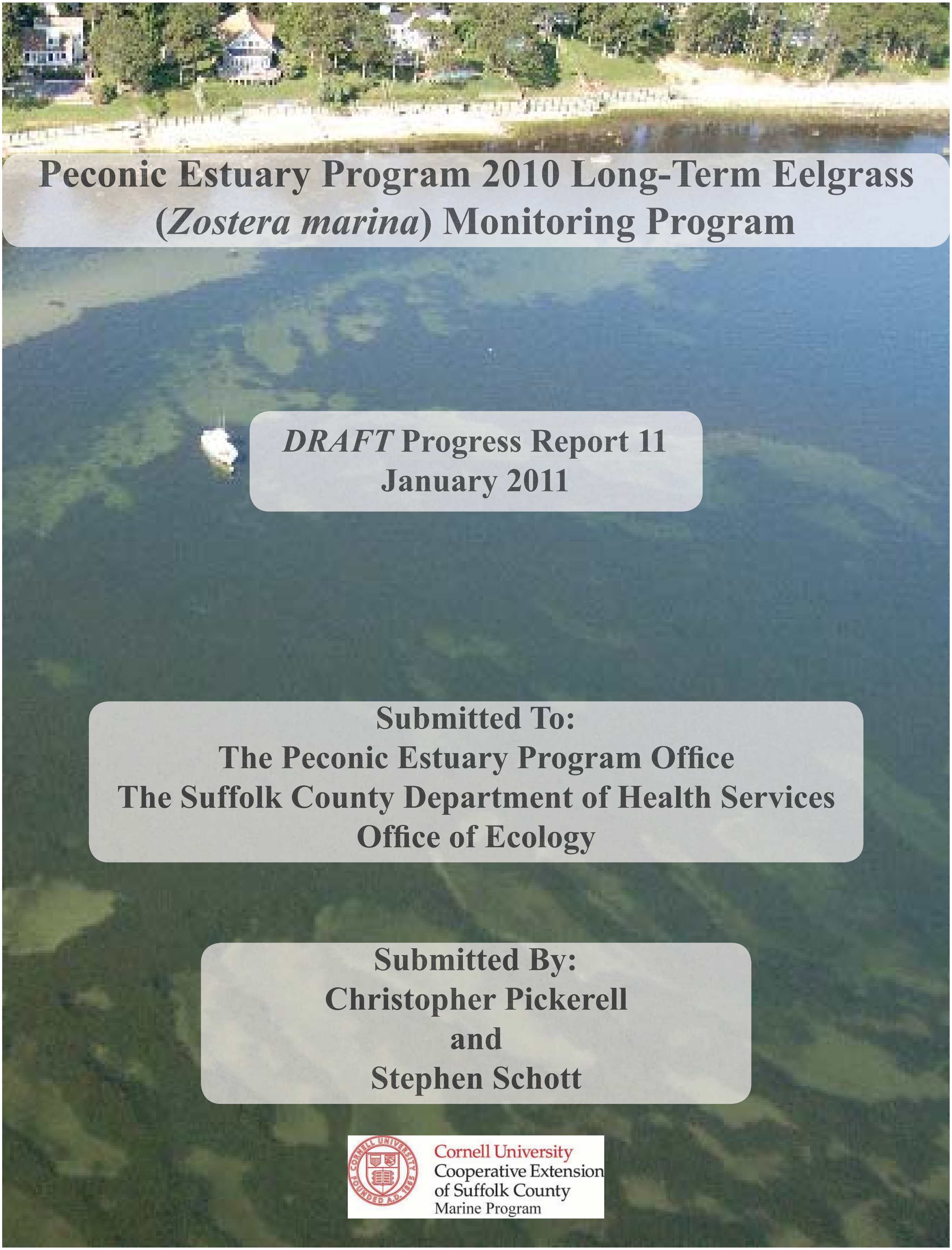

Peconic Estuary Program 2010 Long-Term Eelgrass (*Zostera marina*) Monitoring Program

DRAFT **Progress Report 11**

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Submitted To:

The Peconic Estuary Program Office

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Office of Ecology

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INTRODUCTION

The decline of eelgrass (*Zostera marina* L.) in the Peconic Estuary over the last 70 years has contributed to the degradation of the estuary as a whole. This submerged, marine plant is inextricably linked to the health of the Estuary. Eelgrass provides an important habitat in near-shore waters for shellfish and finfish and is a food source for organisms ranging from bacteria to waterfowl. To better manage this valuable resource, a baseline of data must be collected to identify trends in the health of the eelgrass meadows and plan for future conservation/management and restoration activities in the Peconic Estuary. The more data that is collected on the basic parameters of eelgrass, the better able the Peconic Estuary Program will be to implement policies to protect and nurture the resource.

The basic purpose of a monitoring program is to collect data on a regularly scheduled basis to develop a basic understanding of the ecology of the target species. Since its inception, the Peconic Estuary Program's Submerged Aquatic Vegetation Monitoring Program, contracted to Cornell Cooperative Extension's Marine Program, has focused on collecting data pertaining to the health of the eelgrass beds in the Peconic Estuary. The development of this program reflects the unique ecology and demography of the eelgrass in the Peconic estuary and varies significantly from other monitoring programs like the Chesapeake and other areas on the east coast, which tend to focus more on remote sensing techniques (i.e., aerial photography) for monitoring.

METHODS

The PEP SAV Monitoring Program includes six eelgrass beds located throughout the estuary and represents a range of environmental factors. The name and township location of each of the reference beds are listed in Table Intro-1, with a corresponding aerial perspective of each site found in Figure Intro-3. Included with each image are the locations of the six sampling stations within the bed and the GPS coordinates for each station.

Table Intro-1. The six reference eelgrass beds and the townships in which the beds are located.

Bullhead Bay (BB)	Southampton
Gardiners Bay (GB)	Shelter Island
Northwest Harbor (NWH)	East Hampton
Orient Harbor (OH)	Southold
Southold Bay (SB)	Southold
Three Mile Harbor (TMH)	East Hampton
Cedar Point (CP)	East Hampton
Orient Point (OP)	Southold

The monitoring program has evolved its methodologies from its beginnings in 1997; however the basic parameters of eelgrass health, shoot density, has always been the focus of the program, thus allowing for comparisons between successive years. In the beginning, sampling consisted of the destructive collection of three (four in Bullhead Bay) 0.25 m^2 (50cm x 50cm) quadrats of eelgrass including below ground and above ground biomass that was returned to the laboratory for analysis. The sampling in 1998 and 1999 continued to utilize destructive sampling to collect data, however, sample size was increased to a total of twelve quadrats and there was a decrease in the size of the quadrats to 0.0625 m^2 (12.5 x 12.5 cm).

In 2000, the methodology for the monitoring program was amended to increase the statistical significance of the data collected. The adjustments reflected an increase in the number of sampling stations per site (from 3 to 6), the number of replicate samples per station (from 4 to 10) and the size of the quadrats. However, the 2000 methodology included an increase number of destructively sampled quadrats (24 quadrats) for use in biomass estimations. The 2001 protocols maintained the higher number of replicate samples per bed (60 quadrats) but eliminated the destructive sampling aspect of the program.

Water Temperature Monitoring

In the past, water temperature monitoring was included in the LTEMP report due to the placement of temperature loggers primarily within eelgrass meadows that were monitored in the program. In 2010, additional water temperature loggers were purchased and an expanded plan was enacted to cover more of the Peconic Estuary, including areas of extant eelgrass and sites that formerly supported meadows. Due to the increase in temperature data to consider, it was decided that a separate report should be issued detailing the findings of that project.

Although the results will not be included in this report, it should be noted that water temperature loggers were deployed to five current LTEMP monitoring sites (Bullhead Bay, Cedar Point, Gardiners Bay, Orient Point, and Southold Bay) for the 2010 season. A temperature logger was also deployed in Hands Creek, an extant eelgrass meadow adjacent to the Three Mile Harbor LTEMP site.

Figure Intro-1. A StowAway® temperature logger attached to a cement block, ready for deployment.

Eelgrass Monitoring

The 2010 monitor was initiated on 17 August and completed on 26 August. Sampling at each site was distributed among six stations that have been referenced using GPS. At each of the six stations, divers conducted a total of 10 random, replicate counts of eelgrass stem density and macroalgal percent cover in 0.10 m^2 quadrats. Divers also made observations on blade lengths and overall health of plants that they observed. The divers stayed within a 10 meter radius of the GPS station point while conducting the survey. Algae within the quadrats were identified by genus and if it was epiphytic or non-epiphytic on the eelgrass. Divers were careful not to disturb the eelgrass, so as not to cause plants to be uprooted or otherwise damaged.

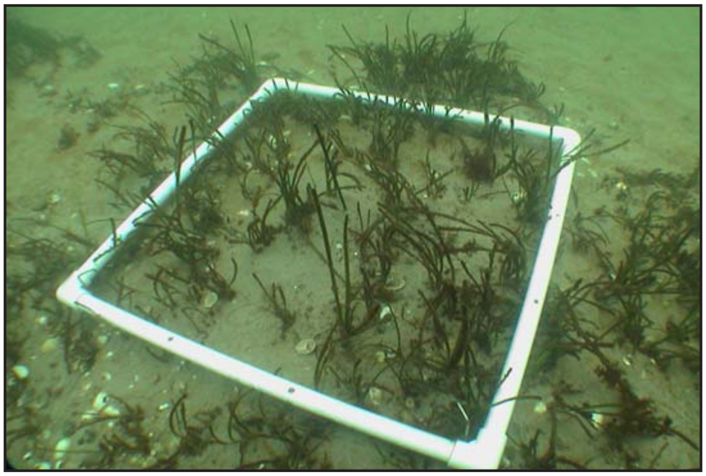


Figure Intro-2. A 0.10 meter^2 PVC quadrat used for eelgrass monitoring.

Data was statistically analyzed using SigmaStat software (SPSS Inc., 1997). The trends, within sites, were analyzed by comparing the 2010 data with the data from the previous years.

Bed Delineation

The deep edge delineations for the 2010 season were to be based on the 2010 Suffolk County Aerial Imagery. The imagery was not released in time for inclusion into this report. However, when the aerial imagery has been released and GIS analysis is completed, the data will be added to the report and an updated issue will be released.

Deep edge mapping using the method described in previous reports of combining a depthfinder with DGPS has become less accurate and efficient due to the continued fragmentation of most of the remaining meadows in the survey. It is for this reason that the survey has come to rely on the availability of aerial photographs to monitor the areal dynamics of the eelgrass meadows. CCE is currently assessing different avenues that would allow for the procurement of aerials the meadows for each survey year.

