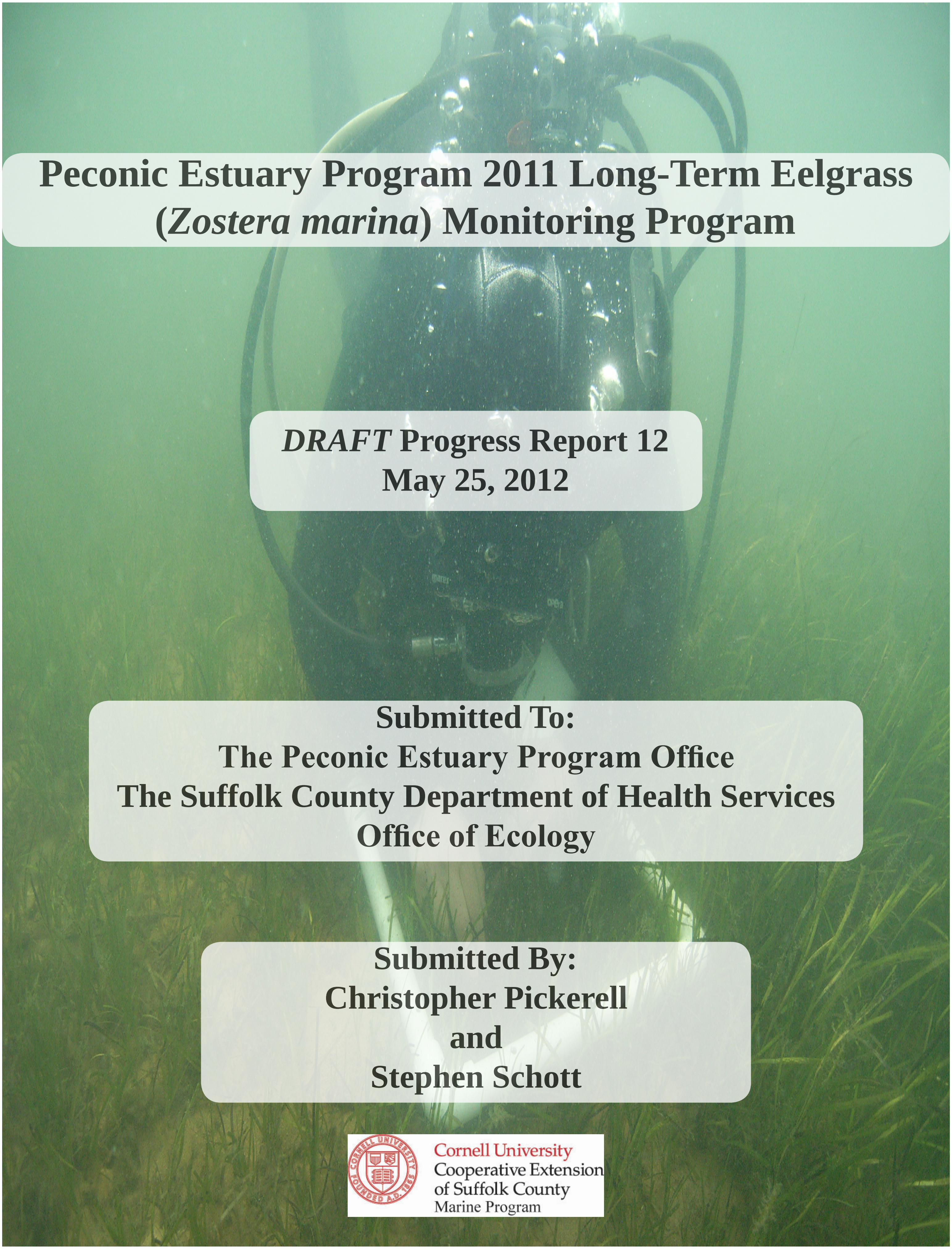

Peconic Estuary Program 2011 Long-Term Eelgrass (*Zostera marina*) Monitoring Program

DRAFT Progress Report 12
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The Peconic Estuary Program Office
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Office of Ecology

Submitted By:
Christopher Pickerell
and
Stephen Schott

Cornell University
Cooperative Extension
of Suffolk County
Marine Program

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 eight 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.

Table Intro-1. The eight reference eelgrass beds and the townships in which they 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

Water temperature has been increasingly identified as an important environmental parameter to monitor in regard to eelgrass health. High water temperatures, above 25°C (77°F) have been found to reduce the ability of eelgrass to efficiently produce energy that can be used for growth or stored in its rhizomes. Very high water temperatures, greater than 30°C (86°F), may cause the plants to slough above-ground biomass (i.e., blades) and possibly result in mortality of the entire plant. Temperature effects eelgrass by influencing the plants primary production efficiency. This efficiency is typically represented as the ratio of photosynthesis to respiration (P:R) in a plant. Eelgrass, being a temperate water plant, has recorded optimal P:R for temperatures ranging from 10-25°C (50-77°F). When temperatures increase above 25°C, the rate of respiration begins to out-pace the rate of photosynthesis, resulting in a net negative production for the plants. However, the imbalance in P:R at high temperatures can be overcome by the eelgrass if the plants receive enough irradiance. Even given unlimited light, water temperatures reaching and exceeding 35°C (95°F) are lethal to eelgrass.

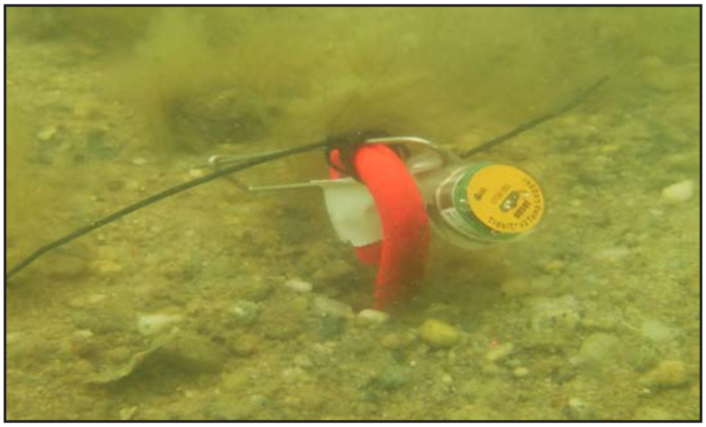

Figure Intro-1. A TidBit v2® temperature logger attached to a screw anchor, deployed on-site.

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. While the complete temperature survey data will be presented in its own report, the data for the included LTEMP sites is included in this report. Water temperature loggers were deployed to five current LTEMP monitoring sites (Bullhead Bay, Cedar Point, Gardiners Bay, Orient Point, and Southold Bay) for the 2011 season. A temperature logger was also deployed in Hands Creek, an extant eelgrass meadow adjacent to the Three Mile Harbor LTEMP site. The water temperature results for the above listed sites will be used in conjunction with the light data collected at the sites.

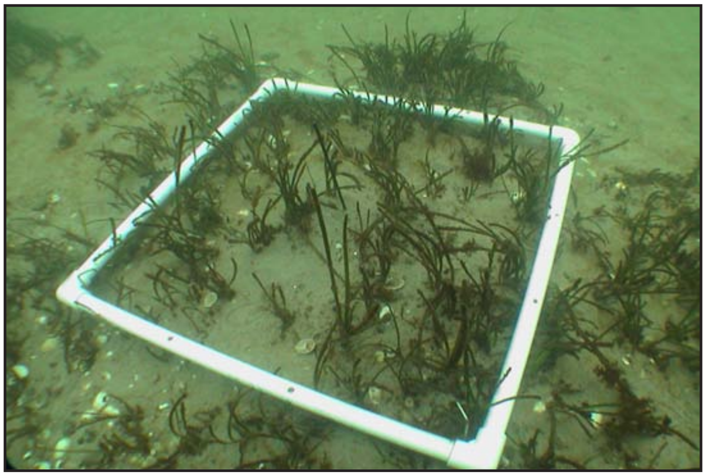

Figure Intro-2. A 0.10 meter^2 PVC quadrat used for eelgrass monitoring.

Light Logger Deployment

The 2011 season saw the first deployment of light loggers in the Peconic Estuary, with Bullhead Bay as one of the target sites. While the light logger project is not part of the PEP LTEMP, but rather its own program under the PEP, the data collected at LTEMP sites will be included in this report.

The Odyssey® PAR loggers continuously record the amount of Photosynthetically Active Radiation (PAR) that reaches the bottom of an embayment, allowing biologists to determine if a system is receiving enough light, at a given depth below mean low water (MLW), to support a submerged plant (i.e., eelgrass). Light data was taken, primarily, at the vegetated sites within the PEP LTEMP including: Cedar Point, Gardiners Bay, and Orient Point. Southold Bay, the site of a recently extinct eelgrass meadow and LTEMP site, was also included in the survey. Bullhead Bay had light loggers deployed only during the summer months, July-September. The loggers were deployed on or around the first day of the month for 7 days of recording. The logger measured the quantity of PAR at set intervals throughout each day. The loggers were retrieved after the 7 days and the data offloaded, then analyzed in Microsoft Excel®.

The light logger data allows for the determination of two important parameters for plants- H_{comp} and H_{sat}. H_{comp} represents the number of hours that eelgrass spends at or over the level of light intensity that is required for photosynthesis to equal the rate of respiration, also known as the Compensation Point. For the Peconic Estuary, it was decided to use the Compensation Point calculated for an eelgrass population in Woods Hole, Massachusetts, which was reported as 10 $\mu mols \cdot m^{-2} \cdot s^{-1}$ (Dennison and Alberte, 1985). The second parameter is H_{sat}, which is the number of hours eelgrass is exposed to PAR at an intensity at which the rate of photosynthesis is no longer limited by the amount of light the plant is receiving. This is known as the Saturation Point. H_{sat} is where plants generate the energy to support growth and development beyond the basic metabolic requirements. As with the Compensation Point, the light intensity for the Saturation Point was taken from Dennison and Alberte (1985) and considered to be 100 $\mu mols \cdot m^{-2} \cdot s^{-1}$ for the Peconic Estuary. Dennison (1987) calculated that his eelgrass population required a daily average of 12.3 hours (h) H_{comp} over the course of the year, to meet basic metabolic requirements, and this was 12.3h period was adopted for the PE eelgrass meadows. In regard to H_{sat}, Dennison and Alberte (1985) calculated that their eelgrass population required a minimum of 6-8h per day. Taking the data collected in the Peconic Estuary in 2010 and comparing it to Dennison and Alberte's calculations, CCE made a conservative estimate that H_{sat} should be closer to 8 hours.

