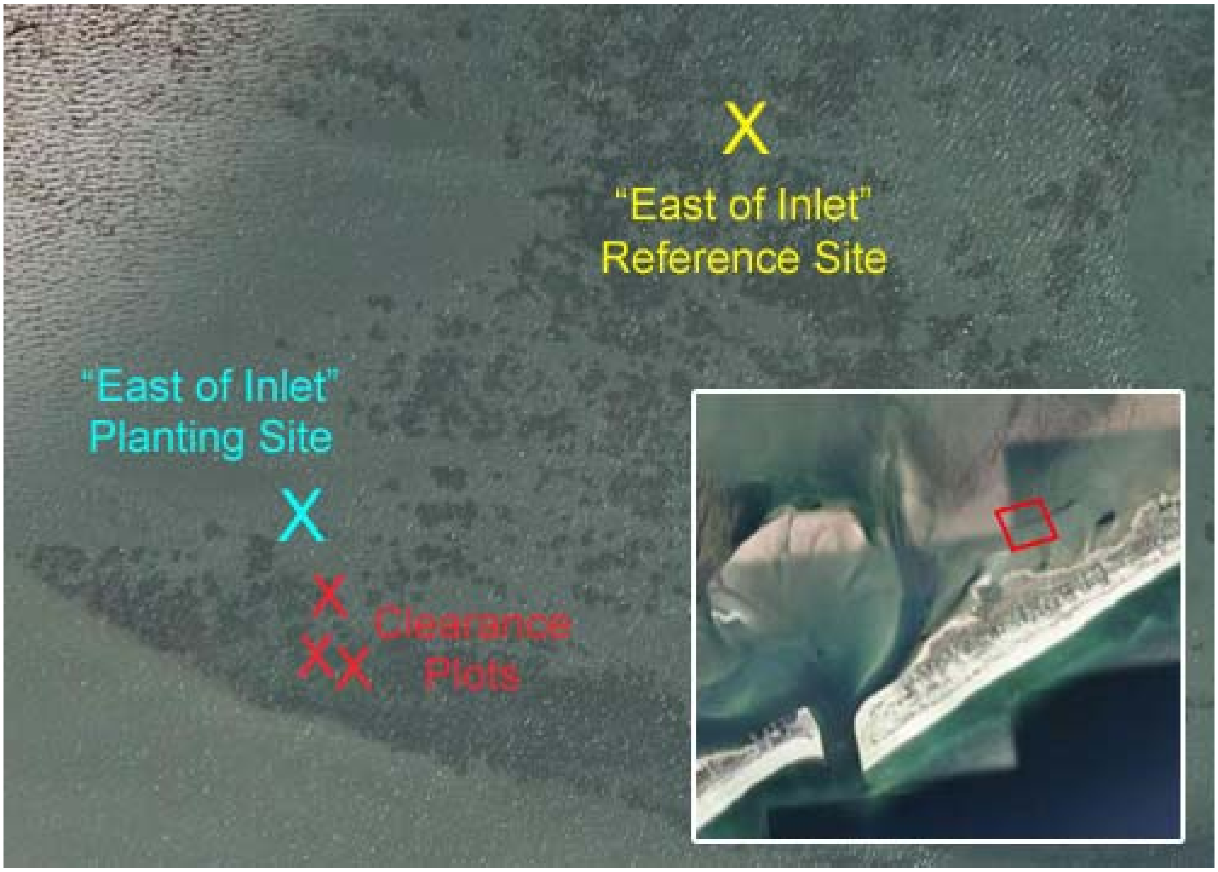

Figure 7. “East of Inlet” Eelgrass Test Planting Site, Clearance Plots and Reference Site.

On 15 November 2006, ten circular 1m^2 eelgrass test plots were planted around near our “East of Inlet” Reference Site. Each plot was planted at a 1m distance from the next nearest plot with all plots centered around a central point marked by DGPS. Each plot had a numbered rock to mark the center and identify the density and person who planted it. Five plots were planted at a high density (100 planting units/m^2) and 5 plots at a low density (12 planting units/m^2-based on Churchill et al. 1978). Shoots were harvested from natural beds adjacent to the planting area.

"Planting units" were used instead of individual shoots because of the large number of lateral shoots present and the extremely small size and fragile nature of the plants. In order to have an accurate estimate of the actual number of individual shoots per planting unit, all shoots were counted. Each planting unit was composed of an average of 2 shoots.