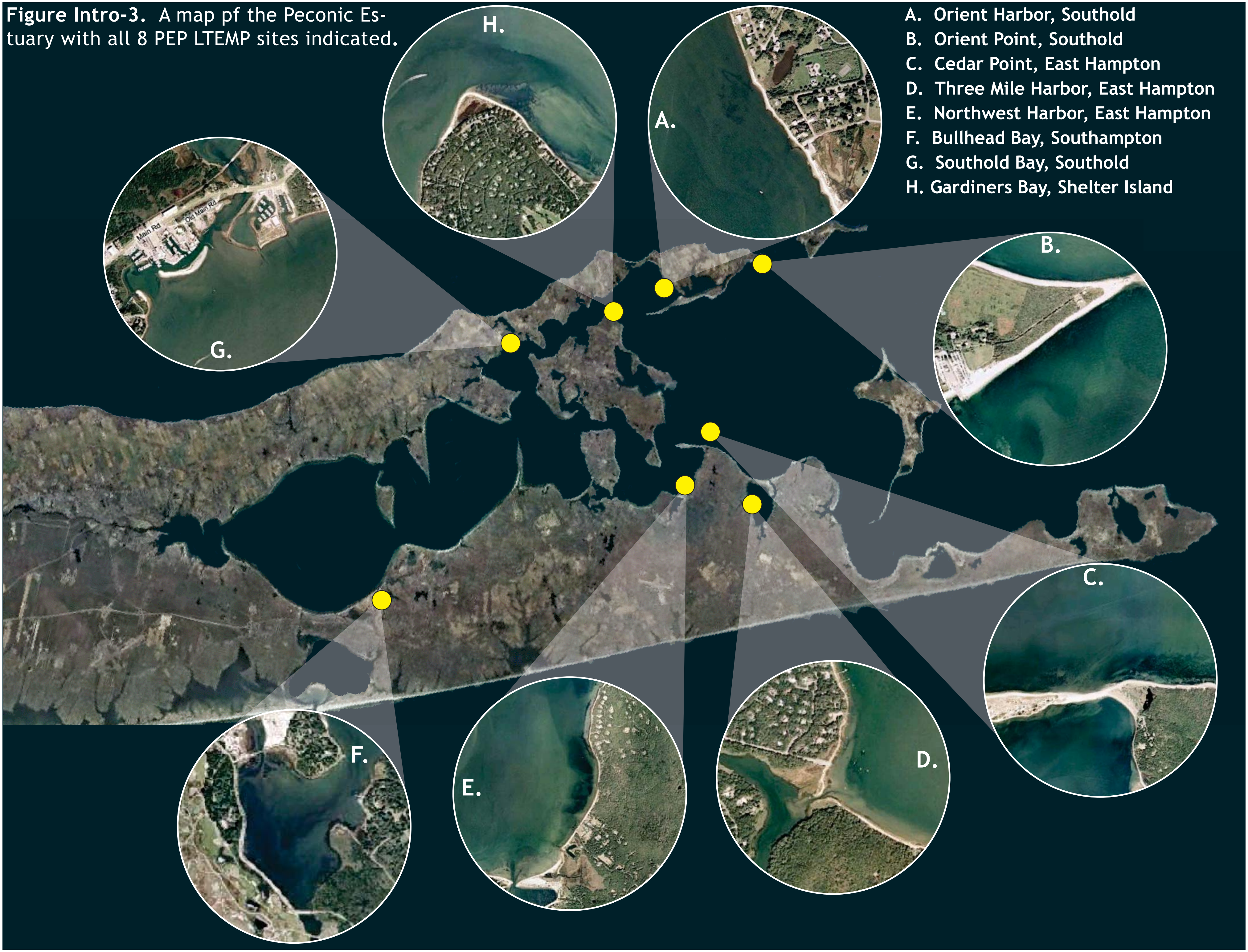


Figure Intro-3. A map pf the Peconic Estuary with all 8 PEP LTEMP sites indicated.

Bullhead Bay is a small sheltered embayment located in the western Peconic Estuary and it is connected to Great Peconic Bay via Sebonnac Creek. The eelgrass meadow at this site is the western most eelgrass population in the Peconic Estuary. This meadow is not only geographically isolated from other extant eelgrass populations, but the environmental conditions under which the eelgrass grows at this site are unique.

Figure BB-1. An aerial view of the Gardiners Bay eelgrass meadow with monitoring stations indicated by the superimposed numbers.

Site Characteristics

Bullhead Bay is a relatively sheltered embayment; however, winds from the north to northwest do influence the bay (Figure BB-1). The sediments of the bay range from coarse sand to loose muck. The sandy bottoms are found along the eastern and southern shore (likely influenced by the winter winds out of the north and northwest) as well as the northern areas of the bay where water is funneled under a bridge. The remaining bay bottom is loose mud of various depths. The mud areas have a relatively high organic content, especially for sediments supporting an eelgrass population. Sediment analysis conducted in 1997 at this site found organic content in some areas exceeded 8% . It seems that this eelgrass population can tolerate these high levels of organics in the sediment. Water quality at the site has always been in question. There is a major golf course (Shinnecock Hills) along the entire west side of Bullhead Bay (separated by a road but with culverts running underneath the road). It is unknown what levels of nutrient/chemical loading may be sourced to the golf course, but it could be significant. Aside from the golf course, the residential housing along Sebonnac Creek could also be a source of nutrient loading for the bay. Bullhead Bay also supports significant populations of mute swans and Canada geese that not only add nutrients from their droppings, but also impact the bed by their grazing on eelgrass. Even though there are several significant potential sources of nitrogen loading to Bullhead Bay, the eelgrass continues to populate this system. One factor that may reduce the impact of poor water quality in Bullhead Bay may be its overall shallow profile. With the eelgrass growing at depths of 6 feet or less at MLW, light is not attenuated to a point where there it is insufficient for eelgrass photosynthesis. Potential research at this site could look at overland runoff and groundwater influences on temperature and/or nutrients on the bay, determining the sources and levels of nutrients, and identifying management practices that could reduce these loads.

Bullhead Bay was visited on 17 August, 2010 for its annual survey. On entering the bay, scattered, reddish patches of water were observed throughout the area.

Table BB-1. Annual mean eelgrass shoot densities and standard error for Bullhead Bay, Southampton.		
Year	Mean Density	S.E.
1997	710	+/- 196
1998	620	+/- 112
1999	548	+/- 79
2000	301	+/- 26
2001	150	+/- 18
2002	201	+/- 14
2004	125	+/- 28
2005	52	+/- 11
2006	171	+/- 34
2007	51	+/- 12
2008	46	+/- 9
2009	19	+/- 8
2010	0*	+/-0

*Eelgrass was observed growing at the site, however it was outside the monitoring stations.

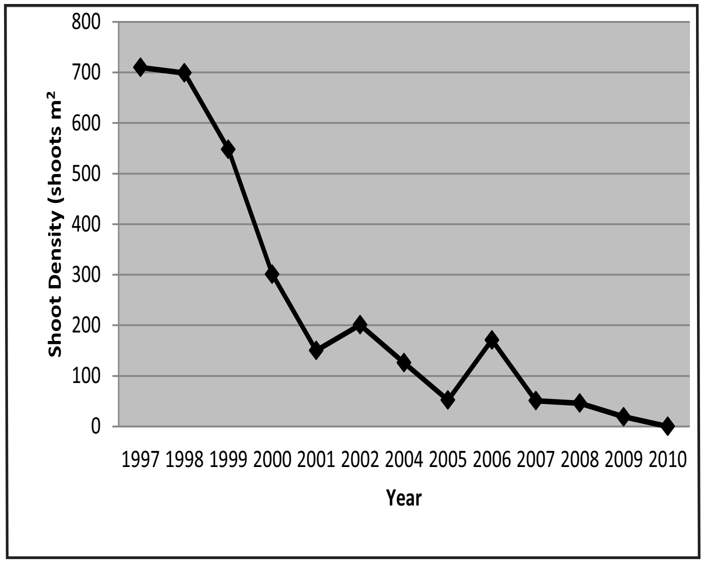


Figure BB-2. Average annual eelgrass shoot density for Bullhead Bay, Southanpton, from 1997-2010.

While a positive identification was not made of the causative agent, it was assumed to be blooms of the dinoflagellate *Cochlodinium polykrikoides*, which was concurrently blooming over large areas of Great and Little Peconic Bays. The bloom was confined to the top two feet of the water column, as observed during the monitoring and did not impact in-water visibility; however, its presence did impair viewing of the bay bottom from the boat, even in some of the shallower locations.

Eelgrass Shoot Density

The monitoring survey for 2010 recorded no eelgrass within the quadrats at any of the six stations in Bullhead Bay. This represents a decline from the 19 shoots•m^{-2} recorded in 2009, and a significant decline from the 46 shoots•m^{-2} from 2008 (Table BB-1, Figure BB-2). Eelgrass was observed by divers swimming between stations in small, 2-12 shoot, clusters throughout the meadow. The plants were small and the clusters appeared to be composed of 1-3 individual eelgrass plants, each supporting several lateral shoots. These observations suggest that these clusters originated from either isolated shoots that had survived from the previous year, or were recruited from seed set the previous year. While individual shoots were not pulled to determine the origin of these eelgrass clusters, it is believed that they are the result of seed recruitment. This hypothesis is supported by the discovery of a relatively large area of extant eelgrass meadow by SUNY Stony Brook researchers in the northwest area of Bullhead Bay, well outside of any of the six monitoring stations. The Stony Brook researchers described the meadow area as patchy, but relatively dense (Carroll and Furman, personal communications). It could be that the plants from this area are producing flower shoots that may become dislodged and "raft" throughout the Bay, dropping seeds in isolated patches. Seeds and seedlings are vulnerible to various disturbance factors and, therefore it is likely that only a small percentage survive to produce the clusters of plants encountered by divers in the LTEMP monitoring area.

Macroalgae Cover

The macroalgae community in Bullhead Bay has proven to be unpredictable (Figure BB-3). The decline of the eelgrass throughout the area has led to a shift in macroalgae species dominance over time. *Spyridia filamentosa* was the dominant macroalgae, but with the loss of eelgrass, which it used to anchor itself, *Spyridia* is no longer the sole dominant macroalgae in the bay. As mentioned in the 2009 report, *Codium fragile* and *Gracilaria tikvahiae* have increased in abundance since eelgrass has declined. *Codium* requires hard substrates to attach, so it has been limited to the southern end of the Bullhead Bay near stations 5 and 6, where the sediment is firm sand and rock and shell are available for attachment.