Eelgrass Monitoring

The 2011 monitor was initiated on 22 August and completed, for six of eight sites on 26 August. Due to mechanical difficulties, scheduling conflicts with boats, and Hurricane Irene, sampling for Southold Bay and Three Mile Harbor was pushed back to 20 September and 26 October, respectively. 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.

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 and Areal Extent

As no current, or even recent, aerial surveys have been conducted for eelgrass in the Peconic Estuary, for this report, it was decided to look at the trends for the 4 extant eelgrass meadows remaining in the LTEMP: Bullhead Bay, Cedar Point, Gardiners Bay, and Orient Point. This trends analysis used the available Suffolk County Aerial Photography for 2004, 2007 and 2010 as a comparison for the initial eelgrass survey conducted in 2000 (Tiner et al., 2003). These aerial photographs were not flown under the standard protocols defined by NOAA's C-CAP resulting in reduced water clarity and contrast needed to accurately delineate submerged vegetation. As such, the results presented should be considered estimates of the areal extent of the target meadows and not exact coverages. Also, where a determination could not be made of where a meadow ended, or if the aerial coverage did not extend offshore far enough to cover the deep edge, a "soft edge" consisting of a dashed line was placed along that edge of the meadow delineation. The aerial photographs and delineated meadows for each site are presented in Appendix 2.

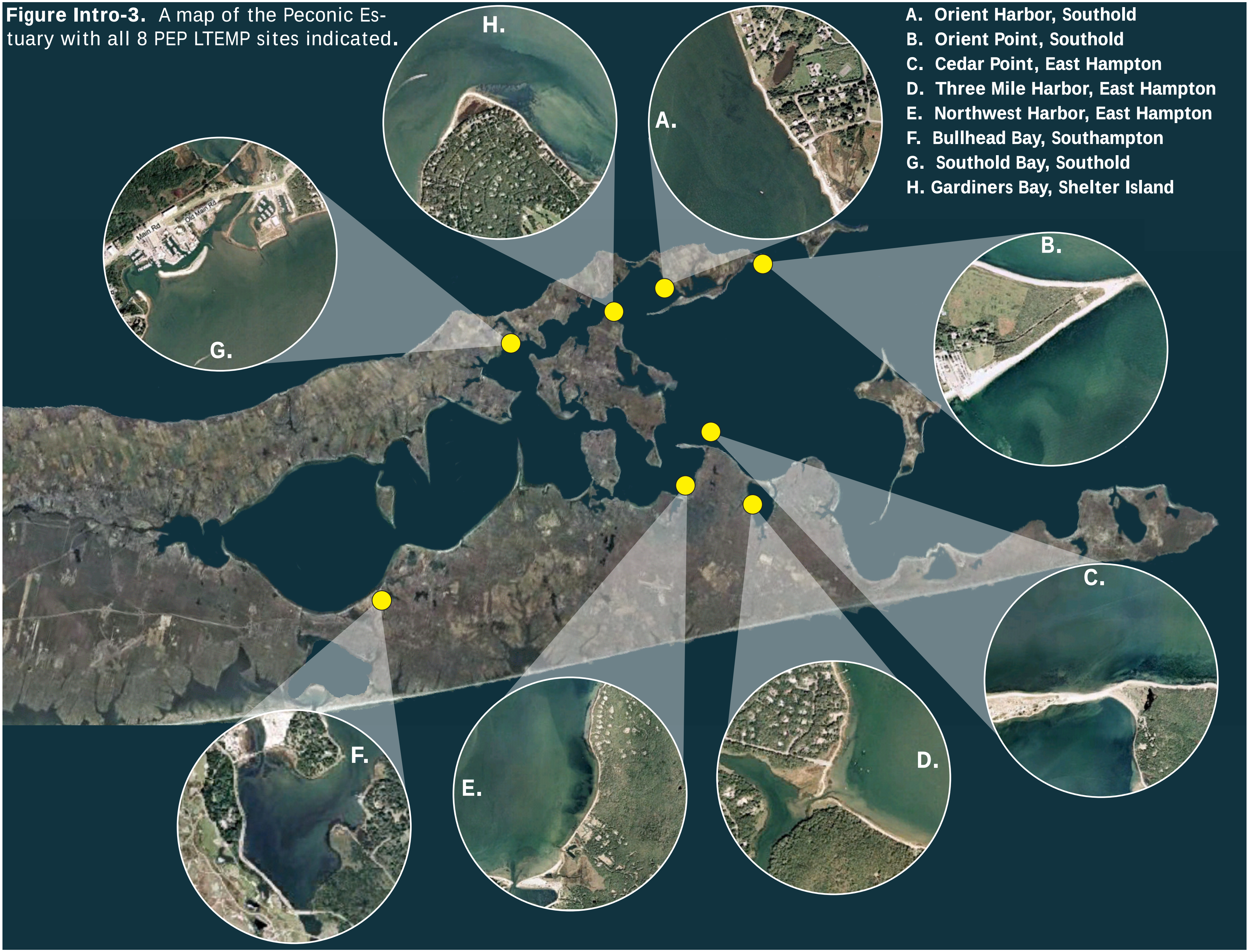

Figure Intro-3. A map of the Peconic Estuary with all 8 PEP LTEMP sites indicated.

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 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.

Light Availability and Temperature

The 2011 season saw the first comprehensive

Table BB-1. H_{comp}, H_{sat} and temperature data calculated from the deployment of Odyssey PAR loggers and TidBit temperature loggers in Bullhead Bay over 7-days for each month, July-September, 2011.

Month	Ave. Daily H_{comp} (Hr)	Net Daily H_{comp} (Hr)	Ave. Daily H_{sat} (Hr)	Net Daily H_{sat} (Hr)	Ave. Monthly Temperature (°C)
July	13.6	+1.3	9.6	+1.6	27.0
August	12.2	-0.1	6.8	-1.2	25.9
September	8.8	-3.5	2.9	-5.1	22.2

deployment of light loggers in the Peconic Estuary, with Bullhead Bay as one of the target sites. The light logger was deployed for 1 week, each month, from July to September at approximately 4ft water depth at mean low water (MLW). The Bullhead Bay logger was situated adjacent to a large patch of eelgrass near Station 2 (Figure BB-1). From the light logger an average daily H_{comp} and H_{sat} were calculated for each of the three deployments. Table BB-1 includes the daily average H_{comp} and H_{sat} recorded for each of the three deployments in Bullhead Bay (July-September). The average daily H_{comp} and H_{sat} for each deployment was compared to the estimated base daily requirements of 12.3h (H_{comp}) and 8h (H_{sat}), resulting in net daily values for both parameters. Based on the data presented in Table BB-1, the eelgrass plants received enough light in July to meet both the basic needs of the plants and provide the energy the plants need to grow and reproduce. However, the meadow did not receive the necessary intensity or period of light to meet the basic requirements for either H_{comp} or H_{sat} for August and September (Table BB-1).

To compound this "deficit" of light experienced by the Bullhead meadow, water temperatures in the bay exceeded 25°C for July and August. Published reports indicate that high water temperatures (i.e., >25°C) may reduce the photosynthesis:respiration balance in eelgrass resulting in increased energy usage by the plants, with reduced photosynthetic capacity to compensate. Temperature has always been a parameter of concern, with regard to its potential impact on the health of eelgrass, in Bullhead Bay. Summer water temperatures regularly exceed 25°C and, during July and August 2011, the monthly average temperature for the bay was above that point (Table BB-1). The daily average temperature for Bullhead Bay broke 25°C on July 2nd and did not drop below that mark until 27 August. The eelgrass in Bullhead Bay experienced a total of 54.5 days over 25°C from July to September 2011.

Eelgrass Shoot Density

The Bullhead Bay eelgrass survey was conducted on 26 August 2011. Unlike 2010, *Cochlodinium* was not obvious in the bay, however, the dark-red patches that are indicative of a bloom were observed near the mouth of Bullhead Bay in Great Peconic Bay. So, while Bullhead Bay did not appear to be "infected" with the dinoflagellate, the possibility of the bloom occurring in this embayment was high. Even without an active bloom, the water clarity was low, providing no more than 3ft visibility in the water column. Stations 1 and 2 (Figure BB-1) were found to support patchy eelgrass. Quadrat counts for these stations ranged from no shoots observed to 180 shoots•m^{-2}. Observations made swimming between Station 1

Table BB-2. 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
2011	22	+/- 6

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

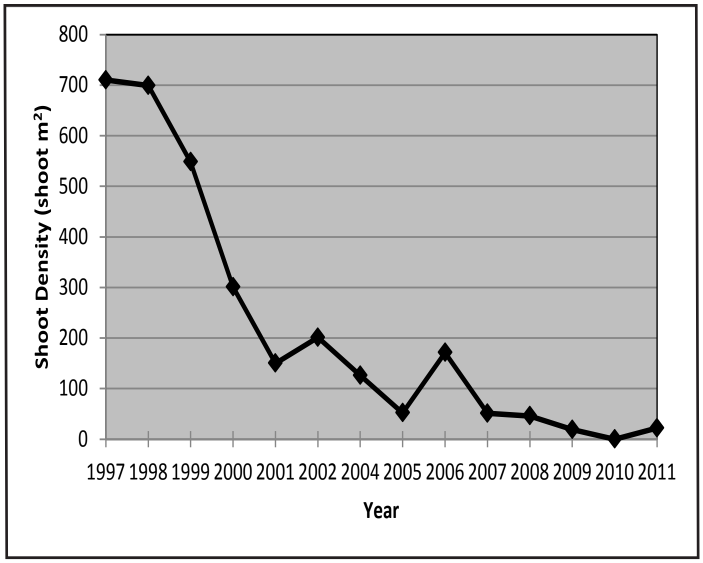

Figure BB-2. Average annual eelgrass shoot density for Bullhead Bay, Southanpton, from 1997-2011.

and Station 2 identified many small patches scattered throughout this area of Bullhead Bay, but none were found to have consolidated into a significant bed. The presence of eelgrass at these two stations was the first to have been observed since 2008. The only other station that had recorded eelgrass in the 2011 survey was station 6, though it was not as abundant as at Stations 1 and 2. The average shoot density for Bullhead Bay was up in 2011 to 22 shoots•m^{-2}, an increase from 2010 when no shoots were observed in the monitoring area (Figure BB-2; Table BB-2).