Table 5. "East of Inlet" - Test planting establishment, reconnaissance and percent survival.

Plot #	# PU's Planted (15 Nov 2006)	Approx. # of shoots	# Shoots 7 Jun 2007	%Survival	# Shoots 25 Sep 2007	%Survival (from 15 Nov 2006)	%Survival (from 7 Jun 2007)
233	100	200	93	46.50	743	371.50	798.92
236	12	24	10	41.67	47	196	470.00
237	12	24	0	0	0	0	0
238	12	24	29	120.83	850	3541.5	2931.03
240	12	24	3	12.50	12	50	400.00
241	100	200	58	29.00	341	170.5	587.93
244	100	200	55	27.50	395	197.5	718.18
245	100	200	40	20.00	365	182.5	182.5
246	12	24	7	29.17	not found		
250	100	200	57	28.50	609	304.5	304.50
Average % Survival:				**35.57**		**557.11**	**710.34**

Plantings were monitored on three occasions following planting: the following spring (7 June 2007) and fall (25 Sept 2007) and then again in spring 2008 (17 June 2008). The results of the 2007 counts are listed in Table 5. In June 2008, plantings had outgrown expectations. All of the transplant markers were located except for #241. There was significant sand movement since our last visit as the markers were buried under nearly 10 cm of sand. Most of the surviving plots were too large now to count shoots, as they had begun to coalesce into the neighboring plots (which were planted over 1m apart). In fact, we had a hard time telling the difference between the nearby natural eelgrass patches and our transplants until our transplant markers were located. It is evident that this area is very conducive to eelgrass growth, as even the natural eelgrass patches in the area have expanded considerably since we began work here.

“Gull Island” Test Planting Site

Figure 8. Gull Island Eelgrass Test Planting Site, Reference Site, and Temperature Logger Location.

On 15 November 2006, eleven $1m^2$ eelgrass test plantings were planted around a marked DGPS location near our “Gull Island” Reference Site. The same plant collection and sorting protocols were used as the “East of Inlet” planting site, and each planting unit also contained an average of 2 shoots. Shoots were harvested from natural beds adjacent to the planting area, except one plot (#225) was planted with 100 units from “East of Inlet” site.

Table 6. "Gull Island" test planting establishment, reconnaissance and percent survival.

Plot #	# Shoots planted 15 Nov 2006	Approx. # of shoots	# Shoots 7 Jun 2007	%Survival	# Shoots 3 Oct 2007	%Survival (from 15 Nov 2006)	%Survival (from 7 Jun 2007)
225	100	200	20	10.00	not found		
230	100	200	25	12.50	not found		
231	100	200	11	5.50	20	10.00	181.81
232	12	24	0	0	not found		
234	100	200	17	8.50	12	6.00	70.59
235	12	24	0	0	not found		
238	12	24	0	0	not found		
6242	100	200	24	12.00	not found		
243	100	200	12	6.00	11	5.50	91.67
247	12	24	3	12.50	14	58.33	466.67
249	12	24	0	0	not found		
			Avg. % Survival	**6.09**		**19.96**	**202.69**

Plantings were monitored the following spring (7 June 2007) and again in the fall (3 Oct 2007). The results of the 2007 counts are listed in Table 6. Spring counts showed poor overall survival of plantings, although those plantings that remained appeared healthy. In Fall 2007, only 4 of the 11 planting markers were located, and those that had remained from spring still appeared healthy, but unfortunately percent survival still remained low, especially when compared to the "East of Inlet" percent survival during this period.

We hypothesize that the poor percent survival of these plantings was likely due to bioturbation, but could also have been affected by shellfishing and by high water temperatures (in early August). Because eelgrass grows just outside the planting area (within 20m), we know that the physical conditions are sufficient to support eelgrass growth, although newly planted eelgrass will likely be more vulnerable to stressors. The bioturbation hypothesis would be supported by the observations made by the bay scallop team, who observed high numbers of predated scallops and crabs in their nearby planting sanctuary. Aerial photos from 2007 show tracks made by shellfishers "easing" throughout the area, sometimes right up to the edges of the thick eelgrass. Since the eelgrass plantings would be hard if not impossible to see from the surface, it is possible that shellfishers "eased" through portions of the planting area.

“Far Pond” Test Planting Site

Figure 9. “Far Pond” Test Planting Site in the northeast region of Shinnecock Bay.