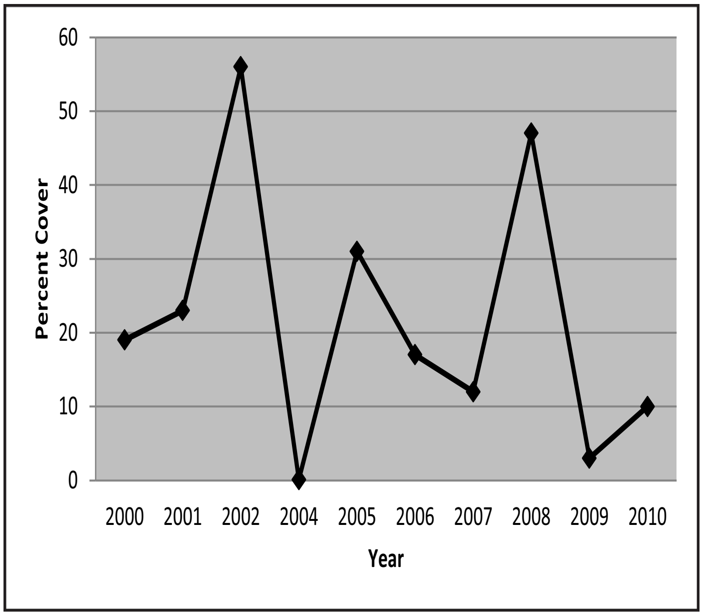
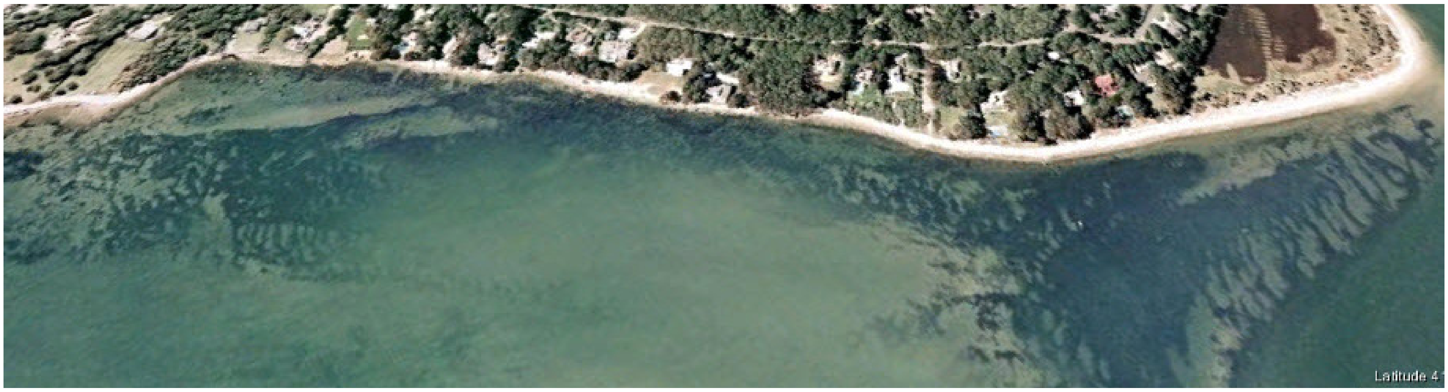


Figure BB-3. The annual mean macroalgae percent cover for Bullhead Bay, Southampton from 2000-2010.

Gracilaria can grow over soft bottom in large mats that are pseudo-anchored to the mud by the burial of the lower portions of the thallus in the mud. *Spyridia* is still found in the bay and it may experience future flucuations in biomass with corresponding changes in the eelgrass population within Bullhead Bay.

Conclusions

The Bullhead Bay meadow has been a dynamic community since at least 2000 (Figure BB-2), suffering some dramatic declines, but also some unexpected recoveries. While the causes of the declines have not been specifically identified, there are several factors that could be contributing to these occurrences. Overall, Bullhead Bay is not an ideal habitat for eelgrass to grow, based on summer high water temperatures, highly organic sediments, poor flushing, and potential nitrogen loading from the golf course and waterfowl. These factors reduce seed recruitment and negatively impact the health of mature eelgrass shoots. Added to these environmental factors the bioturbation caused by waterfowl and crabs and the disturbance by miscellaneous human activities in the Bay and the result is an overall decline over most of the Bullhead Bay eelgrass meadow. The discovery of an isolated, remnant eelgrass meadow in the northwest portion of Bullhead Bay provides an explanation regarding the likely source of the recoveries that have been observed. The future of the Bullhead Bay meadow appears to have several possibilities. First, the remnant meadow could continue to repopulate the rest of the Bay via seed, resulting in an eventual recovery of the entire meadow. Second, this meadow could be transitioning into an annual population, where yearly seed production determines the size of the meadow, and leads into the third possibility for this meadow. If this meadow does evolve into an annual population, due to its small size, it becomes more susceptible to extinction from a single disturbance event. One season of lost or significantly reduced seed production could push the meadow into a position where there is not enough "critical mass," population-wise, to survive over the long term. There are still gaps in our knowledge regarding Bullhead Bay that will hopefully be filled by future work proposed for 2011 and beyond, including a groundwater study, a water-column light availability study, as well as continued temperature and eelgrass monitoring.



The Gardiners Bay eelgrass monitoring site is located on the east side of Hay Beach Point on Shelter Island. The eelgrass meadow starts near the channel connecting Greenport Harbor to Gardiners Bay in the north and extends southward toward Cornelius Point (Figure GB-1). This site is the most exposed, high-energy eelgrass meadow of the original six monitoring sites. The eelgrass meadow is very patchy and an aerial view of the meadow (Figures GB-1 and GB-4) illustrates the natural appearance of a majority of the meadow.

Figure GB-1. An aerial view of the Gardiners Bay eelgrass meadow with monitoring stations indicated by the superimposed numbers.

Site Characteristics

The Gardiners Bay eelgrass monitoring site is situated in an area of high current and is exposed to significant fetch from the north to the east. This exposure causes the site to be especially influenced by winter storms. The current at this site is also the highest encountered at any of the monitoring sites. The eelgrass meadow is established on relatively shallow sand flats to the south and west of one of the two main channels that connect Gardiners Bay to the western Peconic Estuary. Both the high wave exposure and high currents at this site have removed most of the finer sediments leaving the majority of the site's sediment as coarse sand to gravel (and shell). Organic content of the Gardiners Bay site's sediments averaged 0.84% organic material in the sediments with a range of 0.31% to 1.73%. Even this coarse sediment is subject to movement by the hydrodynamic forces acting on this site. Sand waves are readily observable from the air as well as underwater. Mass movement of sediments have been observed to slowly bury eelgrass patches in some areas, while other sections of the meadow experience erosion that leaves eelgrass patches as elevated plateaus. The constant movement of sediments at this site results in a highly patchy eelgrass meadow with a areal coverage that can change significantly over short periods of time.

Water quality has rarely been a factor in the health of this eelgrass meadow. The flushing that this site experiences is more than adequate maintain nutrient concentrations at ambient levels for the eastern Estuary. Due to its significant fetch to prevailing winter winds, the turbidity can become high during storms, but suspended solids tend to settle quickly or be flushed shortly afterward. The changing tides may cause a decrease in water clarity. Depending on the time of year and/or the tide, drift macroalgae can be transported on the currents and significantly reduce clarity. The effects of storms and macroalgae drift are examples of acute events that are infrequent at this site. Chronic water quality issues would be very rare at this site and would likely involve an Estuary-wide event.

Eelgrass Shoot Density

The Gardiners Bay monitoring was conducted on 19 August, 2010. The meadow showed an increase, from 2009 (Figure GB-2; Table GB-1), to an average meadow density, across the all six stations, of 41 shoots•m^{-2}. During the 2010 eelgrass survey at this site, only two stations were found to have recordable (i.e., eelgrass in quadrats) shoot densities; stations 5 and 6. The remaining four stations have lost eelgrass density due to the areal contraction of the meadow by erosional forces. Figure GB-4 illustrates the loss of eelgrass meadow at the Gardiners Bay site from 1999 to 2010. In 1999, all six monitoring stations supported eelgrass within a 10 meter radius of the station midpoint. By 2010, some stations have experienced erosional loss of up to 60 meters shoreward of stations' midpoints (Figure GB-4). The contraction of the meadow from offshore to inshore began in 2006, the first year that multiple stations were found to be devoid of eelgrass, and has steadily continued into 2010. The shoreward erosion is expected to slow as the meadow has retreated to water depths that alleviate some of the disturbance events that have promoted erosion in the past, including prop scars from boats and wave action, which should be breaking further offshore over unvegetated bottom.

Macroalgae Cover

The Gardiners Bay eelgrass meadow has supported the most diverse macroalgae community of all the LTEMP sites. Over thirty diffent species of macroalgae have been identified since 1999. The majority of the species found in this meadow are drift macroalgae that have been transported to the site via currents where it was entangled in the eelgrass meadow. With the meadow shrinking in area and retreating inshore, less macroalgae is being caught by the meadow resulting in a declining trend in macroalgae percent cover for Gardiner's Bay (Figure GB-3). The site still maintains a high diversity with more than 8 species of macroalgae observed, but the loss of eelgrass structure resulted in higher percentages of macroalgae that are simply swept past the site. Unlike other sites that have lost eelgrass, the normal of increased sediment grain size and, consequently, the recruitment of larger macroalgae, like Codium, have been prevented at the Gardiners Bay site due to the high currents.

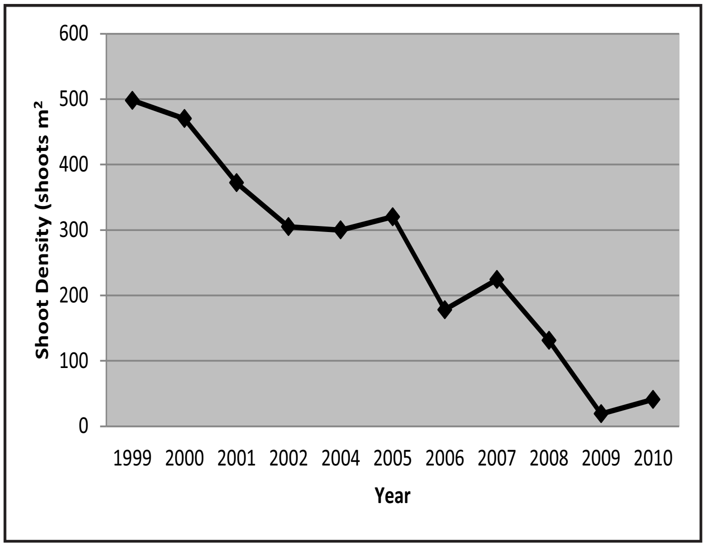


Figure GB-2. Average annual eelgrass shoot density for Gardiners Bay, Shelter Island.

Table GB-1. The average annual eelgrass shoot density for Gardiners Bay from 1999 to 2010, including standard error.

Year	Mean Density	S.E.
1999	499	+/- 37
2000	470	+/- 23
2001	373	+/- 16
2002	306	+/- 25
2004	300	+/- 26
2005	320	+/- 26
2006	178	+/- 31
2007	224	+/- 40
2008	131	+/- 25
2009	19	+/-7
2010	41	+/-14

Conclusions

The major impacts on this meadow are the erosional forces presented by the high current velocity and wave action from storms. The Gardiners Bay site is a large, shallow flat extending out from shore several hundred meters. As seen in Figure GB-4, a little more than a decade ago, the eelgrass extended a distance offshore on this shallow sand flat. Since 1999, not only have the natural processes of current, wave and bioturbation been acting on the eelgrass meadow, but anthropogenic disturbances in the forms of prop scarring and shellfishing have combined to fragment the meadow and facilitate the erosion of eelgrass, especially in offshore areas. The declining trend in eelgrass shoot density reflects the overall loss of eelgrass to the site, but this is due to the decrease in area,

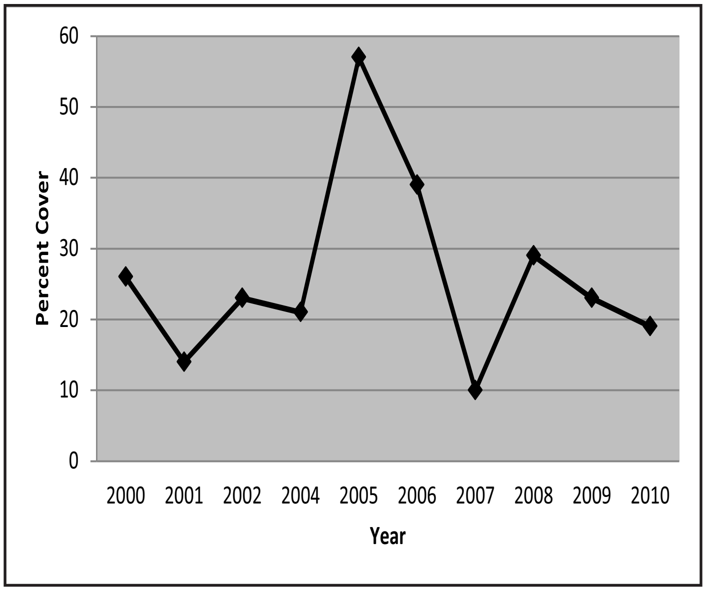


Figure GB-3. Annual mean macroalgae cover for Gardiners Bay from 2000 to 2010.

not specifically due to a decline in the health of the eelgrass meadow. In fact, when the shoot densities are analyzed, omitting stations that have been lost to erosion (all but stations 5 and 6), and compared between years since 2000, there has been no statistically significant change in shoot density since 2002. This shows that, barring the loss of area, the health of the eelgrass, based on shoot density, has been relatively constant for over 6 years.