Macroalgae Cover

The macroalgae population experienced a small increase in percent cover in 2011 over 2010 in Bullhead Bay (Figure BB-3). Station 5, in the southeast corner of the bay (Fig. BB-1), supported the highest biomass and percent cover of macroalgae in Bullhead Bay. The common species encountered in this area of the bay include *Spyridia filamentosa* and *Gracilaria tikvahiae*. *Codium fragile* and *Ulva lactuca* were also observed, but infrequently. The eelgrass around Station 1 (Fig. BB-1) provided anchorage for *Spyridia* as well as *Ulva prolifera* and *Chaetomorpha linum*. Drift macroalgal species have always dominated Bullhead Bay, but they have definitely suffered a decline with the reduction of eelgrass coverage in the bay. Since 2009, macroalgae percent cover has shown an upward trend for two years (Fig. BB-3). The last time this occurred, during the 2000-2002 seasons, the following survey season recorded a significant drop in the macroalgae cover (Fig. BB-3). If this pattern

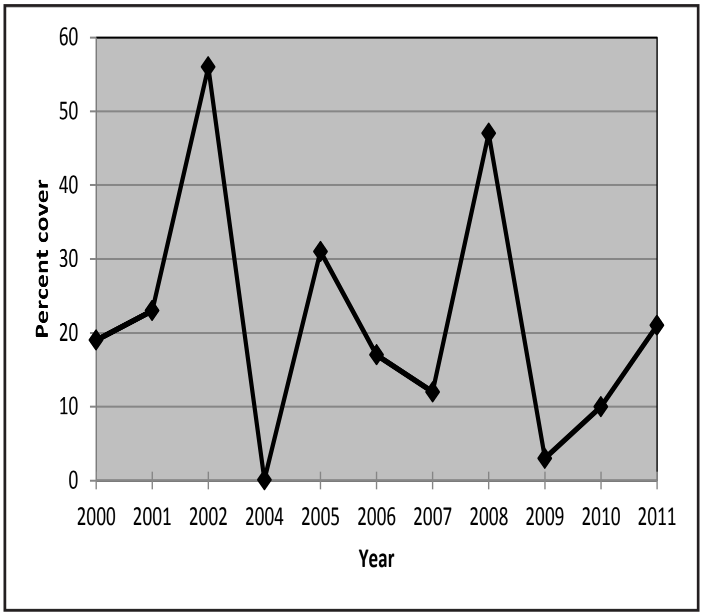

Figure BB-3. The annual mean macroalgae percent cover for Bullhead Bay, Southampton from 2000-2011.

is repeated in 2012, a comparison between the earlier event and the current event may indicate a causative factor and allow for future predictions regarding the annual dynamics of the macroalgae population in Bullhead Bay.

Bed Delineation and Areal Extent

The areal extent of the Bullhead Bay meadow was determined for the 2004 and 2010 Suffolk County Aerials and compared to the delineation published by Tiner et al. (2003) from the 2000 aerials (Table BB-3). The 2007 Suffolk County Aerials were of such poor quality for Bullhead Bay that no delineation could be made. In 2000, the estimated cover for Bullhead Bay was 54.75 acres (Tiner et al., 2003) (Table BB-3), but by 2004, the meadow had significantly contracted and only covered 10.87 acres. As mentioned above, the 2007 were of such poor quality that no accurate delineation could be made. The 2010 aerials provided excellent clarity and the meadow was found to cover approximately 5.58 acres. While

Table BB-3. Estimated areal coverage of the Bullhead Bay eelgrass meadow for select years from 2000-2010.

Year	Estimated Area
2000	54.75 acres (22.16 hect.)
2004	10.87 acres (4.40 hect.)
2007	ND
2010	5.58 acres (2.26 hect.)

no newer images are available for analysis in GIS, Google Earth™ had posted aerials that are dated from 6 March, 2012, and show the eelgrass meadow in Bullhead Bay to have expanded since 2010, possibly due to the mild winter of 2011/2012. An approximation taken from the Google Earth™ image indicates that the meadow has at least doubled in size. Field observations have substantiated this expansion, but an estimate of the meadow's extent requires an aerial perspective that can be analyzed in a GIS program.

Conclusions

The eelgrass population in Bullhead Bay continues to persist, even though environmental conditions, specifically light availability, water temperature, and even the sediment that it grows in, have been shown to be less than optimal. As the light logger survey is the first of its kind to attempt to elucidate the light conditions in Bullhead Bay, its results still leave some questions to be answered. Foremost of these questions is, "How can eelgrass survive in an environment that seems to be incompatible with the basic needs of the plant, in terms of light and water temperature?" One plausible answer would be that, "It can't," and there must be an issue with the data collected. Regarding data collection, the light loggers were only recording for seven days each of the three months. It is possible that those were among the worst weeks for measuring sunlight due simply to weather conditions. It is also possible that the loggers recorded low numbers only some of the time during a "bad day" as a reflection of some object (e.g., algae, animals, sedimentation) preventing the light logger from accurately measuring the light due to shading of the sensor. Another possible explanation for the survival of eelgrass in Bullhead Bay, given the conditions described by the light and temperature data, is that the eelgrass meadow receives enough light the rest of the year, with much lower water temperatures, to support the population through a few months of reduced photosynthetic capacity. Southern ecotypes of eelgrass slough off all aboveground biomass for the summer months to reduce the metabolic needs of the plants, which enables them to survive on energy stored in the rhizomes. While this situation has not been observed in Bullhead Bay, the plants maintain a low aboveground biomass through the summer, whereas eelgrass populations inhabiting cooler waters in the Estuary show prolific shoot growth. The only way to gain a more accurate picture of the light regime of Bullhead Bay would be to have a repetitive deployment in 2012 to verify the data collected in 2011. The temperature data has been shown to reflect the conditions in Bullhead Bay based on several years of data taken at several sites within the bay. However, this does not discount the possibility that there may still be some factor, like groundwater upwelling, that could mitigate temperature for small areas throughout the meadow, which have been missed in past temperature logger deployments.

The aerial photography analysis showed that the meadow has definitely contracted since 2000, but the 2012 imagery on Google Earth™, as well as preliminary observations made in June 2012, suggest that he meadow has rebounded back to at least the 2004 areal cover and may even exceed it. Continued analysis of aerial imagery of the bay may provide information that could definitively identify the factor(s) that influence the health and extent of this meadow. This information could them be applied to CCE's restoration activities to better choose sites and increase transplant survivorship.

The eelgrass meadow in Bullhead Bay may also be inhibited by the sediment that it grows in. Parts of the bay are dominated by organic-rich, fine sediments which have been shown to negatively impact seedling recruitment and potentially contribute to die-backs of adult plants. The organic constituents of sediment supporting eelgrass are considered important for the health of the plants, however, at the same time, these sediments also produce hyydrogen sulfide, a known phytotoxin.The detrimental effects of growing in highly organic sediments has been linked to other conditions, such as low light or high temperatures, which have been shown to be a factor in Bullhead Bay. These conditions prevent the eelgrass plants from photosynthesizing at levels at which the plants can sufficiently oxidize their rhizosphere, protecting the plants from hydrogen sulfide. The duration and extent of a plant's contact with H_2S determines the impact on the plants, ranging from reduced growth rates to death.

Even with the suboptimal conditions suggested by the light and temperature data, an established eelgrass population should be able to deal with these deficit days by tapping stored energy in the rhizomes. A young, or newly established, eelgrass population, derived from seedling recruitment, would not have the same energy reserves and would be more susceptible to periods of reduced photosynthesis. It has been proposed that Bullhead Bay has a small eelgrass population, believed to be situated in the northwest section of the bay, that survived the initial event(s) that resulted in the loss of the majority of the eelgrass in the southern half of the bay between 2002 and 2004. This isolated remnant meadow of established adult plants produces flower shoots each year of a density that varies with the environmental conditions. Under good conditions, there may be a mast year where a large number of flower shoots, and seeds, are produced which recruit as seedlings, and produce the widespread small patches that have been observed throughout the bay over the last several years. Conversely, when conditions are suboptimal (e.g., high water temps, algae blooms, etc.), the remnant population would be stressed and reproduction would be significantly reduced, resulting in low seedling recruitment and fewer patches. Eelgrass that had recruited in the previous, “favorable” season(s) would likely see their patch sizes decrease due to large-scale dieback of the youngest plants. There still remain many questions regarding Bullhead Bay’s eelgrass population that will hopefully be answered by continued monitoring of the population and investigating other environmental parameters that may influence eelgrass survival in the bay.

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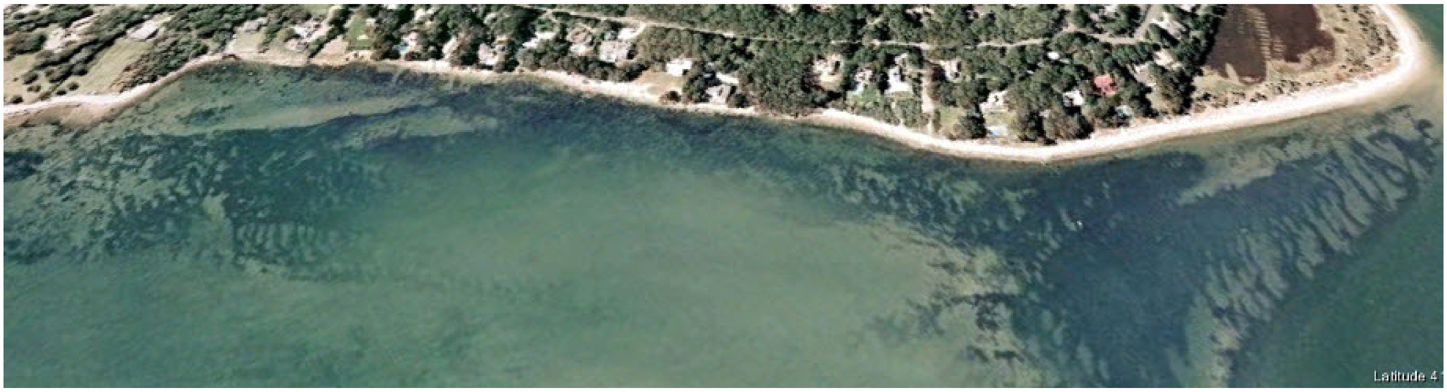


The Gardiners Bay eelgrass monitoring site is located on the east side of Hay Beach Point on Shelter Island. The eelgrass meadow starts near the channel connecting Greenport Harbor to Gardiners Bay in the north and extends southward toward Cornelius Point (Figure GB-1). This site is the most exposed, 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 an 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 to 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. Water clarity also tends to decline with the outgoing tide. 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.