A new transplant was conducted on 3 Oct 2007 in the northeast corner of Shinnecock Bay, near the mouth of Far Pond. Five circle plots (1 m^2 in size each) were planted, each with densities of 100 shoots.

Reconnaissance of Far Pond plantings occurred on 17 June 2008. No plots remained. Evidence of “easing” was observed throughout the planting area. “Easing” trenches were ~1ft deep and some were several feet wide. “Easing” had also occurred within a few feet of natural eelgrass at the site.

Eelgrass Flower Shoot Assessment: Seed Yields, Flower Shoot Densities, and Seed Development

Eelgrass reproductive (flower) shoots from several locations were observed for potential harvesting for restoration purposes. Two sites were considered the most optimal for collection due to the high yield of seeds and relative health of the meadow: “Warner Island” and “Shinnecock Rd” reference sites. Because the “Warner Island” site is near a busy boating channel, the “Shinnecock Rd” site is the most ideal for collecting. Table 8 below lists the data collected on flower size and yield. More information on flower collecting protocol can be found in Appendix 1A.

Table 7. Flower shoot metrics and yield.

Site	Mean Plant Length (cm)	Mean # Rhipidium per Shoot	Mean # Spathes	Mean # Ovules per Shoot
Shinnecock Rd (30 June 2006) shallow	36.2	3.30	13.00	47.35
Warner Island (30 June 2006)	52.9	4.45	17.85	166.6
Shinnecock Rd (17 June 2008) deep	81.5	4.75	10.08	105

General observations

Throughout the course of our field work we were able to make general observations regarding the interaction between human activities (e.g., boating and shellfishing) and existing eelgrass habitat. The most frequent observations included those days when we were in the field conducting the tasks described above. On these days, we had the occasion to observe commercial shellfishers working in or near existing eelgrass meadows and on more than one occasion we observed mats of recently uprooted and otherwise healthy eelgrass floating in the water downwind of this activity. From this it can be assumed that the shellfishing activity of one or more of these shellfishers was having a direct impact on the persistence of eelgrass.

In an effort to get a broader-scale view of the interaction between shellfishing and eelgrass, and to better understand existing meadow distribution, we also conducted several aerial flights of Shinnecock and Moriches Bays using a helicopter. These flights not only showed us the unique patterns of eelgrass colonization, growth and expansion in this system, but also showed the extent to which shellfishing (in particular “easing” of razor clams) was affecting the continued growth and expansion of existing eelgrass. In particular, we observed that shellfishing directly up to the edge of existing grass and in some cases into the grass was reducing the extent of these meadows and preventing the natural tendency of these areas to expand outward through rhizome elongation (clonal growth) and seedling recruitment (sexual reproduction). As a result, better management of shellfishing activities could have an immediate and significant positive impact on the eelgrass cover in Shinnecock Bay. Please see Appendix VI for photos of shellfishing and other human disturbances on eelgrass.