The Gardiners Bay meadow should begin to see a decrease in the rate of erosional loss from current, waves and boating activities due to the retreat of the meadow to the relative safety of the shallower waters close to shore. However, the meadow is still susceptible to impacts from shellfishing, specifically clamming, and boat-related damage from several boats that are moored in the meadow along the shore. Another potential threat to the meadow in the future may be the hardening of the shoreline at this site. With sea level rise, shoreline hardening prevents the inshore migration of seagrass. Bulkheads also can directly impact nearshore eelgrass meadows by reflecting wave forces back into the meadows resulting in erosion or burial of the shallow edge of the meadow.

Some decisions need to be addressed by the PEP regarding the eelgrass monitoring at this site and the overall protection of the eelgrass meadow. First, with regard to monitoring the eelgrass meadow, the health of the meadow (shoot denisty) is being overshadowed by the loss of area. A proposal will be taken to the PEP TAC, after consideration during the 2011 field season, to move the stations that are no longer in or near existing eelgrass to locations within the new borders of the meadow. Secondly, this meadow needs to be protected from prop-scarring caused by boaters traveling from Greenport to Gardiners Bay. Too many of these boaters stray out of the channel and run across the shallow flats that once supported eelgrass at this site. This situation could be alleviated by the placement of an additional navigation buoy between Hay Beach Point, Shelter Island and the navigation buoy near Bug Light (G "7"). If an navigation buoy would not be allowed, even a seasonal buoy indicating the area to be a seagrass meadow and to avoid boating, similar to the signage used in Florida and Gulf states, could reduce the boating impact to this site.

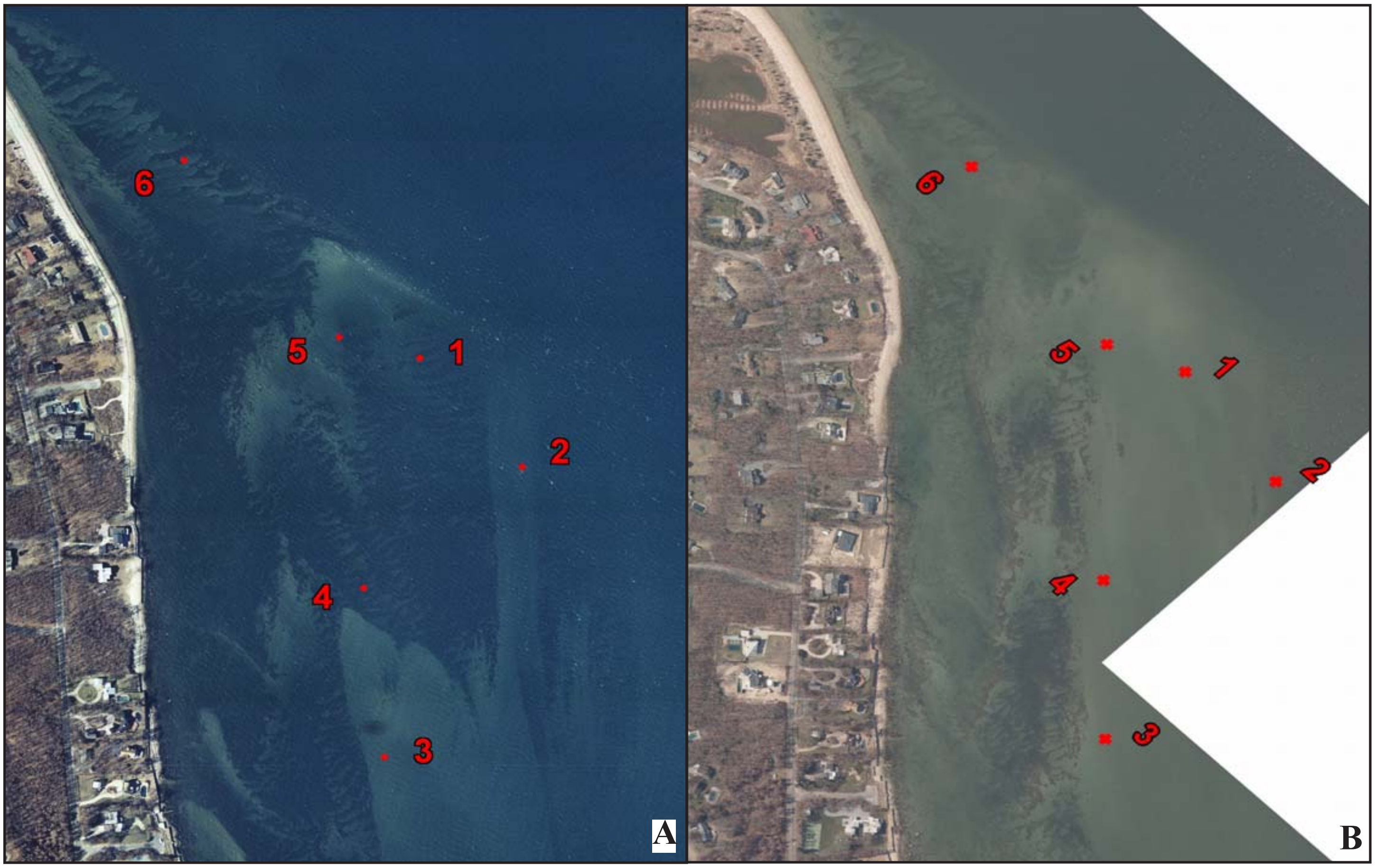


Figure GB-4. Aerial photographs of the Gardiners Bay eelgrass meadow from (A) 1999 and (B) 2010. The erosional loss of eelgrass is evident for stations 1-5 over the 11-year period.

Northwest Harbor is moderately, sheltered harbor located in western East Hampton Town. The Harbor is separated from Gardiners Bay by Cedar Point. While the site has limited fetch in most directions, summer westerlies can create chop and moderate wave action in the Harbor. Figure NWH-1, shows the area of the Harbor that the monitoring program has focused on since the meadows inclusion into the program in 1997.

Figure NWH-1. An aerial view of the Northwest Harbor eelgrass meadow with monitoring stations indicated by the superimposed numbers.

Site Characteristics

As indicated in Figure NWH-1, the monitoring program in Northwest Harbor is relegated to the southern half of the harbor. Within this half of Northwest Harbor, depths range from 3ft (MLW) in the southern areas (Station 1) to 9ft (MLW) at the northernmost stations. The sediment at the site is almost uniform and is dominated by sand. Organic content of the sediment is low, averaging 0.70%. An increase in shell hash, primarily *Crepidula fornicata* shells, has been observed over the years at the deeper station. The shallow stations, in the southern areas, show a general lack of coarse sediment or shell. As mentioned above, Northwest Harbor is relatively sheltered in all directions. The harbor rarely experiences high wave action and most of the monitoring stations are in water deeper than 6ft (MLW), so there is likely limited impact by waves on these areas of the bed. Current in Northwest Harbor is minimal as well.

Water quality in Northwest Harbor is relatively good. There is abundant flushing and development around the Harbor is minimal, resulting in few sources of significant nutrient inputs. Where water quality is not an issue in Northwest Harbor, however, water clarity can be very low at times. Even under moderate winds, that the Harbor experiences, a good amount of material can be suspended, reducing visibility to a few feet.

Eelgrass Shoot Density

The 2010 eelgrass survey of Northwest Harbor was conducted on 17 August, 2010. Unlike western sections of the Peconic Estuary and Orient Harbor, Northwest Harbor had no visible *Cochlodinium* blooms and the water was exceptionally clear for the time of year. The survey of the six stations found no eelgrass, making 2010 the fourth year of no observable eelgrass surviving in the monitoring area (Fig. NWH-2; Table NWH-1). For the second straight year, reports of eelgrass from the north section of Northwest Harbor were made based on the observation of rafted eelgrass material and eelgrass that was

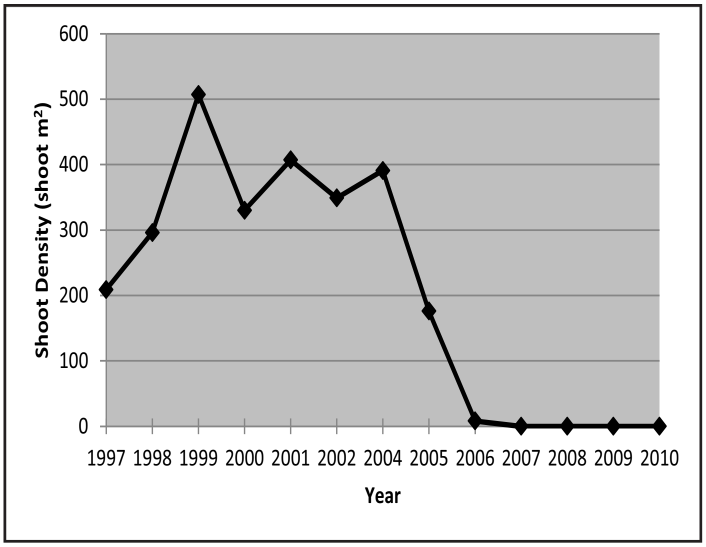


Figure NWH-2. Average annual eelgrass shoot density for Northwest Harbor, East Hampton.

pulled up on an anchor. Unfortunately, the locations of these reports were not exact, so the exact sites were not located. A new aerial survey of the Peconic Estuary may be able to locate possible existing eelgrass, but currently, it represents too large of an area to survey solely by divers.

Macroalgae Cover

Macroalgae percent coverage showed a subtle decline from 2009 to 2010 (Figure NWH-3) from 4.3% down to 2.3%. The macroalgae community in Northwest Harbor seems to have stablized since the abrupt collapse of the eelgrass meadow in 2006. Statistical analysis of the macroalgae cover data shows no

Table NWH-1. The average annual eelgrass shoot density for Northwest Harbor from 1997 to 2010, including standard error.

Year	Mean Density	S.E.
1997	209	+/- 24
1998	310	+/- 21
1999	507	+/- 57
2000	330	+/- 21
2001	409	+/- 20
2002	350	+/- 19
2004	291	+/- 18
2005	176	+/- 16
2006	8	+/- 3
2007	0	+/- 0
2008	0	+/- 0
2009	0	+/- 0
2010	0	+/- 0

significant changes in macroalgae percent cover since 2005, when it dropped from just over 90% down to under 10% in 2006. It is clear that the macroalgae community was dependent on the eelgrass meadow to provide anchorage. With the loss of the meadow, there has been a significant decline in the macroalgae and the overall habitat value for Northwest Harbor.