Table GB-1. H_{comp}, H_{sat} and temperature data calculated from the deployment of Odyssey PAR loggers and TidBit temperature loggers in Gardiners Bay over 7-days for each month, May-October, 2011.

Month	Ave. Daily H_{comp} (Hr)	Net Daily H_{comp} (Hr)	Ave. Daily H_{sat} (Hr)	Net Daily H_{sat} (Hr)	Ave. Monthly Temperature (°C)
May	13.9	+1.6	10.5	+2.5	15.2
June	14.4	+2.1	11.8	+3.8	20.0
July	14.4	+2.1	11.9	+3.9	23.8
August	12.8	+0.5	9.7	+1.7	24.1
September	11.6	-0.7	8.5	0.5	21.7
October	9.5	-2.8	6.0	-2.0	17.1

Light Availability and Temperature

The data collected by the light and temperature loggers at the Gardiners Bay site are summarized in Table GB-1, above. The light data indicates that the eelgrass plants at this site meet or exceed their needs for both H_{comp} and H_{sat} through the summer, but begin to experience light deficits with the more volatile weather of the Fall (i.e., September and October). For June and July, the H_{sat} at the site approaches 12h of light with an intensity >100 $\mu mols \cdot m^{-2} \cdot s^{-1}$. Based on the estimations of Dennison and Alberte (1985), the maximum H_{sat} for the Peconic Estuary would be approximately 13h, indicating that for at least the deployments for these two months, the eelgrass at Gardiners Bay experienced close to the maximum H_{sat} possible for this region. Add to the abundant light, the relatively low average daily temperatures occurring at this site (Table GB-1), and the plants would be able to photosynthesize at maximum capacity. The eelgrass meadow did not experience any time with water temperatures >25°C, based on the TidBit temperature data.

The eelgrass at this site did not encounter insufficient light conditions until the September and October deployments. The eelgrass would have run a deficit for H_{comp} for both September and October, with only October having a shortfall for H_{sat}. The deficit for September was minor, but, the limited light recorded during the October deployment could have resulted in the plants having to use stored reserves, at least for the short duration represented by the light logger deployment

Table GB-2. The average annual eelgrass shoot density for Gardiners Bay from 1999 to 2011, 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
2011	28	+/- 10

Eelgrass Shoot Density

The Gardiners Bay meadow has experienced the same decline in eelgrass shoot density and areal coverage that have occured in all the original LTEMP sites. Added to the program in 1999, Gardiners Bay was a moderately dense meadow with an average shoot density around 500 shoots per $meter_2$ (Table GB-2; Figure GB-2). Gardiners Bay has shown a more moderate rate of decline in shoot density than the other monitoring sites. The period between 2002 and 2004, where most of the other monitoring sites saw a significant decline in eelgrass shoot density, Gardiners Bay remained relatively unchanged. The decline in shoot density from 2005 to 2006 resulted from the complete loss of eelgrass from 2 stations and significant losses in two other stations in this meadow. The two stations that have completely lost eelgrass were stations that were on the outside edge of the meadow. This is a dynamic area where storms and currents cause sand to erode one area and accrete in another. Eelgrass patches are either eroded by the waves and currents, resulting in plants being uprooted, or buried by advancing waves of sand. The meadow

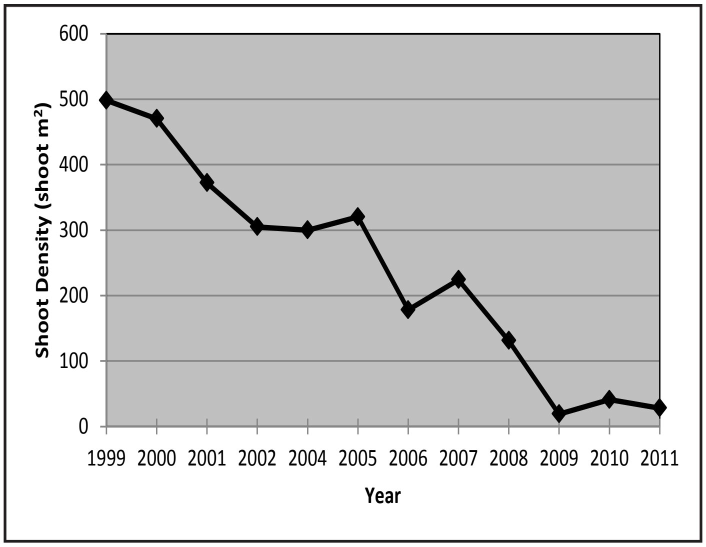


Figure GB-2. Average annual eelgrass shoot density for Gardiners Bay, Shelter Island.

has become more patchy since 1999. Some of this fragmentation can be attributed to natural events, but much of the fragmentation that can be observed in the more contiguous sections of meadow near shore is resultant from anthropogenic activities in these areas. Along with several moorings that are located within the eelgrass meadow, shellfishing (commercial and recreational) damage the continuity of the meadow and eventually lead to blowouts. Another source of damage to the meadow is the prop scarring caused by boaters that either don't know how to navigate via channel marking buoys or simply ignore the marked channels to take shortcuts. At MLW, much of this meadow is covered by less than 6ft of water. At this depth, prop interaction with the bottom is frequent and the resulting damage can cover meters to tens of meters in length, contributing significantly to the fragmentation of this meadow. This particular disturbance is completely preventable if boaters stayed in the designated channel. The addition of another channel marker closer to Greenport, on the south side of the channel could aid boaters in navigating to the next marker, and eliminating accidental "shortcuts" across the eelgrass meadow. The monitoring stations that have shown significant loss have likely succumbed to a lethal combination of wind, waves and boats.

Macroalgae Cover

The location of the Gardiners Bay eelgrass meadow puts it in a prime location to intercept drift macroalgae from Gardiners Bay and the western Estuary, depending on the tide. While the site is not conducive to growth of attached macroalgae, due to the shifting sand, gravel and shell sediment, the presence of eelgrass allows for the entanglement and continued growth of a wide variety of drift macroalgae. Even though the site experiences high waves and current that would make it difficult for unanchored macroalgae to remain on-site in high density, the Gardiners Bay eelgrass meadow has consistently supported a moderate amount of macroalgae (Figure GB-3). As with previous years, the species diversity remains relatively high due to the influx of drift macroalgae from the western Estuary and from Gardiners Bay.

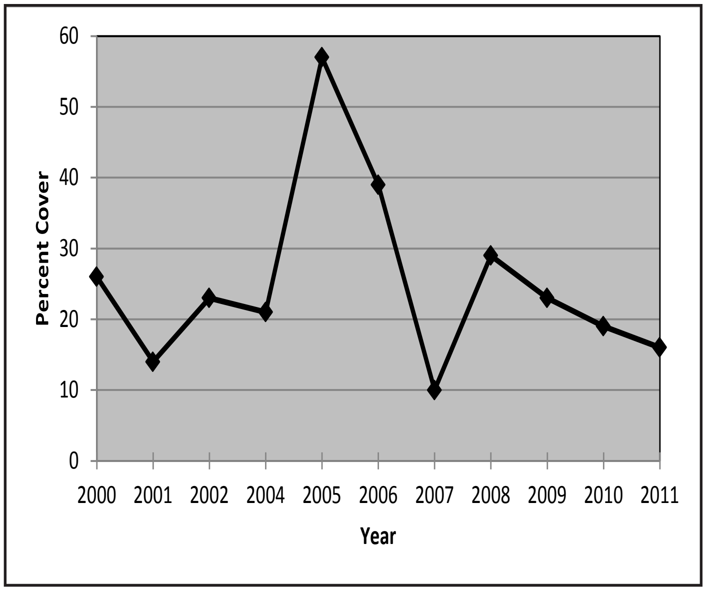


Figure GB-3. Annual mean macroalgae cover for Gardiners Bay from 2000 to 2011.

Bed Delineation and Areal Extent

The Gardiners Bay eelgrass meadow was initially determined to cover 78.64 acres in 2000. Between 2002 and 2004, there was a significant decrease in the area covered by the meadow, representing an approximate 50% loss over the intervening years. Most of that loss was isolated to the offshore portions of the meadow that where, by 2000, already showing the effects of the powerful erosional forces encountered at this site, as well as the impact of increased boat traffic through this area. The aerial photographs, with their cor-

Table GB-3. The estimated areal coverage of the Gardiners Bay eelgrass meadow from 2000-2010.

Year	Estimated Area
2000	78.64 acres (31.83 hect.)
2004	39.03 acres (15.80 hect.)
2007	35.65 acres (14.43 hect.)
2010	34.88 acres (14.12 hect.)

responding overlays found in Appendix 2, show the consistent loss of the offshore sections of the meadow and the expansion some of the open patches within the inshore meadow. Since 2004, the areal loss of the meadow has slowed considerably, but the offshore edge continues to erode and new holes in the meadow open up.

Conclusions

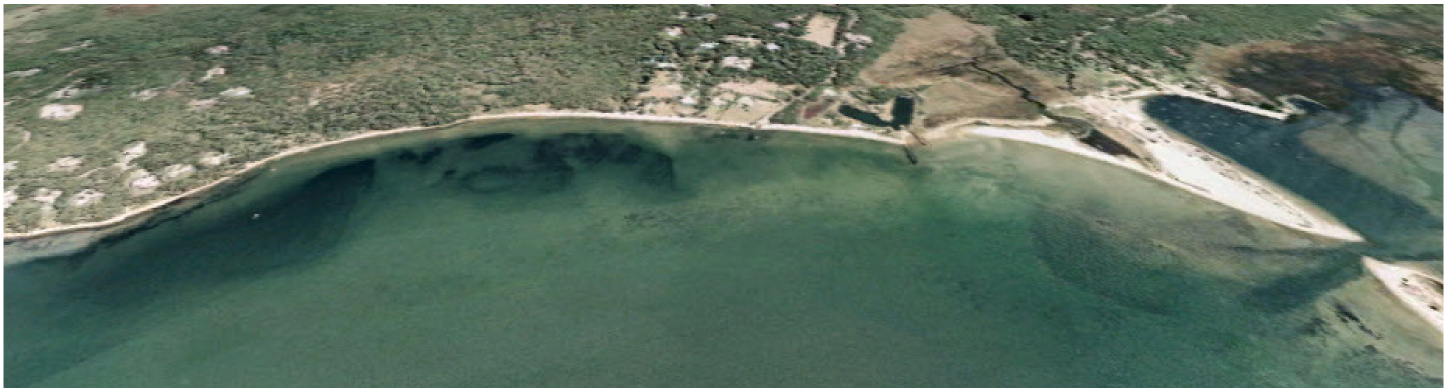
The Gardiners Bay eelgrass meadow is the original high-exposure meadow in the eelgrass monitoring program. The meadow is exposed to relatively high currents with each changing of the tides which may result in an increase in light attenuation, deposition of drift macroalgae and movement of sediments (both accretion and erosion), but the eelgrass meadow also benefits from the high rate of flushing to moderate both temperature and nutrient loading at the site. The periodic wave events, while potentially damaging in the extreme, also benefit the bed by “stirring things up,” and dislodging accumulated drift macroalgae and assisting in sloughing epiphyte-loaded blades. The movement of sand by currents and waves is the most significant, natural factor influencing this meadow, yet these are conditions that the eelgrass population has dealt with since its establishments and alone, this factor alone would not lead to the extinction of the meadow, barring a catastrophic event.