All Bay Scallop Monitoring and Restoration Methods and Results

TASK 2 – Monitoring for existing scallops and planting site selection

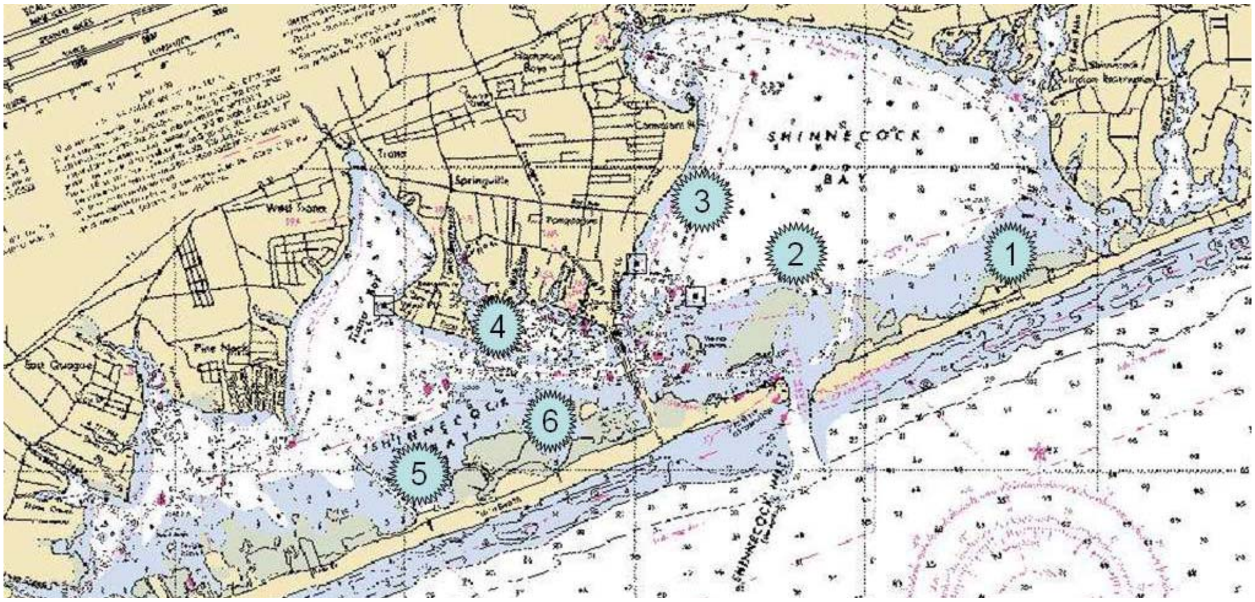

Figure 10. Bay scallop spat collection locations.

Natural Recruitment/Spawning Events/Spat collection

Bay scallop spat collectors were placed at six sites: three west and three east of the Ponquogue Bridge on 7 June 2007 in order to qualitatively estimate times and magnitude of bay scallop sets in the bay. A total of 12 spat collectors were assembled, each with a concrete block as an anchor, two fine mesh bags (one low, one high) stuffed with rigid plastic netting, a small subsurface float on each bag and a larger marker float at the top. Two sets of collectors (for a total of four collectors per site) were placed.

Every three weeks one set of collectors was removed and a new set placed. The removed collectors were brought back to the Suffolk County Marine Environmental Learning Center for analysis. The first scallop spat were found on 5 September 2007 and measured three to 14 millimeters in shell height. The last collector was sampled on 28 November 2007; at that time scallops found measured 13 to 25 millimeters.

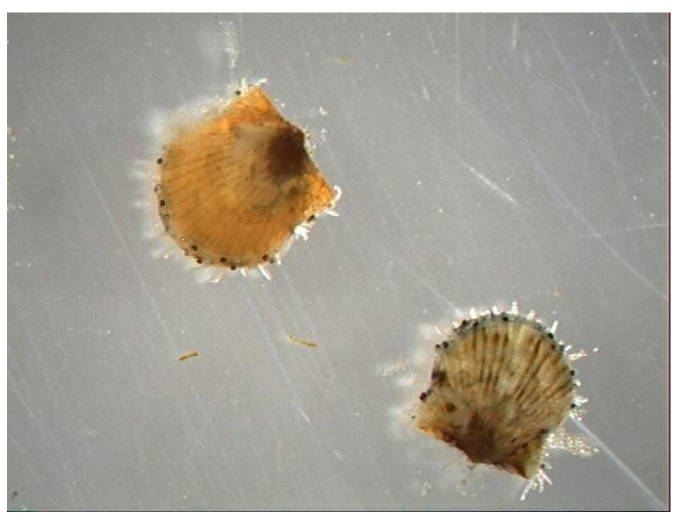

Figure 11. Scallop juveniles at thirty-five days (ca. 0.5mm); these are ready for field nursery.

Table 9. Date and number (mean height) of spat per collector (both bags) at all stations in 2007

Site	*21 July*	*3 August*	*5 September*	*16 October*	*28 November*
1	0	0	2 (10mm)	4 (14mm)	1 (13mm)
2	0	0	3 (4mm)	0	4 (26mm)
3	0	0	2 (4mm)	0	0
4	0	0	1 (6mm)	0	0
5	0	0	0	0	0
6	0	0	3 (10mm)	2 (9mm)	0

It is apparent from this data that there were at least two main spawning events in Shinnecock Bay in 2007. Spat that settled in the collectors grew at a rapid rate, despite the small and fouled mesh. Only one site (5) located near Tiana Beach showed no spatfall. Data from spat collectors should not be viewed as formal quantitative data; rather they show qualitatively where competent-to-set larvae may be found. These areas may change drastically from year to year, based on weather patterns and broodstock population and health.