Conclusions

The eelgrass meadow in the southern half of Northwest Harbor has been extinct since 2007, after a precipitous decline from 2004 to 2006. There has been anecdotal reports that eelgrass still exists along the northern shore of Northwest Harbor, but, to date, CCE has not received a specific location to survey. The 2010 Suffolk County aerial photography was flown in the winter of 2010 and was not available during the 2010 field season. When it becomes available in 2011, it may facilitate the location of any extant eelgrass remaining in Northwest Harbor.

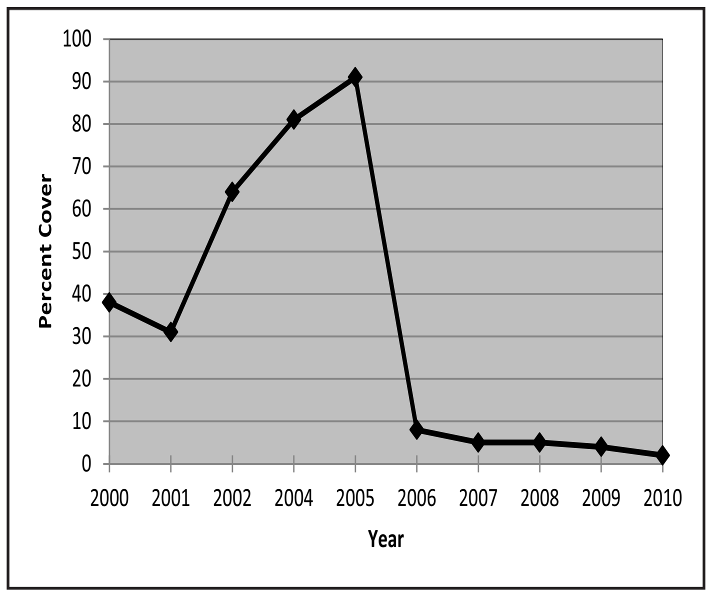


Figure NWH-3. Annual mean macroalgae cover for Northwest Harbor from 2000 to 2010.

Orient Harbor was one of the largest remaining eelgrass meadows when it was chosen for inclusion in the PEP LTEMP in 1997. The meadow, at the time, stretched from the Orient Yacht Club pier to the mouth of Hallock Bay. The meadow covered from 3ft to 10ft depth (MLW) (observations based on 2000 monitoring season) where it abruptly ended. While patchy in some areas of the meadow, the majority of the meadow was continuous eelgrass. The meadow, situated on the eastern shore of Orient Harbor (Figure OH-1) is protected from most of the prevailing winter winds, but northwest, west, and southwest winds have a large fetch across Orient Harbor and moderate wave events are not uncommon. Currents over the eelgrass meadow are relatively low.

Site Characteristics

Figure OH-1. An aerial view of the Orient Harbor eelgrass meadow with monitoring stations indicated by the superimposed numbers.

The Orient Harbor eelgrass meadow, while sheltered from most of the prevailing winter winds, does experience moderate wave action from winds out of any of the western directions that blow for a significant duration. The sediment in Orient Harbor is predominantly sand (average of 62.9%), but it also contains a significant gravel fraction of 30.8%. The average organic content is higher than Gardiners Bay and Northwest Harbor, but it is still at a level that is within eelgrass's tolerance at 1.18%. Typically, the coarser sediments are found closer to shore in the shallower waters with the sand and organic content increasing in the offshore portions of the meadow.

Water quality has generally been favorable for eelgrass in Orient Harbor. Since 1997, there has been an increase in the development along Orient Harbor including new homes and hardened shorelines. While there has been no indication in past analysis of water quality data for this site that this development has had any direct impacts, the building of several large new homes with septic systems in close proximity to the harbor represents a potential impact to the eelgrass meadow. A problem identified at the Seagrass Experts Meeting in 2007 identified that groundwater inputs of nutrients (i.e. nitrogen) and herbicides could have direct impact on eelgrass in some areas of the Estuary. A preliminary study by Suffolk County in 2000-2001 indicated that Orient Harbor had some significant areas of groundwater upwelling. Given the amount of farming that has historically occurred in Orient, it is possible that upwelling water in Orient Harbor may contain contaminants harmful to eelgrass. There are future plans to pursue this issue throughout the Peconic Estuary, with Orient Harbor as a potential site for analysis.

Eelgrass Shoot Density

The eelgrass field survey of Orient Harbor was completed on 26 August, 2010. The presence of *Cochlodinium* was obvious as the boat entered Orient Harbor as large rust-red patches and streaks on the waters surface. The bloom was especially concentrated toward the center of the Harbor near monitoring stations 3-5 (Figure OH-1). Water clarity was below average at the site due, in part, to the *Cochlodinium* bloom that extended from the surface down to almost 3ft under the surface. Absent the bloom, water clarity was further impacted by flock in the water that extented throughout the water column. Monitoring efforts yielded no observed eelgrass in Orient Harbor for the third consecutive year (Fig. OH-2; Table OH-1). The last eelgrass observed within a monitoring station occurred in 2007, when relatively high eelgrass shoot densities were observed at Station 5. Follow-up surveys in subsequent years have not found any eelgrass in this area, even when divers scouted the areas adjacent to the station further than the standard 10-meter radius used for normal monitoring.

Macroalgae Cover

Macroalgae percent cover has displayed highs and lows over the history of the eelgrass monitoring in Orient Harbor (Figure OH-3). The macroalgae percent cover is up slightly from 2009, but it is significantly lower than 2008, when cover exceeded 30% (Fig, OH-3). Patches of macroalgae were observed throughout the site, however a higher percentage of the bottom was unvegetated. Small patches, 1-2 meters^2, of *Spyridia filamentosa* were the most common macroalgae observed by divers. *Codium fragile*

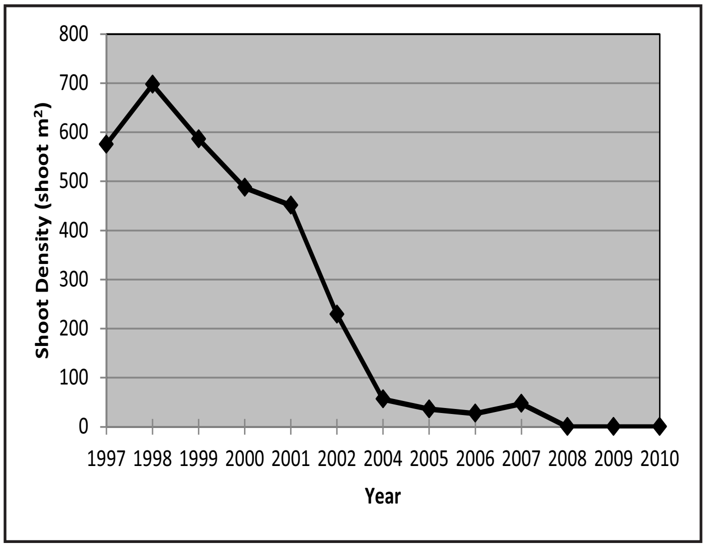


Figure OH-2. Average annual eelgrass shoot density for Orient Harbor, Southold.

Table OH-1. The average annual eelgrass shoot density for Orient Harbor from 1997 to 2009, including standard error.

Year	Mean Density	S.E.
1997	573	+/- 68
1998	696	+/- 82
1999	587	+/- 50
2000	488	+/- 26
2001	452	+/- 16
2002	230	+/- 13
2004	56	+/- 15
2005	36	+/- 12
2006	27	+/- 12
2007	47	+/- 22
2008	0	+/- 0
2009	0	+/- 0
2010	0	+/- 0

formed much smaller clusters, due to its need of a hard substrate to attach, which is limited in Orient Harbor. Several *Ulva* species were observed, but represented a small percent of the macroalgae in the Harbor.

Conclusions

While no eelgrass has been observed in the monitored section of the Orient Harbor meadow for a number of years, eelgrass has been observed in small, scattered patches in adjacent areas. Specifically, eelgrass was observed outside of the mouth to Hallock Bay off of both the Peter's Neck and the Orient State Park shorelines. The patches were small and isolated, but their presence suggests that other, more significant patches of eelgrass may exist in Orient Harbor. Extant eelgrass in the harbor may indicate that conditions at the monitoring site, or at least these areas of the harbor, are favorable for eelgrass growth and may experience an increase in the eelgrass population over time. Aquiring current aerial photographs of Orient Harbor will allow for the current extent of eelgrass in these areas, outside of the eelgrass monitoring area, to be determined and changes in the populations to be tracked over time.

Natural repopulation of the Orient Harbor meadow remains a possibility based on the proximity of extent eelgrass, even though biomass is minimal, and the relatively close proximity (<5 miles) of significant eelgrass population at Hay Beach Point (Gardiners

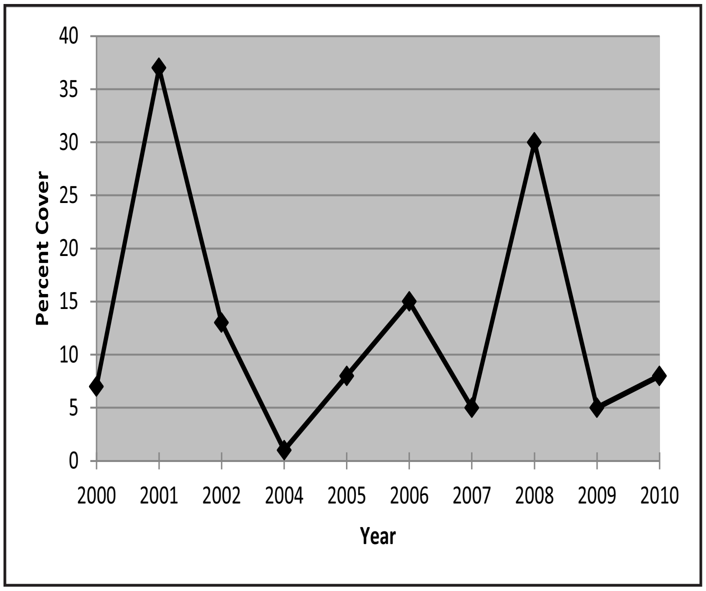


Figure OH-3. Annual mean macroalgae cover for Orient Harbor from 2000 to 2009.

Bay LTEMP site), a large meadow off of Gillette Drive, East Marion, and several newly-identified meadows in Greenport Harbor. Any of these populations could contribute propagules (e.g. rafted flower shoots or vegetative shoots) that could recruit into Orient Harbor.

Eelgrass restoration in Orient Harbor could be considered, but conditions in the Harbor would need to be evaluated to determine if they would support eelgrass transplants. Also, due to shelfishing activities, both commercial and recreational, in Orient Harbor, some protection would have to be afforded to any restoration to minimize human impact.

Southold Bay was the western most eelgrass meadow on the north shore of the Peconic Estuary when it was added to the monitoring program in 1999. The meadow was situated at the mouth of Mill Creek, Southold, which connected Hashamomack Pond to Southold Bay (Figure SB-1). This meadow is located in a high boat traffic area and has three boating channels that divide it. The site is relatively shallow, especially on the eastern side of the meadow, except for the boat channels.

Figure SB-1. An aerial view of the Southold Bay monitoring site with monitoring stations indicated by the superimposed numbers.