The inclusion of light and temperature loggers during the growing season have added another perspective to assessing the health of this meadow. The light data collected during the 2011 season indicates that the Gardiners Bay meadow does not suffer from low light conditions or water temperatures that would negatively impact eelgrass during the summer. The light deficits experienced by the plants in September, but more so, in October, resulted from 2-3 days of stormy conditions during a 7-day deployment. A reduction in the periods of H_{comp} and H_{sat} should be expected during the Fall due not only to the frequent storms and windy weather, but also the shortening of the day length. Eelgrass has adapted to the changing seasons and takes cues from changes in water temperature, specifically its decrease through 15°C, as well as day length. By October, the plants are beginning to revert to their winter morphology, resulting in significantly smaller above-ground biomass, which requires less energy to maintain, and a reduced respiration rate, due to the lower water temperature.

Figure GB-4. An aerial photograph (2008) showing the patchiness of one section of the Gardiners Bay eelgrass meadow.

While most of the conditions in the Gardiners Bay eelgrass meadow are within the tolerance of the plants, the meadow continues to suffer loss of area. Impacts to the meadow from boating (prop scarring) and shellfishing (i.e., recreational clamming) result in fragmentation of the meadow and create edges that can be eroded by waves, currents and animals. The hardening of the shoreline over more than half the length of the meadow exposes the nearshore edge of the meadow to reflected wave forces and erosion.

While the hardened shoreline is not a problem with a simple solution, the impact from boats and shellfishing could potentially be solved with education and the posting of advisories indicating the presence of eelgrass and its importance to the Estuary. Also, the placement of a navigation buoy between Hay Beach Point and the existing buoy would likely reduce the number of boats that “cut” the buoy and cross the eelgrass meadow.



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 stations. 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 the moderate winds that the Harbor experiences, a good amount of material can be suspended, reducing visibility to a few feet.

Light Availability and Temperature

Northwest Harbor was not one of the sites from which light and temperature data was collected. Data was collected from adjacent areas, including Northwest Creek, Sag Harbor and Cedar Point. As every site is potentially different, even a nearby site, it may prove inappropriate to use the data collected at the three previously mentioned sites to describe the light availability in Northwest Harbor. However, based on observations from several seasons, water clarity in Northwest Harbor tends toward low turbidity, so light penetration is likely not limited. Water temperature is

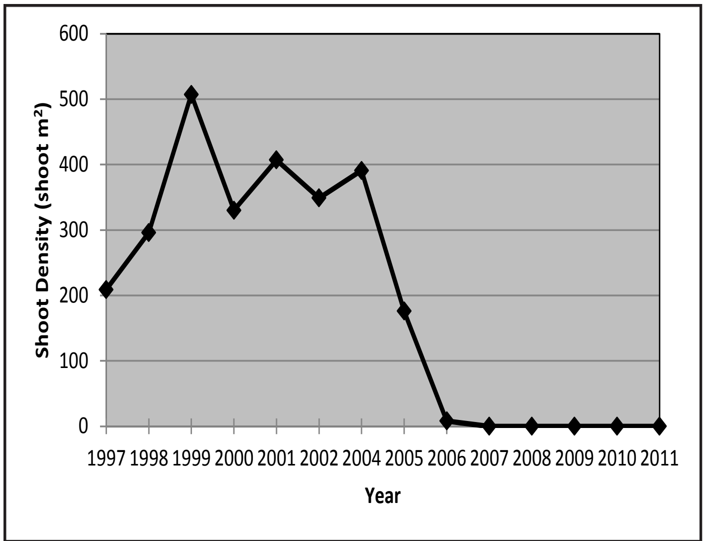


Figure NWH-2. Average annual eelgrass shoot density for Northwest Harbor, East Hampton.

a parameter that generally does not vary greatly over short distances, so considering water temperatures for Sag Harbor and Cedar Point, Northwest Harbor should not exceed an average daily temperature of 25°C for either July or August, based on 2011 temperature data (CCE, unpublished data).

Eelgrass Shoot Density

The greater portion of Northwest Harbor supported eelgrass at the start of the LTEMP in 1997. Based on aerial photographs, it was not a solid, continuous meadow, but most of the harbor bottom from 4-10ft MLW supported eelgrass. Northwest Harbor was one of the few meadows in the program that did not experience a decline between the 2002 and 2004 surveys, however, after 2004, the meadow declined rapidly until in 2007, no eelgrass was observed at any of the 6 monitoring stations in the harbor (Figure NW-2; Table NW-1). There has been no indication of eelgrass recovery since 2007.

Suggestions that pockets of eelgrass meadow still remain in Northwest Harbor have been investigated, but at this time no extant eelgrass has been discovered.

Macroalgae Cover

As it has been stated in previous reports, the primary macroalgae community inhabiting Northwest Harbor was *Spyridia filamentosa* and its population was growing almost entirely as unattached drift which anchored itself in the eelgrass. With sudden loss of eelgrass in the harbor, the macroalgae community suffered a precipitous drop from 2005-2006 (Figure

Table NWH-1. The average annual eelgrass shoot density for Northwest Harbor from 1997 to 2011, 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
2011	0	+/- 0

NW-2), as *Spyridia* lost its anchorage. The macroalgae cover in Northwest Harbor has continued to slowly decline and *Spyridia* is slowly be replaced as the predominate macroalgae by *Codium fragile* which attaches to exposed clam shells and the infrequent rock on the bottom. Hard substrate is uncommon throughout the site, so *Codium*'s distribution is minimal at this time.

Conclusions

A significant portion of Northwest Harbor has not supported eelgrass since 2007, as confirmed by

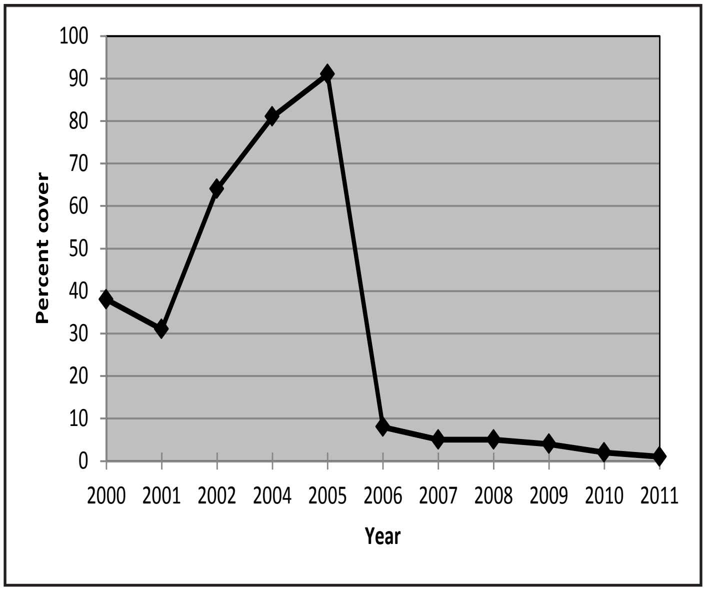


Figure NWH-3. Annual mean macroalgae cover for Northwest Harbor from 2000 to 2011.

subsequent LTEMP surveys at the site. The initial cause of the eelgrass decline and eventual loss is not known, but, based on work conducted at adjacent sites, Sag Harbor and Cedar Point, it is unlikely that light availability or high summer water temperatures were the cause. Anthropogenic activities that could impact eelgrass are few, but clamming is a common activity, recreationally and commercially. Clamming can be damaging to eelgrass meadows, but the scale of these activities that would have been necessary to impact such a large area in a short time has not been observed in the harbor. The loss of the Northwest Harbor eelgrass meadow was caused by some, as of yet, unknown event that affected at least the southern half of the harbor.

The loss of the eelgrass meadow has had a significant effect on the macroalgal community in Northwest Harbor. Not only has biomass declined, but there has been a shift in the dominant macroalgae species from *Spyridia* to *Codium*, due to the loss of anchorage that eelgrass provided for *Spyridia*. The algae population would likely shift back to back to a *Spyridia*-dominated system if eelgrass was restored to the harbor.

Northwest Harbor is one of several Peconic Estuary sites being considered for the planting of a restoration test plot in 2012. Further data will be gathered on the site to determine its potential as a future eelgrass restoration site.

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.

Light Availability and Temperature

Orient Harbor was not included in the light and temperature survey in 2011 due to the absence of eelgrass at the site. As mentioned previously, the priority of the light/temperature survey was to determine the conditions that support growth in extant eelgrass meadows, then compare them to sites that once supported eelgrass, or have been considered for restoration, to determine where in the Estuary eelgrass could still grow. Orient Harbor will be added to a future light and temperature survey, with that data presented in a future LTEMP report.

Eelgrass Shoot Density

The 2011 eelgrass survey of Orient Harbor failed to locate any extant eelgrass within or adjacent to the monitoring area (Table OH-1; Figure OH-2). Review of the 2010 Suffolk County aerial photographs also showed no indication of eelgrass growing near any of the Stations. Aerial signatures indicating the possible presence of eelgrass in Orient Harbor were noted and will be investigated during the 2012 season.