Bay Scallop Planting Site Selection

During the eelgrass monitoring work of Fall/Winter ’05, data on scallop presence/absence and size was collected. Small numbers of animals including bugs and adults were collected at two of stations where present. Additional bay scallop monitoring took place in spring 2006 along with the eelgrass monitoring effort.

TASK 5 – Bay scallop plantings

On 9 May 2006, 20,000 bay scallops with an average shell height of 39 mm were planted on a test plot (with existing eelgrass) in Shinnecock Bay, west of the Ponquogue Bridge (see Figure 13). Each test plot measured 400 square meters and was planted with 10,000 scallops (avg. of 50/m^2) averaging 35 millimeters in shell height.

Figure 12. Hatchery manager Mike Patricio planting bay scallops on 9 May 2006.

On 2 October 2007, three 20 meter by 20 meter (400 m^2) plots were set up in the study area. Two were placed in Shinnecock Bay (one east and one west of the Ponquogue Bridge) while the third was in Tiana Bay (see Figure 13). These three sites were selected with Southampton Town Trustee advice and were all somewhat different in terms of depth, bottom type and presence or absence of eelgrass.

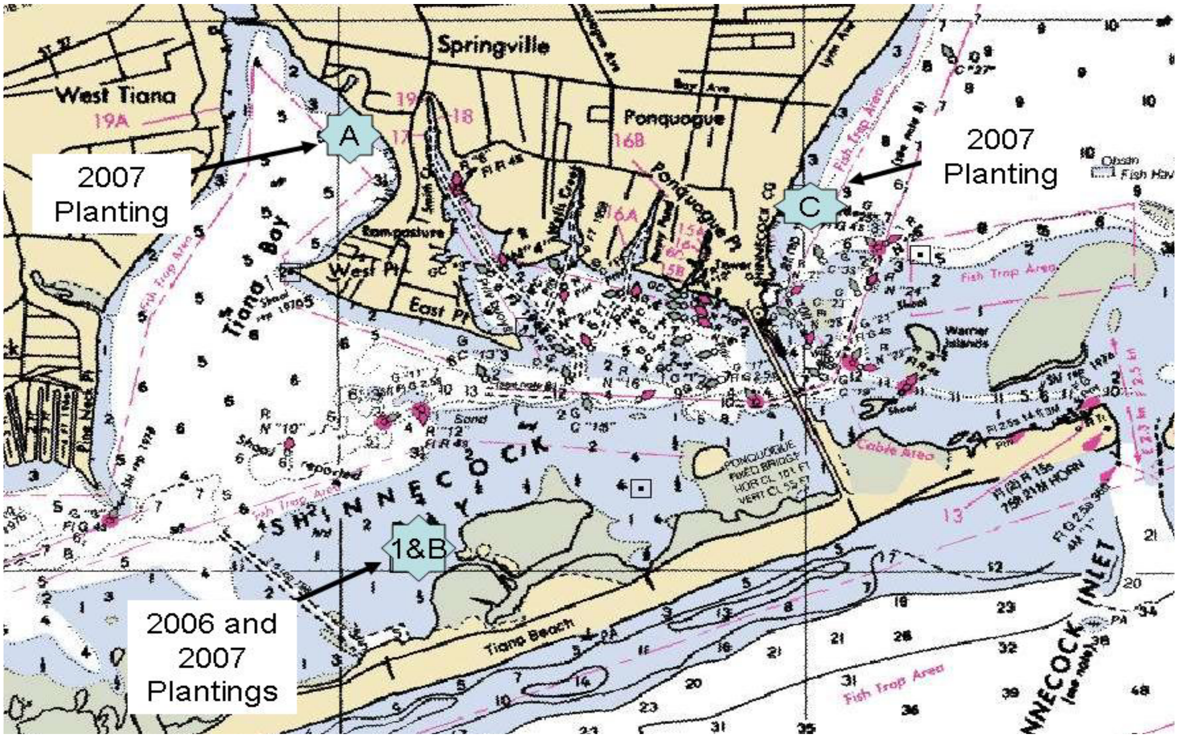

Figure 13. Bay scallop spawner sanctuary locations for 2006 and 2007.

All three spawner sanctuaries were planted on 16 October 2007, each with 10,000 bay scallops spawned at the Suffolk County Marine Environmental Learning Center in Southold. The average shell height of these scallops was 35 millimeters. Water temperature in the area ranged from 15 to 17 degrees Centigrade. The scallops were dispersed as evenly as possible, with a theoretical density of 25 scallops per square meter.