Site Characteristics

The Southold Bay eelgrass bed is sheltered from most prevailing winds, so wave exposure is generally low to moderate. However, some storm event in the past, when positioned correctly, have exposed this meadow to high wave action that lead to substantial erosion of the barrier beach and mass movement of sediment within the meadow. The sediment composition of this site is predominantly sand (~80%) with a minimal amount of organic content included in the mix (0.81%). On the eastern side near the channel to Goldsmith's Boatyard and Mill Creek Marina, are boulders, submerged and emergent, that are dense close to shore but decrease in frequency moving offshore. Across the main channel to Mill Creek toward the area of Budds Pond, the sediment becomes less firm, indicating an increase in the finer silt/clay fraction and organic content.

Water temperatures within the Southold Bay meadow contributed to the chronic stress that the eelgrass population faced during the summer months. The shallow nature of the bed allowed for rapid warming, especially on calm, summer days and lead to stress in the shallowest areas. In addition to this, the warm water flushing into the meadow from Hashamomack Pond, and the temperature stress on eelgrass at this

Table SB-1. The average annual eelgrass shoot density for Southold Bay from 1997 to 2009, including standard error.

Year	Mean Density	S.E.
1999	805	+/- 69
2000	471	+/- 31
2001	467	+/- 32
2002	384	+/- 16
2004	210	+/- 23
2005	30	+/- 8
2006	0	+/- 0
2007	0	+/- 0
2008	0	+/- 0
2009	0	+/- 0
2010	0	+/- 0

site could contribute substantially to the stress the meadow already experienced from the turbidity, nutrient loading and constant boat traffic.

Water quality at Southold Bay has always been an issue. While the site receives adequate flushing from the tidal currents moving between the western Estuary and Gardiners Bay, the eelgrass meadow is also positioned to receive waters from Hashamomack Pond, which is a warm, nutrient-loaded water body. The waters from Hashamomack are also turbid, causing periodic low light events in the eelgrass meadow throughout the year.

Eelgrass Shoot Density

Southold Bay has not supported eelgrass within any of the monitoring stations since 2006 and, it is believed, the entire area since 2007 (Table SB-1; Figure SB-2). The eelgrass survey visit to the site on 17 August, 2010 followed the trend of previous years with no recorded observations of extant eelgrass at the Southold Bay site. The conditions on the day of the survey were calm, but water clarity across the site was poor. The high turbidity reduced visibility to under 2-feet. This has been an issue at this site since it was first included into the LTEMP program in 1999. The poor water quality would definitely have negatively impacted the eelgrass that once grew in the deeper water at this site (>6 ft), but it is unlikely that the level of turbidity commonly encountered at the site would have prevented shallow-growing eelgrass from receiving enough light to grow. Temperature stress and disturbance events are likely the primary factors in the loss at this site.

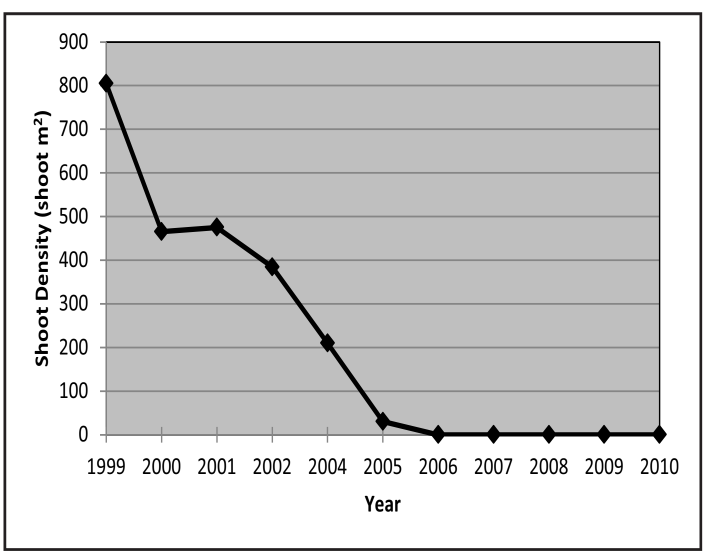


Figure SB-2. Average annual eelgrass shoot density for Southold Bay, Southold.

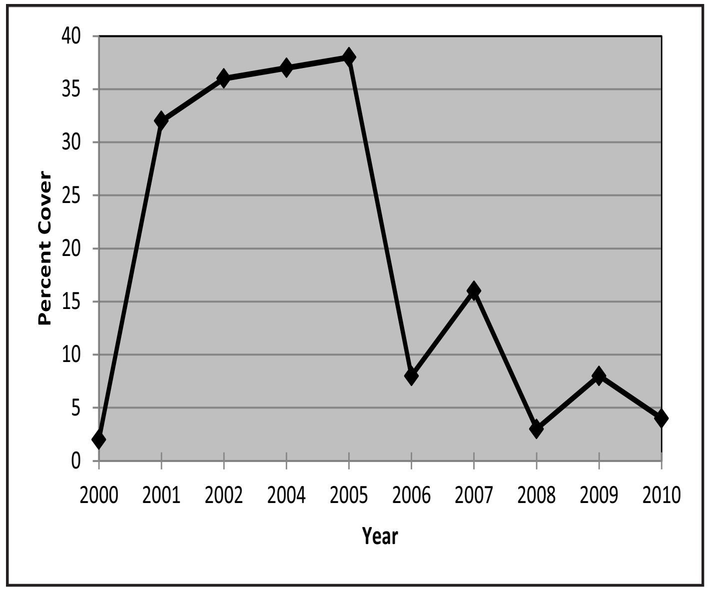


Figure SB-3. Annual mean macroalgae cover for Southold Bay from 2000 to 2009.

Macroalgae Cover

As mentioned above regarding water quality, the Southold Bay site receives a pulse of nutrient-laden water from Hashamomack Pond with every outgoing tide. With this source of nutrients, it should be expected that the site would support a large and healthy macroalgae community. However, this has not been the case since the eelgrass meadow suffered a major die-back from 2004-2006 (Fig. SB-2). With the loss of eelgrass, there is little anchorage for macroalgae at this site. Due to currents and wave action, drift macroalgae has a very short residence time on the shallow flats, and larger macroalgae, like *Codium,* are confined to the submerged boulders situated near the channel to Goldsmith's Marina (near station 1), or to the few, large hard clam shells that have not been buried by sedimentation.

Conclusions

The water quality conditions at the Southold Bay site will be evaluated in 2011, specifically water temperature and light availability. Depending on those results, further testing may be conducted to determine the total suspended solid (TSS) and Chlorophyll A (ChlA) in the water column and if they represent a major limiting factor to eelgrass growth. With the recent identification of eelgrass meadows around Greenport Harbor (~2 miles away), if conditions are found to be comparable in Southold Bay, CCE might consider trying some test plantings to determine the potential of Southold Bay to, once again, support an eelgrass meadow.

Three Mile Harbor is the eastern most meadow in the eelgrass monitoring program. Situated inside a large, protected harbor, the eelgrass once thrived throughout this system. The monitoring site for the PEP is located on the western side of the Harbor near the mouth of Hands Creek (Figure TMH-1). The area includes an East Hampton Town mooring field as well as a designated water ski area that has been extended over the years to include the water over Stations 1 and 2 (Figure TMH-1).

Figure TMH-1. An aerial view of the Three Mile Harbor monitoring site with monitoring stations indicated by the superimposed numbers.

Site Characteristics

The monitoring site in Three Mile Harbor has minimal fetch in all directions and is considered a low wave exposed site. The sediments over much of the monitoring area would support this sheltered classification as they tend to be higher in silt/clay and organic material than the some of the other more energetic sites. The sediments within the eelgrass meadow were composed of 86% sand and 13% silt/clay. The organic content averaged to 1.78% (with a maximum of 2.3%). Generally, the inshore stations have the lower silt/clay and organic content and the outer station, especially Station 2, have the finer sediments with higher organic content.

Water temperature at this site has never been directly monitored by deployed instruments, however anecdotal evidence suggests that this meadow rarely experienced temperatures higher than 25C. Temperature has never been considered a significant stressor for this eelgrass meadow.

Three Mile Harbor's water quality is relatively good. Considering the boating population, as well as the residential population surrounding the Harbor, the potential for eutrophic conditions is very high. The boating population is supplied with a pumpout boat and the various marinas also have these capabilities

Table TMH-1. The average annual eelgrass shoot density for Three Mile Harbor from 1997 to 2009, including standard error.

Year	Mean Density	S.E.
1999	361	+/- 49
2000	193	+/- 17
2001	209	+/- 13
2002	135	+/- 10
2004	29	+/- 6
2005	8	+/- 3
2006	0	+/- 0
2007	0	+/- 0
2008	0	+/- 0
2009	0	+/- 0
2010	0	+/- 0

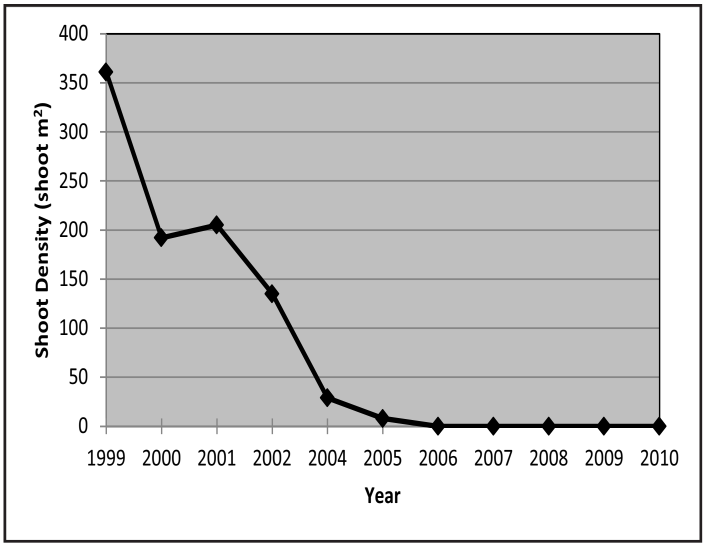


Figure TMH-2. Average annual eelgrass shoot density for Three Mile Harbor, East Hampton.

and that seems to have that source of nutrient loading under control. There have been no other indications that water quality, in regards to nutrient loading, is a problem in Three Mile Harbor near the eelgrass monitoring site. Water clarity issues have been encountered in the meadow, stemming from the proximity of the water ski area, which had been expanded to include the eastern portion of the meadow (Stations 1 and 2; Figure TMH-1). Ski boats running this area at low tide readily fluidize and suspend the finer sediments which, in turn, reduce the light penetration at the site. As it may take hours for fine particles to settle back out of the water column, it is possible that eelgrass at this site suffered lower light availability for a considerable length of time after the initial point of disturbance.

Eelgrass Shoot Density

The 2010 eelgrass monitoring survey of Three Mile Harbor recorded no observations of eelgrass within the monitoring area (Figure TMH-2; Table TMH-1), when visited on 18 August 2010. Eelgrass was last observed growing at the site in 2005, but in the following years, floating eelgrass wrack was found near the monitoring area, leading to the possibility that there was an extant patch of eelgrass in the vicinity of the Three Mile Harbor site. As was mentioned in the 2009 PEP LTEMP report, eelgrass was discovered in Hands Creek, adjacent to the monitoring area, during an eelgrass study CCE was conducting for East Hampton Shellfish Hatchery. The eelgrass density in 2009 in Hand Creek was 91 shoots·m^2 and in 2010, the average shoot density was 98 shoots·m^2 (Petersen-Manzo, et al., 2009a; 2009b; 2010a; 2010b).