Macroalgae Cover

With the loss of eelgrass over the monitoring area, there has been an increase in the percent cover of large, anchored seaweeds at the site. This is likely due to the slow change in sediments from dominantly sandy to a higher percentage of gravel and shell. Of interest is the increase in the nonindigenous, green seaweed *Codium fragile* at this site. While *Codium* is not the primary species in Orient Harbor, it is becoming more common as the sediment shifts and suitable substrate for anchorage becomes available. The red seaweeds *Spyridia filamentosa* and *Agardhiella subulata* were the most prevalent species in the Harbor during the 2011 survey. *Ulva* species (e.g. *U. lactuca*, *U. intestinalis*, etc.) are also relatively common. The seaweed population dynamics should be monitored in the future, especially that of *Codium*, as there is the potential of *Codium* beds preventing the recolonization of areas that previously supported eelgrass. It is also worth mentioning that 2011 was the third season that the diatom *Cochlodinium polykrikoides* has been observed forming small blooms within Orient Harbor.

Table OH-1. The average annual eelgrass shoot density for Orient Harbor from 1997 to 2011, 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
2011	0	+/- 0

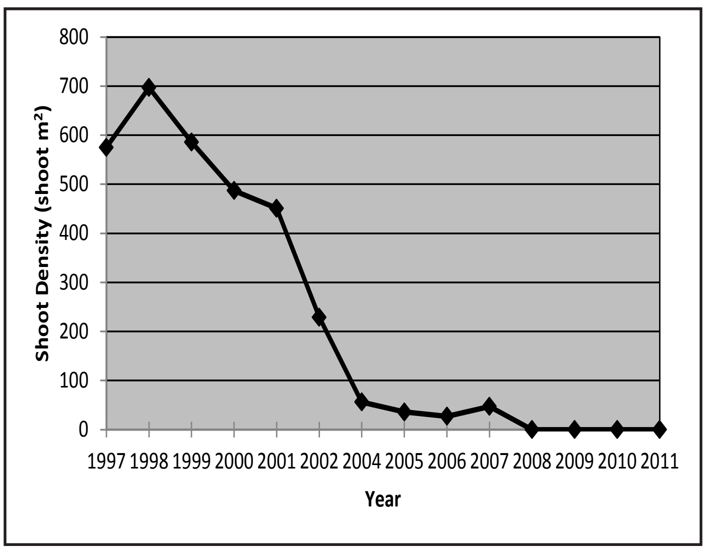


Figure OH-2. Average annual eelgrass shoot density for Orient Harbor, Southold.

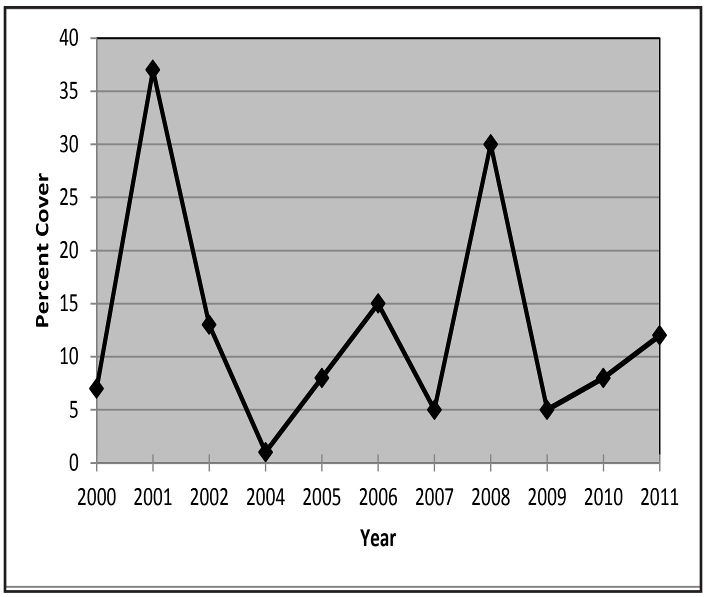


Figure OH-3. Annual mean macroalgae cover for Orient Harbor from 2000 to 2011.

The blooms have been encountered near Stations 4 and 5 each year (Figure OH-1).

Conclusions

Even with no eelgrasss remaining in or around the monitoring stations in Orient Harbor, there remains the possibility that there could be some recovery of eelgrass in adjacent areas due to seedling recruitment and vegetative expansion from extant patches/populations that have not been identified. This area of Orient Harbor receives a significant amount of eelgrass wrack from the Gardiners Bay meadow at Hay Beach Point, as well as smaller meadows in East Marion and Greenport Harbor, providing the potential of drifting flower shoots to deposit seeds. While the possibility for natural recruitment exists, it is more likely that recovery of this meadow will require substantial restoration efforts. Prior to any restoration, a comprehensive survey of several parameters would be required, and a small-scale test planting would need to be conducted and evaluated through a full summer season.

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 connects 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.

The monitoring site is also significantly influenced by its proximity to Hashamomack Pond, which empties into Southold Bay via Mill Creek. The warm water flushing into the meadow from Hashamomack Pond may influence the temperature experienced by this site. Water temperatures within the Southold Bay meadow are thought to have contributed to the chronic stress that the eelgrass population faced, before its extinction at the site, during the summer months. The shallow nature of the bed also allowed for rapid warming, especially on calm, summer days and leading to stress in the shallowest areas.

The waters that the Southold Bay meadow receive from the flushing of Hashamomack Pond not only influence temperature, as noted above, but also expose the site to nutrient-laden water that has been found to negatively impact eelgrass meadows by reducing eelgrass growth, while increasing macroalgae growth at the site.

Light Availability and Temperature

When the Southold Bay site supported eelgrass, prior to 2006, it was perennially the most turbid meadow in the LTEMP program. With that history in mind, the

Table SB-1. H_{comp}, H_{sat} and temperature data calculated from the deployment of Odyssey PAR loggers and TidBit temperature loggers in Southold Bay over 7-days for each month, May-October, 2011.

Month	Ave. Daily H_{comp} (Hr)	Net Daily H_{comp} (Hr)	Ave. Daily H_{sat} (Hr)	Net Daily H_{sat} (Hr)	Ave. Monthly Temperature (°C)
May	13.5	+1.2	10.8	+2.8	16.2
June	14.2	+1.9	10.9	+2.9	21.1
July	13.8	+1.5	9.5	+1.5	25.1
August	12.5	+0.2	8.1	+0.1	24.9
September	11.0	-1.3	8.0	0.0	22.1
October	10.8	-1.5	8.1	+0.1	17.1

light data collected in 2011 (Table SB-1) was much better than was expected. The site did not experience a negative net daily H_{comp} until the September deployment, making it through the summer months with greater than the 12.3h H_{comp} minimum requirement. H_{sat} met its 8h minimum requirement for the entire period from May-October (Table SB-1). H_{sat} did show a decline from the summer into fall, however, lower numbers for the Fall months are to be expected due to the shorter day length and more frequent stormy weather. The decline in duration of the higher intensity light at this site could indicate an isolated event during this deployment or a trend at the site leading into the lower levels expected in the fall.

Water temperature was likely not a major factor at this site in 2011, based on the data collected. The monthly averages only barely peaked above 25°C for the month of July. Overall, the site experienced 36 days of water temperatures ≥ 25°C, with the longest consecutive period extending from 16 July through 14 August, 2012. While this is a relatively long period of time with temperature circum-25°C, the plants would have been receiving adequate light, resulting in a minor P:R imbalance at this temperature.

Eelgrass Shoot Density

Southold Bay has not supported eelgrass within any of the monitoring stations since 2006 and it is believed the entire site since 2007 (Table SB-2; Figure SB-2). With the complete extinction of all eelgrass from this area, there is little possibility of recovery of eelgrass in Southold Bay without active restoration. Although eelgrass has been reported to the east of the site, this has not been confirmed. When Southold Bay was included into the monitoring program in 1999, it was described as an eelgrass meadow in decline. While the final conclusion of the meadow may not have been in doubt at that time, it is surprising how quickly the meadow succumbed to this fate. Past PEP LTEMP reports have indicated dredging may have had an indirect impact on half of this meadow, when

Table SB-2. The average annual eelgrass shoot density for Southold Bay from 1997 to 2011, 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
2011	0	+/- 0

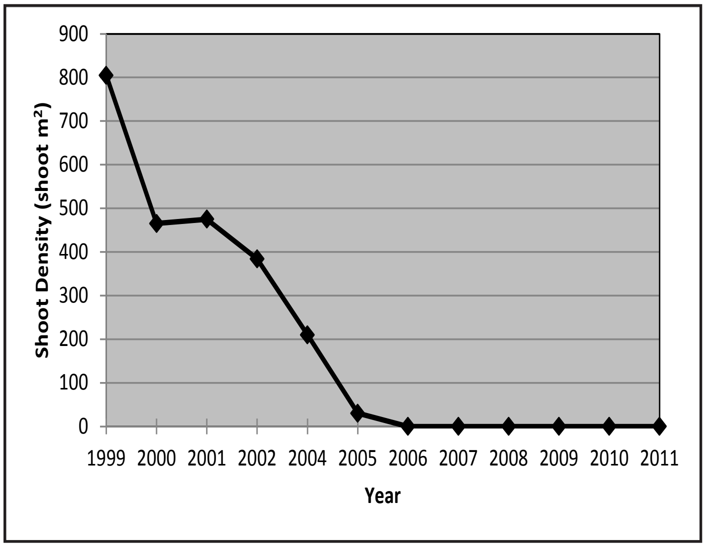


Figure SB-2. Average annual eelgrass shoot density for Southold Bay, Southold.

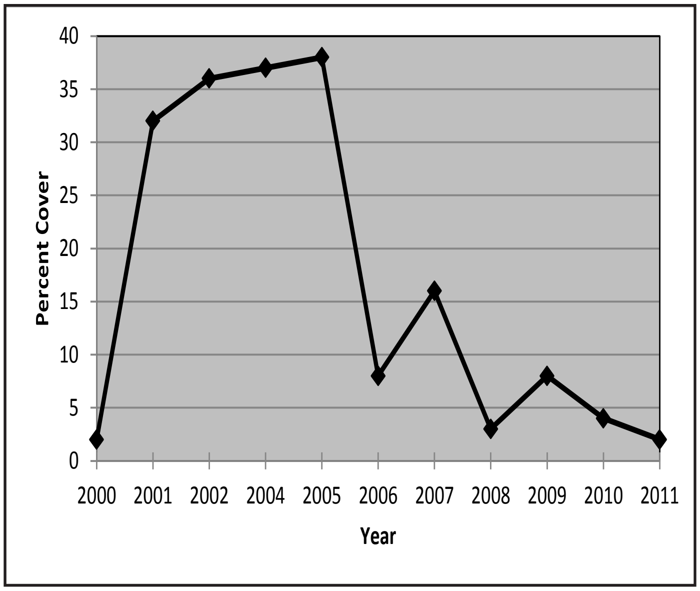


Figure SB-3. Annual mean macroalgae cover for Southold Bay from 2000 to 2011.

a winter storm washed the fresh dredge materials off of the barrier beach fronting the western half of the meadow, resulting in a significant portion of the being subsequently buried. This coupled with other disturbances at this site have helped to increase its rate of loss to the point of extinction that is its current condition.