TASK 7 - Monitoring of bay scallop seeding (Year 1 & 2)

The 9 May 2006 planting was assessed for survival and growth on 13 September 2006 by divers performing 20 random square meter counts. Ten each live and dead (single valve) scallops were measured for shell height. Survival averaged only 1% (0.6 scallops/m^2). Live scallops averaged 50 mm in shell height. Single shells (from dead scallops) averaged 44 mm. The abundance of predators at this site appeared to be the cause of mortality. Sea stars, blue crabs and large spider crabs were observed during the survey.

The 2 October 2007 planting was assessed on 22 October 2007. Ten square meter counts were made by SCUBA divers at each of the three spawner sanctuaries. The Tiana Bay site was sandy mud and devoid of eelgrass and shell hash. This site had no survival in the sampled square meters and many broken scallop shells were found, indicating crab predation. In the western Shinnecock Bay site, where the bottom was a mix of sand and patchy thick eelgrass, survival averaged 27% with cracked shells and live crabs found.

The eastern Shinnecock sanctuary had thick eelgrass and showed an average of 25% survival. Fewer predators were seen here compared to the other two sanctuary sites, although this may be due to the thick eelgrass which provides a refuge to scallops and predators.

During the spring of 2008, areas that were planted with scallops in October of 2007 were re-sampled, excepting the Tiana Bay site, which had no survival due to heavy predation within the first month of planting. Also, along with the eelgrass team, potential planting sites for future plantings were surveyed in the summer of 2008.

The corners of each of the remaining two sites (each 20 meters square) in western and eastern Shinnecock Bay were approximated with GPS and sampled by SCUBA divers as corner markers were removed before scallop season. Less than one scallop per square meter was found, despite planting 25 per square meter at a mean shell height of 35 millimeters. Large green and blue claw crabs were found at each site. Due to thick eelgrass and warm water temperatures it was not possible to enumerate the crabs- they were difficult to see and moved out of our square meter quadrats quickly when we approached.

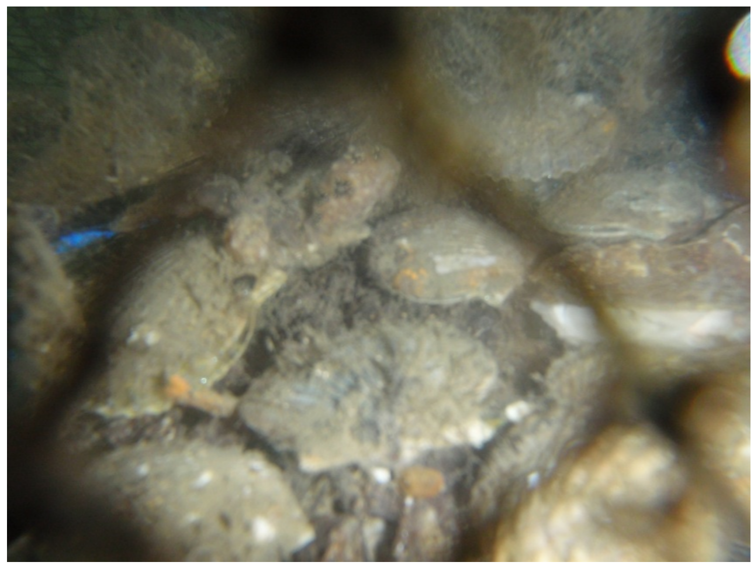

Figure 14. Scallops in lantern nets prior to transplant to Shinnecock Bay.

It is thought that while additional predation had taken place since the last sampling in October of 2007, perhaps some harvesting of these scallops occurred as well, especially since few dead shells were found. Some of these scallops could have grown to a legal size of 57 millimeters the last few months of 2007, and all had “shock” rings that could have been mistaken for growth rings put down the previous winter, making them look older than they were. Many scallop boats were noted on opening day in November, 2007 near the planting site east of the Ponquogue Bridge.

Despite large seed planted in dense eelgrass, our test plantings would not last to spawn the following summer. It seems that protecting bay scallops from predators (both marine and human) will be necessary in the South Shore Estuary Reserve if they are to survive to spawn.

TASK 3 – Planting Suitability Index Model (Year 1)
The *"Eelgrass and Bay Scallop Restoration Blueprint"* including the *Planting Suitability Index Model,* portion of the results will be included as an appendix to this report.