Macroalgae Cover

Macroalgae percent cover had been on the increase since 2004, and continued to increase in 2010 (Fig. TMH-3). The 2010 eelgrass survey found the site average macroalgae cover to be just under 50% for the site, which represents the highest cover ever recored for the Three Mile Harbor site. The majority of the macroalgae recorded was concentrated in stations 3-6 over the sand and gravel sediment found inshore and throughout the mooring area. Large patches of *Gracilaria tikvahiae* and *Spyridia filamentosa* were commonly encountered in the area of Stations 4-6 (Fig. TMH-1). *Codium*, while present, was primarily observed as drift, tangled in one of the mats of algae described above.

Conclusions

Past PEP LTEMP reports have listed the number of disturbance factors that this meadow had faced prior to its complete collapse in 2006. In the 2009 report, it was suggested that test plantings of eelgrass outside of the areas of influence of boating traffic, both from the mooring field and water skiing area, might determine how detrimental to eelgrass growth these activities are. However, with the technology that CCE currently possesses, there is no need to sacrifice eelgrass transplants to determine if turbidity is an issue in Three Mile Harbor. Instead, light loggers could be deployed to the site for up to one week at a time to collect data on the quality and quantity of

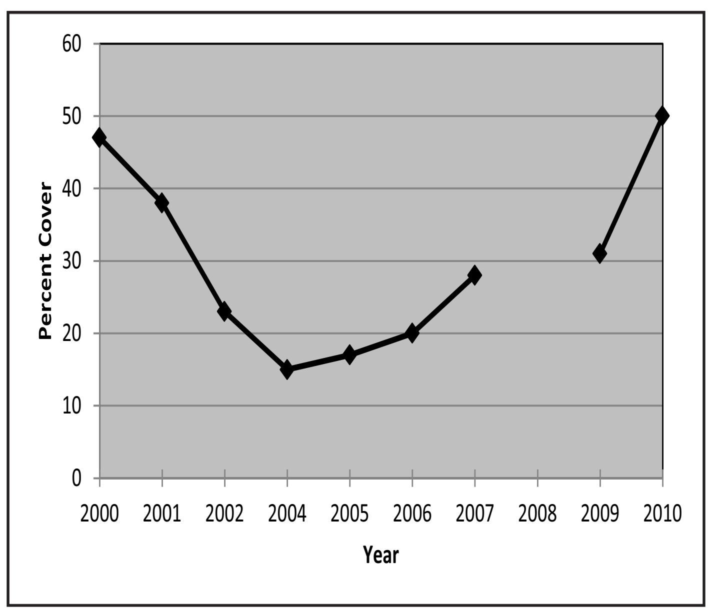


Figure TMH-3. Annual mean macroalgae cover for Three Mile Harbor from 2000 to 2009.

light received near the sediment. Comparing this data over the course of a growing season to the known light requirements of eelgrass, a determination could be made whether eelgrass could currently grow at the site, based solely on the light conditions. Once the light conditions are addressed, other water quality and disturbance parameters should then be investigated before restoration could be considered.

Cedar Point is a narrow peninsula that separates Gardiners Bay from Northwest Harbor in East Hampton Town. The north shore of Cedar Point (Gardiners Bay side) supports a large, but patchy, eelgrass meadow. The site is highly exposed to winds out of the north and there is a moderate current. The Cedar Point site was added to the PEP LTEMP in 2008. It has supplied the program an extant eelgrass meadow, providing data on eelgrass health, which can no longer be collected from the several meadows that have lost their eelgrass. An overview of the site and the monitoring stations can be found in Figure CP-1, below.

Figure CP-1. An aerial view of the Cedar Point monitoring site with monitoring stations indicated by the superimposed numbers.

Site Characteristics

Cedar Point is open to all northern fetches across Gardiners Bay. High wave exposure during winter storms would be common and the sediments and eelgrass patch dynamics support this fact. Although the sediment analysis for this site have not been completed at the time of this draft, they will be included in the 2011 LTEMP report. Observations made during the eelgrass monitoring survey and other actvities suggested that the overall sediment texture would be coarse. The first impression one gets is of diving on a rocky shore along the eastern Long Island Sound. There are plentiful boulders, rock and gravel. Sand would likely be the dominant substrate, but gravel will likely be the secondary sediment in some sections of the meadow. Whatever the results, the large rocks and boulders that characteristic at Cedar Point will not be sampled, as they are too large for the sediment corers.

Water temperature and quality should be similar Gardiners Bay. The water should be relatively low in nutrients (specifically, nitrogen) and the summer high water temperatures should follow those of Orient Point. Cedar Point was included in a water temperature monitoring in 2010 and that data will be included in a separate report, specifically detailing the Estuary-wide results of that survey.

Eelgrass Shoot Density

The 2010 eelgrass survey was the third season of data collection at Cedar Point. Observations for the survey were collected on 18 August, 2010. Conditions were calm and visibility approached 10-feet. Average eelgrass shoot density increased for the third year. The 500 shoots·m^2 eelgrass density represented a significant increase in shoot density from 2009 (Fig. CP-2; Table CP-1). This increase if likely in part due to the

Table CP-1. The annual average eelgrass shoot density for Cedar Point for 2008-2010, including standard error.

Year	Mean Density	S.E.
2008	285	+/-28
2009	385	+/-34
2010	500	+/-34

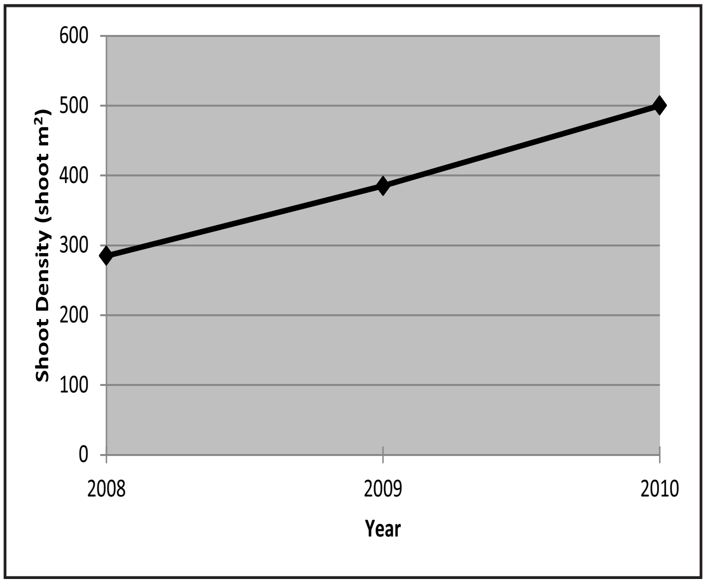
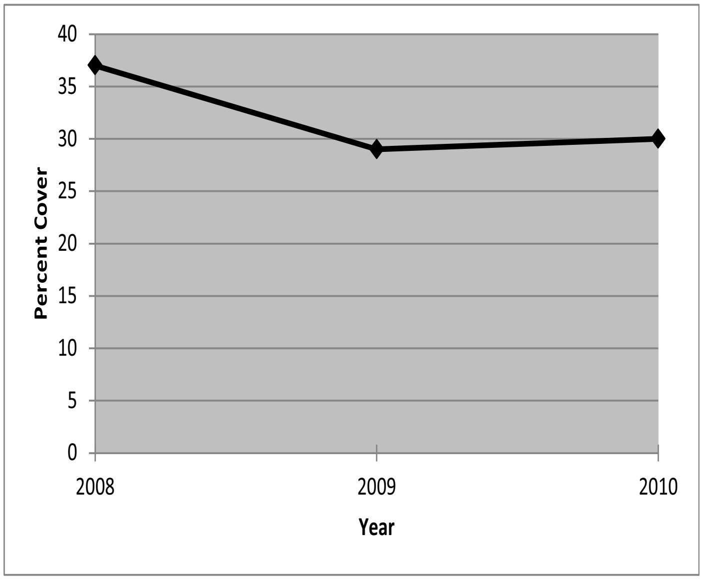


Figure CP-2. Annual mean eelgrass shoot density for Cedar Point, East Hampton for 2008-2010.

reduced number of erosional holes in the meadow, especially at Stations 5 and 6. Also, there may have been a significant increase in the number of lateral shoots present in 2010 over the 2009 survey. Overall, the meadow and individual plants looked healthy.

Macroalgae Cover

Cedar Point supports a high biomass and diversity of large macroalgae, including *Sargassum filipendula*, *Halosiphon tomentosus, Fucus* species, and the infrequent *Saccharina latissima*, due to the prevalence of boulders and other coarse substrate at the site. The large substrate slowly decreases in frequency as one moves offshore, but smaller macroalgae take advantage of what hard substrate remains. The macroalgae percent cover for Cedar Point was up slightly from 2009, but at 30% cover, it is still on the low end of macroalgae cover when compared to other LTEMP sites. Other seaweeds observed during the 2010 survey included: *Spyridia filamentosa*, *Ectocarpus siliculosus*, *Champia parvula*, and *Polysiphonia* species in the drift, while C*hondrus crispus*, *Petalonia* and *Punctaria* colonized rock, shell and exposed eelgrass rhizome.



Conclusions

Cedar Point is an excellent example of a healthy, and relatively undisturbed natureal eelgrass meadow. The rocky nature of the site discourages shellfishing and boating in the meadow. The pound net that was located near station 6 in 2009, was not redeployed in the area for 2010. The upland adjacent to the site is a Suffolk County park, so the meadow is also protected from terrestrial impacts, including hardening of the shoreline and residential runoff. From 2009, it appearred that some of the erosional “blow-outs” that were observed have filled in and eelgrass is starting to recolonize the open patches.