Macroalgae Cover

The macroalgae community at this site has always been dominated by drift macroalgae. Due to the fine, sandy sediment and the relatively rare, except in the eastern boulder field, substrate suitable for anchorage, large macroalgae have not been common here. With the loss of eelgrass between 2005 and 2006, the macroalgae cover dropped from an average percent cover in the 30s to less than 10% in one season (Figure SB-3). The macroalgae cover continues to remain low with the 2008 season observing only a 3.1% mean macroalgae cover for the site. The boulder field to the east still maintains high macroalgae coverage, but this is a limited area and the seaweeds common on the boulders, *Codium*, *Fucus*, and *Sargassum*, can not anchor on the finer sediments prevalent over the rest of the site.

Conclusions

The data collected in 2011 for both light and water temperature showed that the conditions at the Southold Bay site are not as degraded as expected from observations made in previous LTEMP surveys, including those when the site still supported eelgrass. The light conditions were found to be adequate to support eelgrass, based on the 7-day, monthly deployments. Water temperatures exceeded the 25°C threshold for a little more than one month total, which is a period a healthy eelgrass meadow should be able to endure, especially when adequate light is available to offset increased metabolic needs due to the high temperatures.

The light data ran counter to what was expected for the site based on years of observations, however, this could reflect an overall increase in water quality in the surrounding water bodies, specifically Mill Creek and Hashamomack Pond. It had been speculated in earlier LTEMP reports that these two water bodies contributed to the high turbidity at the Southold Bay site, even prior to the extinction of the meadow. In recent years, Hashamomack Pond has the focus of water testing with the intention of opening more areas of the pond to shellfishing. It is possible that in the intervening years since eelgrass was last recorded at the Southold Bay site, that there has been some improvement in water quality in the adjacent pond.

Eelgrass may not have been completely lost to the Southold Bay area. While it is most certainly extinct within the boundaries of the LTEMP site, reports of extant eelgrass to the east and west of the Brick Cove Marina channel have been brought to CCE's attention. Scouting for this extant meadow was briefly attempted late in 2011, but conditions were poor with low visibility due to wind and recent storms. The site will be scouted in 2012 to verify the presence of eelgrass in the vicinity of the Southold Bay site, which could potentially be used as a donor site for future restoration test plantings in the area.

Three Mile Harbor is the eastern-most meadow in the eelgrass monitoring program. Situated inside a large, protected harbor, 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 stations, 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 25°C. Temperature has never been considered a significant stressor for this eelgrass meadow.

Water quality, specifically nutrient loading, in Three Mile Harbor has generally been good. Pump-out facilities at the marinas and an East Hampton Town pump-out boat have assisted in the maintenance of good water quality by providing the boating popula-

Table TMH-1. The average annual eelgrass shoot density for Three Mile Harbor from 1997 to 2011, 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
2011	0	+/- 0

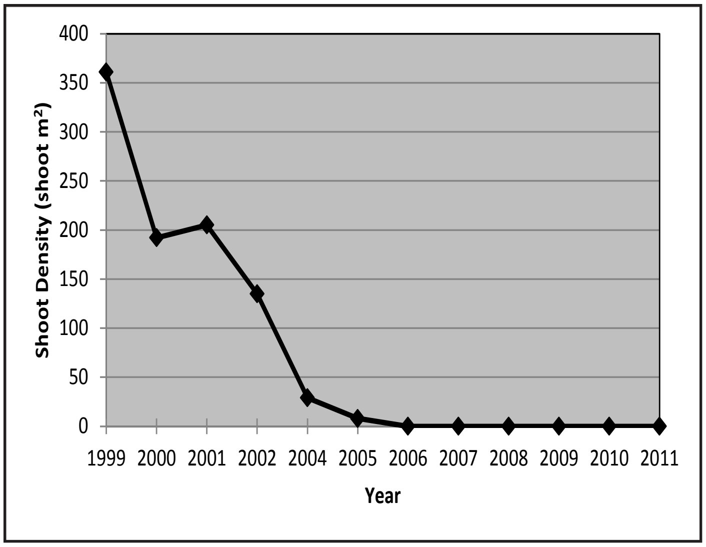


Figure TMH-2. Average annual eelgrass shoot density for Three Mile Harbor, East Hampton.

tion in the harbor with convenient and environmentally responsible methods of disposing their wastes. While nutrient loading may not have been a significant stress to the eelgrass meadow in Three Mile Harbor, water clarity may have been a contributing factor to the loss of eelgrass at this site. The proximity of the water ski area, which had been expanded to include the eastern portion of the former meadow (Stations 1 and 2; Figure TMH-1), along with the boats moored in the meadow area, would have had an influence on water clarity, and subsequently, light availability. Mooring chains sit on the bottom, but as the buoy or boat moves in response to the wind, the chain scribes an arc through the eelgrass, eventually removing a complete circular area around the mooring anchor. Given enough moorings placed in an eelgrass meadow, the damage can result in a significant increase in the patchiness of a meadow. 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 could suffer lower light availability for a considerable length of time after the initial point of disturbance.

The 2011 LTEMP survey of Three Mile Harbor was delayed past its usual survey period in late August, to 23 October, 2011. The delay in conducting the survey was due to weather, including a hurricane, and mechanical issues with the boats to be used for the survey. The delay should not pose any issues with regard to the comparability of the eelgrass data, as there was no change from the previous years'. The macroalgae data may show some seasonal influence as biomass of macroalgae in the fall should start to decline from the higher levels typically observed in the summer.

Light Availability and Temperature

The Three Mile Harbor LTEMP site was not part of the light and water temperature survey conducted in 2011, although loggers were deployed in the adjacent Hands Creek, where eelgrass is still growing. While the two sites are situated in close proximity, several factors are different between the two water bodies that may influence the availability of light and possibly water temperature. Light loggers may see deployment at the Three Mile Harbor LTEMP site in 2012, allowing for an accurate characterization of the light availability in regards to the needs of eelgrass to grow.

Eelgrass Shoot Density

The 2011 eelgrass survey found no eelgrass within the boundaries of the LTEMP site. Divers, swimming from station to station, encountered no small patches or other evidence that recent eelgrass growth had occurred on the site. CCE activities in the adjacent Hands Creek confirmed the presence of eelgrass in that water body, however, a June 2011 survey found that shoot density and areal cover of eelgrass had declined from the previous survey completed in December 2010 (Petersen-Manzo et al., 2011).

Macroalgae Cover

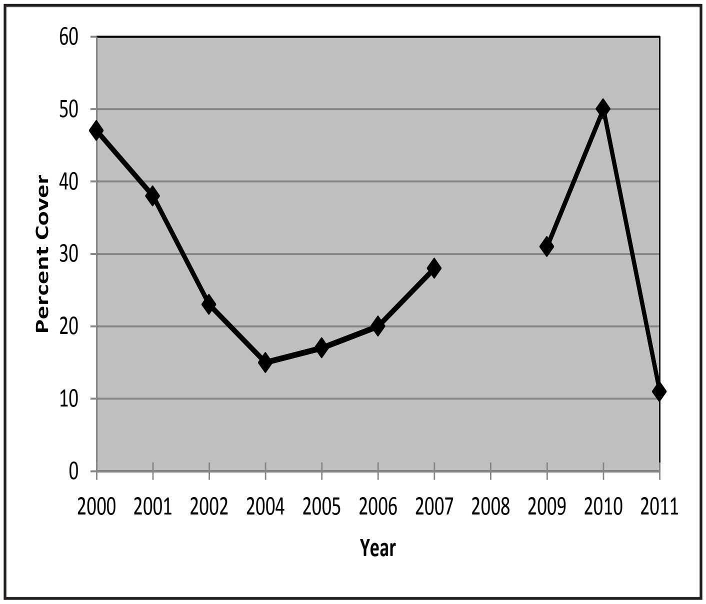
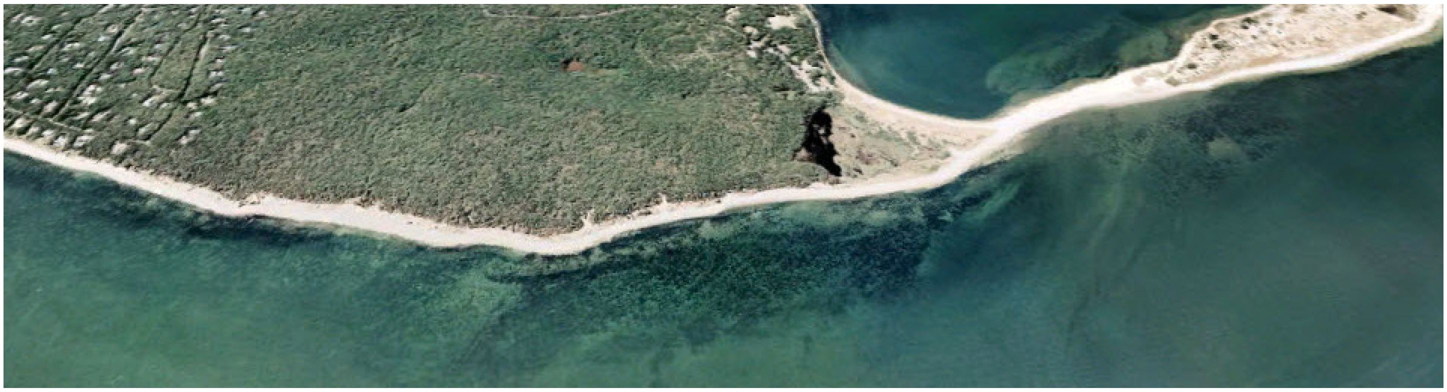


Figure TMH-3. Annual mean macroalgae cover for Three Mile Harbor from 2000 to 2011.

Three Mile Harbor's macroalgae percent cover had peaked in 2010 to an all-time high of 50%, but 2011 saw that number decline significantly to 11% (Figure TMH-3). This decline may be an artifact of sampling in the fall, when macroalgal biomass generally decreases, or it could reflect the relatively dry summer and reduced nutrient availability that resulted from the low rainfall. While macroalgae abundance suffered a decline, the species diversity was unchanged from 2010. The dominant species continue to include *Codium fragile, Spyridia filamentosa*, and *Gracilaria tikvahiae*, with several other filamentous red algae and *Ulva* species also observed. The more offshore sections of the site, with finer sediment, *Codium* is lost and *Spyridi*a and *Gracilaria* remain.