Conclusions

Using the methods described above, we were able to successfully complete this study, including observing and characterizing existing eelgrass and bay scallop populations in Shinnecock Bay. As part of this effort, we also tested various planting methods for both species in order to better define appropriate restoration protocols. In general, these species have suffered from multiple stressors including declining water quality and direct human impact. Reduced water quality has likely resulted from cumulative impacts of near-shore development within adjacent watersheds that feed into the bays. Here, higher water temperatures, fine sediment texture and low light clearly limit growth and colonization of eelgrass. In other areas where water quality is suitable for the growth of eelgrass, lack of propagules will likely prevent natural recolonization within a reasonable time frame (less than 10 years). Based on all of our observations, we have developed a detailed restoration blueprint for Shinnecock and Moriches bays that defines specific restoration protocols for these areas that are propagule-limited.

Figure 15. "Easing" tracks through patchy eelgrass meadow.

Observations from both in the water and from the air have indicated that shellfishing conflicts are impacting otherwise healthy eelgrass in much of Shinnecock Bay. Although most shellfishers seem to avoid contact with eelgrass, there is evidence that some areas are under stress from both recreational and commercial shellfishing activities. The impacts are of two types. The first is the direct removal of adult shoots from the edges of meadows as the shellfishers dislodge eelgrass shoots in the process of removing shellfish from the sediments (e.g. "power-easing", bull raking etc). When this happens, the shellfishers may knowingly be uprooting shoots in an effort to reach the shellfish. The second impact is more subtle and may have an even greater impact on recovery of eelgrass in the bay. It is apparent that very small seedlings, the main mechanism for eelgrass establishment and spread in Shinnecock Bay, are being uprooted by shellfishing adjacent to and within meadows. These very small plants would not be visible from above the water during certain times of the year (winter, spring) and the person involved with this activity would likely be unaware of the impact. Given the situation, possible management suggestions for these areas include (ranging from the most restrictive to least restrictive):

- Setting aside areas where shellfishing will not be permitted (e.g. critical fish/shellfish habitat zones).
- Establishing buffers around the existing patches to allow for the eelgrass to expand (e.g. no shellfishing X feet from an existing meadow or patch and no shellfishing between existing patches within a low density meadow).
- Prohibiting “easing” around and within sparse patches where small seedlings are just becoming established.

Other less severe but avoidable impacts to eelgrass related to boating activity were observed on several occasions during the duration of this project. Boaters often strayed from marked channels and were navigating into shallow flats that often contain eelgrass. It was not clear whether this occurred as a result of inexperience or general disregard for general navigational rules. Regardless of the reasoning, these activities can result in direct impact to eelgrass meadows and/or damage to vessels and in the most severe cases personal injury. Prop-scar damage within shallow eelgrass flats were most obvious evident from the air and at low tide. Photos of this type of disturbance can be seen in Appendix VI. Suggested alternatives to minimize such impacts may include:

- Clearly marking navigation channels and/or shallow areas (e.g. additional buoys, signs)
- Public education on the importance of following channel markers (e.g. sign near boat ramp, handouts, etc.)
- Some form of enforcement presence near areas of frequent disturbance

Protecting bay scallops used for restoration projects from predators (both marine and human) will be necessary in the South Shore Estuary Reserve. Large numbers of crabs, especially portunids (swimming crabs such as blue claws and calicos) are fast moving and can consume large numbers of even large scallop seed in days. Using predator traps around planting sites is costly and of dubious efficacy; placing the broodstock scallops in containment is a better approach. Creating management areas around restoration sites off limits to recreational and commercial harvesting of all shellfish (not just scallops) is important and requires the cooperation of the responsible political body.

Site selection is critical to the success of a bay scallop restoration project. Listening to local fishers and officials familiar with the area then ground truthing potential sites well in advance of deployment is wise.

The use of containment gear is site specific- what works in one area may not work in another. Lantern nets have been used in the Peconic Estuary to provide protection for scallops for decades but would be less useful in the shallower waters of the SSER. In the SSER, “corrals” that contain the scallops while keeping out predators may offer an efficient method of protecting large numbers of spawning stock. In addition, post spawn the fencing used may be easily removed so that the scallops may be harvested later in the year.

In many instances, both eelgrass and bay scallops share the same requirements to thrive. Thus an agency or environmental group may get more “bang for the buck” by designing projects that attempt to bring back both species to an area at the same time.

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