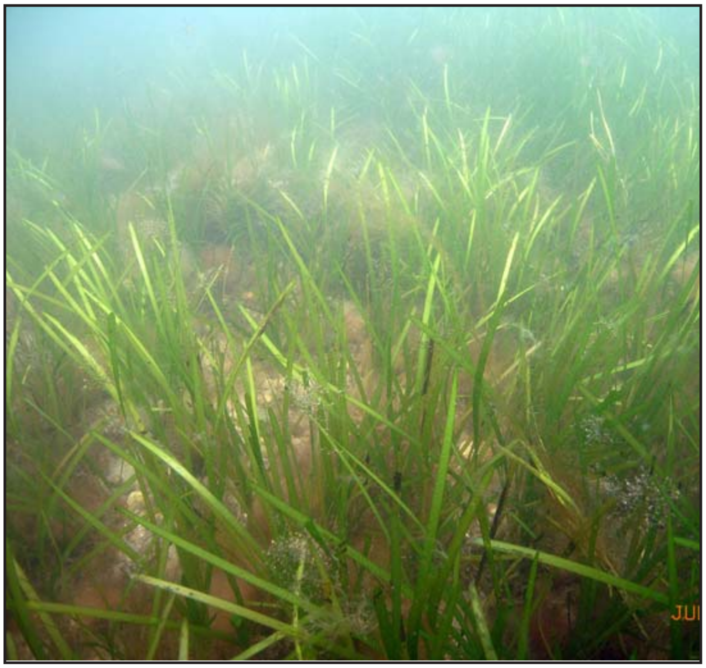
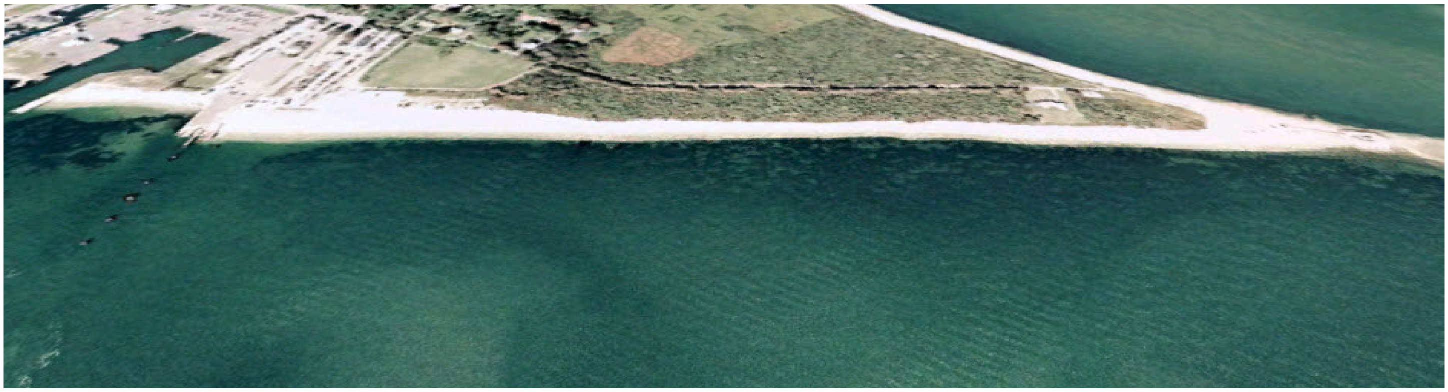


Figure CP-2. An underwater view of an eelgrass patch at Cedar Point, East Hampton.



Orient Point is the eastern tip of the north fork of Long Island. To the south of the point is Gardiners Bay and the eelgrass meadow that was added to the Peconic Estuary Program Long-term Eelgrass Monitoring Program for 2008. The meadow was a large, relatively dense meadow until October of 2006, when, after a week of strong winds out of the east, the meadow suffered extensive losses from the mid-bed to the deep edge. The nearshore area of the meadow saw minimal loss, but the result was that three-quarters of a large, healthy eelgrass meadow was devastated in a short period of time. Since that time, CCE has established a sentinel site at Orient Point to monitor the recovery of the meadow along three permanent transects (Fig. OP-4). It was also decided around this same time to add two new meadows to the PEP LTEMP to balance the loss of eelgrass at four of the six monitoring meadows and Orient Point was chosen for the opportunity to monitor a meadow in recovery.

Figure OP-1. An aerial view of the Orient Point monitoring site with monitoring stations indicated by the superimposed numbers.

Site Characteristics

The Orient Point meadow has large fetches in almost all directions. Except for winds out of the west and northwest, the site will feel the influence of almost any wind at the site. Waves, such as those experienced during the storm event in October 2006, can be large and result in mass movement of sediments at this site. Orient Point is considered to be a high wave exposure and moderate current site. The meadow shows obvious indications that the wave and current forces influence the meadow. Erosional "blowouts" are common throughout the shallow portions of the meadow. Where these blowouts occur, the eelgrass meadow abruptly end at a drop off of several inches to one foot. The edge of the meadow is often left hanging over the "blow-out."s Figure OP-2 shows a characteristic blowout found in the Orient Point meadow.

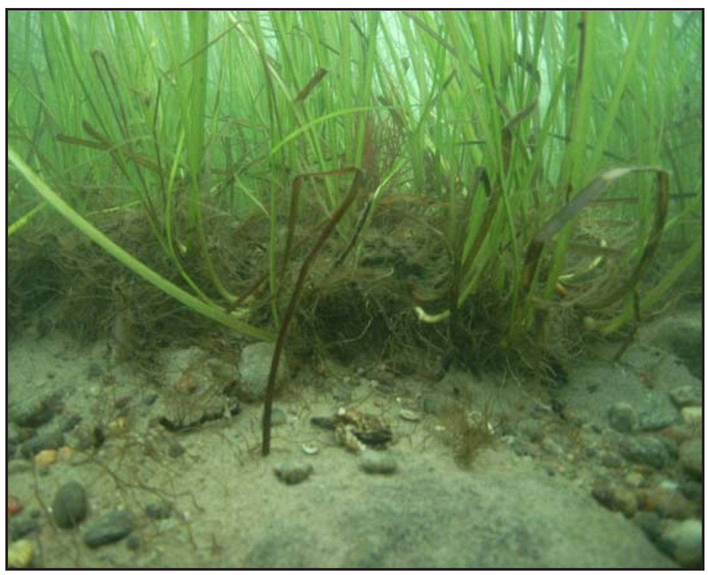


Figure OP-2. A side view of a "blowout" where a openning has been eroded in the meadow. The eelgrass is left to grow out over the edge where it is eventually dislodged. Also notice the coarse sediments left behind after the erosion.

Table OP-1. The annual, average eelgrass shoot density for Orient Point, including standard error.		
Year	**Mean Density**	**S.E.**
2008	47	+/-9
2009	171	+/-28
2010	298	+/-33

The sediments at this site were analyzed initially in 1997, when the site was considered for the monitoring program. The 1997 analysis found that the sediment was predominantly sand (68.5%) with a significant amount of gravel (26.7%). Organic content of the sediment was found to be relatively low at an average of 0.86%.

Eelgrass Shoot Density

After 4 years of recovering from a series of autumn storms that resulted in almost 2/3 of the eelgrass being physically uprooted/damaged by waves, the Orient Point meadow is starting to see some improvement. Eelgrass shoot density has continued to show significant increases, particularly in the mid to shallow sections of the meadow. Deeper areas of the meadow (<10-feet) have not yet recovered fron the erosional loss of eelgrass. The storms had left very small remenant fragments that were then susceptible to crab damage and burial/erosion from other winter storms. The recovery of the deep section of meadow has proven slow, but there is evidence that it is progressing, based on the merging of many small patch-

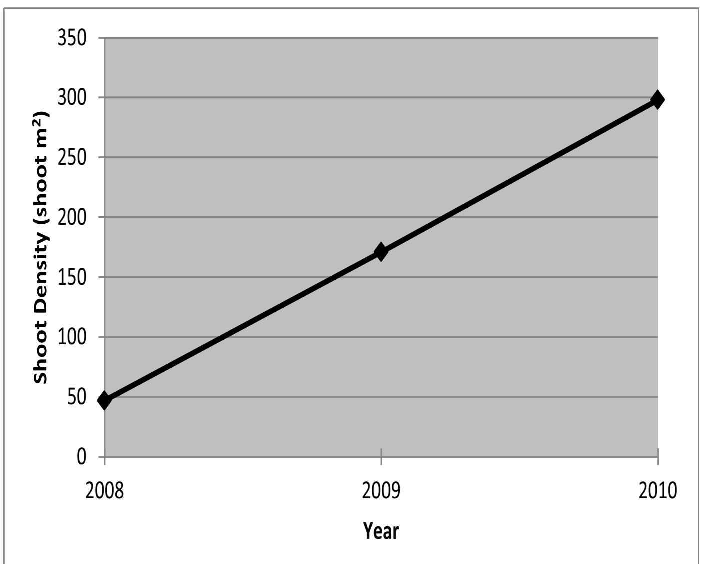


Figure OP-2. The annual average eelgrass shoot density for Orient Point for 2008-2010.

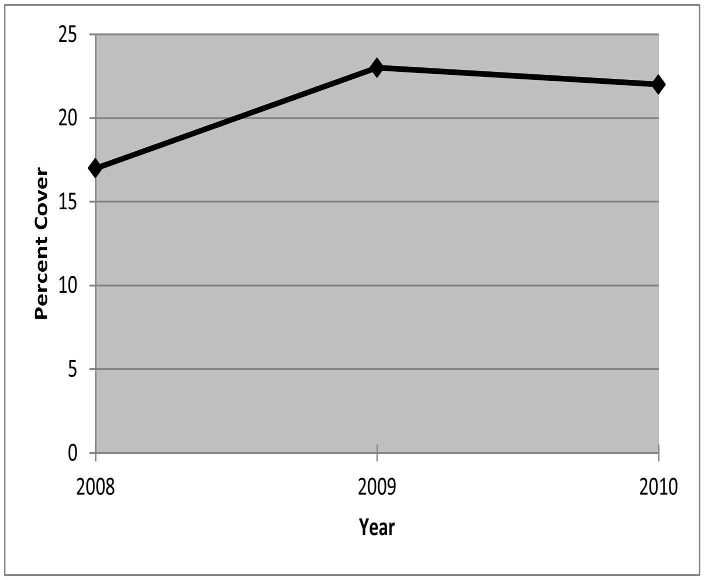


Figure OP-3. The annual mean macroalgae percent cover for Orient Point.

es. Station 6, the northernmost station and closest to Plum Gut, has shown little recovery, likely due to the high current and wave energy to which this station is exposed. The average shoot density for the meadow is slowly approaching pre-storm density, but the 2010 density of 298 shoots·m^2 (Fig. OP-2; Table OP-1), is still short of the 400-500 shoots·m^2 that once characterized this meadow.

Macroalgae Cover

The macroalgae percent cover did not change significantly since 2009. Compared to the pre-storm conditions, there is far less algae at the site due to the loss of so much of the meadow that provided anchorage and reduced erosion and scour around the existing hard substrate. As the meadow fills back in, an increase in the cover of macroalgae is expected.

Conclusions

There is a significant recovery occuring in this meadow, as evidenced by the three years of data presented in this report. While eelgrass is recolonizing areas that were lost to the 2006 event, observations suggest that the deeper sections of the meadow (>10ft), once extending over 200 meters offshore, may experience a very slow recovery, if at all.

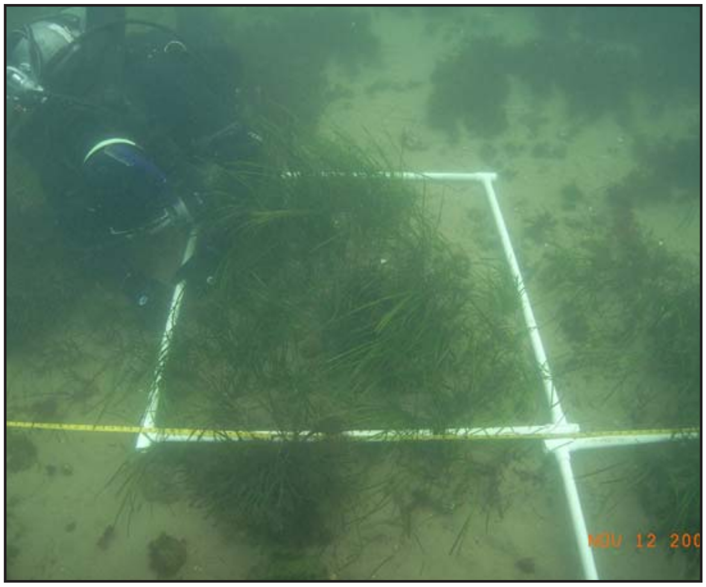


Figure OP-4. A CCE diver counts eelgrass shoots in a 1-meter^2 quadrat along one of three permanent transects established in Orient Point to monitor the meadows recovery from a 2006 storm.

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