Conclusions

After several monitoring seasons without any observations that might suggest the possibility of natural recruitment to this site, and with the only nearby source of propagules, Hands Creek, having experienced a decline of its own, it should be accepted that the Three Mile Harbor meadow will not recover without substantial effort. The most efficient approach to determining if this site would be a candidate for future restoration would be to evaluate the environmental parameters that influence the health and growth of eelgrass. Such a survey would include collecting data on light availability, water temperature range, sediment types, and other parameters. For the 2012 season, a deployment of a light logger for at least a week in both July and August could determine if light could be limited during the summer months when the plants would be most stressed by high water temperatures. Having an understanding of just light and temperature at the site would be enough to indicate whether a restoration effort at this site would be efficable, but other factors, such as the proximity to the water ski area and the mooring field, would weigh heavily on any decisions regarding restoration.



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 activities 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 the Peconic Estuary Ligh and Water Temperature Survey conducted from May-October, 2011, and that data is presented below.

Light Availability and Temperature

The light and temperature data for Cedar Point is presented in Table CP-1 and represents 7-day light logger deployments for each month from May-October 2011. It is expected that the meadows in Gardiners Bay should not be deficient in light or limited by high water temperatures at any point of the year, based on these meadows being the largest and healthiest looking in the Peconic Estuary. The H_{comp} and H_{sat} data in Table CP-1 support this assumption with plants easily receiving enough light to satisfy their H_{comp} needs, but also receiving more than 2h over their basic H_{sat} throughout the summer months. Stormy weather during the September and October deployments resulted in H_{comp} (both months) and H_{sat} (October) both coming in below their baselines, however, as was mentioned previously for the Gardiners Bay site, by October, the plants are beginning to change into their "winter"

Table CP-1. H_{comp}, H_{sat} and temperature data calculated from the deployment of Odyssey PAR loggers and TidBit temperature loggers in Cedar Point, E. Hampton, over 7-days for each month, May-October, 2011.

Month	Ave. Daily H_{comp} (Hr)	Net Daily H_{comp} (Hr)	Ave. Daily H_{sat} (Hr)	Net Daily H_{sat} (Hr)	Ave. Monhly Temperature (°C)
May	13.9	+1.5	11.3	+2.6	14.2
June	14.7	+2.3	12.0	+3.5	19.3
July	14.4	+2.0	11.9	+3.4	23.3
August	13.4	+1.0	10.8	+2.3	23.5
September	11.8	-0.7	8.6	+0.1	21.2
October	10.8	-1.7	6.6	-1.9	16.6

mode, requiring less energy and minimizing the impact of less light for the plants.

Water temperature never approached 25°C at Cedar Point, so its impact on the eelgrass at this site is negligible.

Eelgrass Shoot Density

With 2008 being the first year of data collection for this meadow, there is not enough data to determine, or even speculate, trends. Whereas CCE has spent a significant amount of bottom time at the Orient Point meadow and can make some observation regarding the possible directions the eelgrass population may take at that site, the Cedar Point meadow has just become an important meadow in terms of eelgrass restoration as well as for the eelgrass monitoring program. The 2008 monitoring survey found that the average eelgrass shoot density for Cedar Point was 285 shoot per meter^2. The maximum shoot density counted at the site was 770 shoots per meter^2. In many ways, the Cedar Point eelgrass meadow resembles the Orient Point meadow, prior to the October 2006 storm that caused large-scale loss. Both sites are patchy with evident blowouts caused by wave action and bioturbation (i.e., crab digging along meadow edges). The two populations show similar range in shoot density and the meadow phenology is similar, with seeds coming to maturity at approximately the same time.

Table CP-2. The annual average eelgrass shoot density for Cedar Point for 2008 and 2011, including standard error.

Year	Mean Density	S.E.
2008	285	+/-28
2009	385	+/-34
2010	500	+/-34
2011	389	+/-19

Figure CP-4 shows a typical underwater view of an eelgrass patch at Cedar Point.

Macroalgae Cover

Cedar Point is a coarse substrate site. The site includes a significant amount of larger materials, in the form of boulders, that would not be reflected in the sediment analysis. All of this large substrate is ideal for the attachment of large amounts of macroalgae. Cedar Point supports one of the largest *Sargassum filipendula* beds in the Peconic Estuary and this brown seaweed is often encountered growing interspersed with eelgrass patches at this site. Other species to note include the brown seaweed *Scytosiphon lomentaria* (a.k.a.- sausage-weed), which can grow up over 4ft tall from late spring to early summer throughout this meadow. The macroalgae cover recorded for the eelgrass monitoring survey was found to average around 37%, which is considered low to moderate

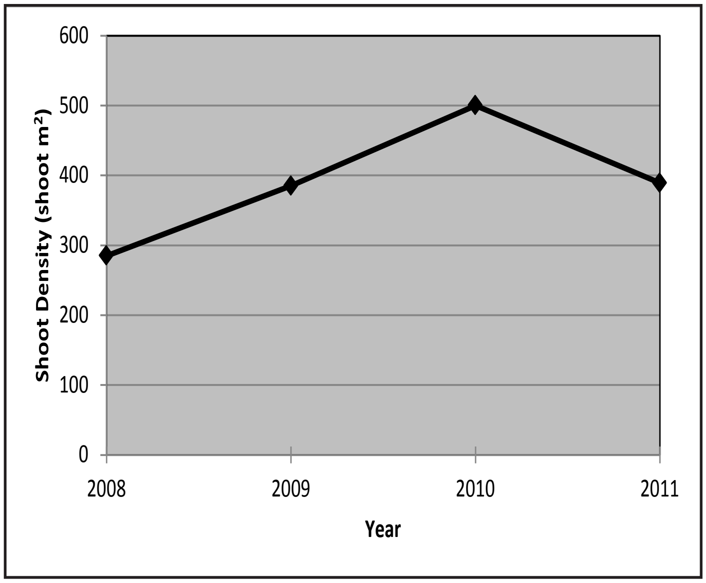


Figure CP-2. The average annual eelgrass shoot density for Cedar Point for 2008-2011.

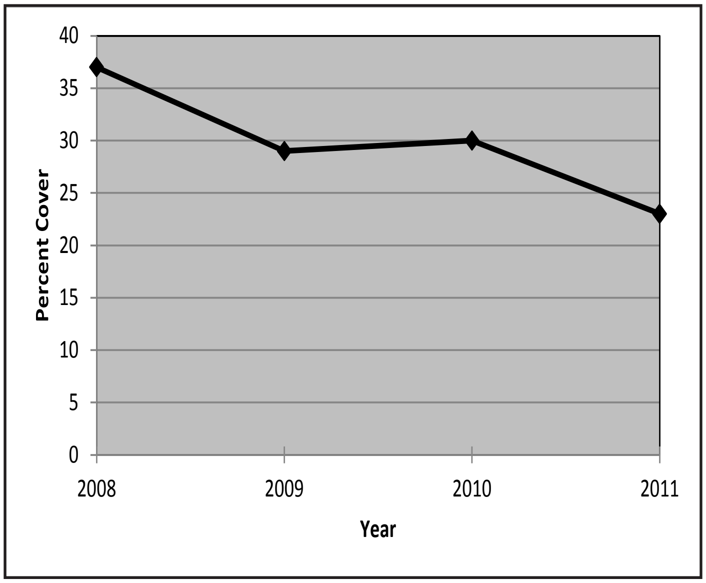


Figure CP-3 Annual mean macroalgae cover for Cedar Point, East Hampton from 2008 to 2011.

compared to other eelgrass meadows in the Peconic Estuary.

Bed Delineation and Areal Extent

Accurately delineating the Cedar Point eelgrass meadow requires very good aerial imagery as the meadow extends offshore to water depth greater than 9 feet. Also, the patchy nature of this meadow compounds the difficulty of identifying the deep edge as no continuous signature is evident in the aerial. The underestimation of the Cedar Point meadow from the 2000 aerial photography was likely due to the combination of poor water conditions preventing clear identification of eelgrass and a general unfamiliarity of the site by the photo-interpreter. Based on the 2004, 2007 and 2010 aerials and several years of field experience at this site, the 2000 delineation missed 150-200 acres of eelgrass. When the other three years are considered, there is not much difference between the three years regarding the coverage. The differences in the estimated area of eelgrass presented in Table CP-3 may be accounted for by the quality of the aerial, the spatial coverage of each aerial and the subjectivity of

Table CP-3. The estimated cover of the eelgrass meadow at Cedar Point from 2000-2010.

Year	Estimated Area
2000	35.20 acres (14.25 hect.)
2004	168.12 acres (68.04 hect.)
2007	224.46 acres (90.84 hect.)
2010	171.81 acres (69.53 hect.)

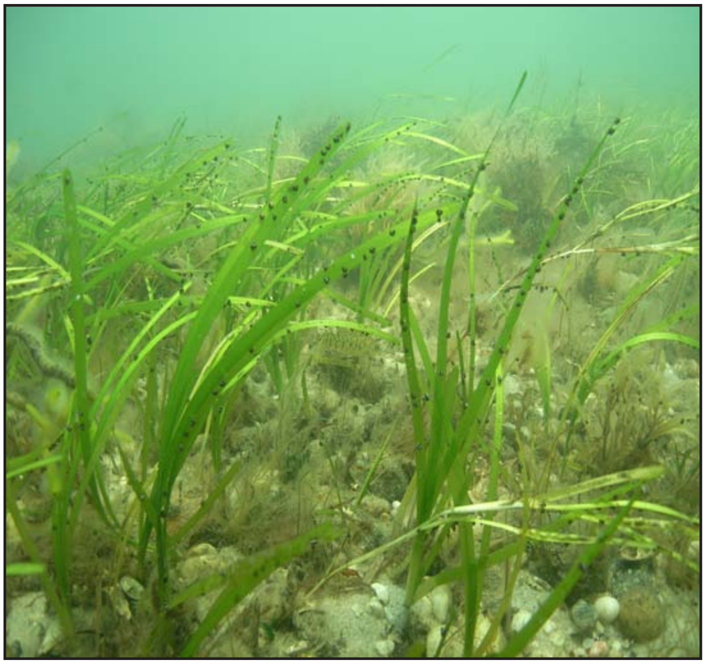


Figure CP-4. An underwater view of an eelgrass patch at Cedar Point, East Hampton.

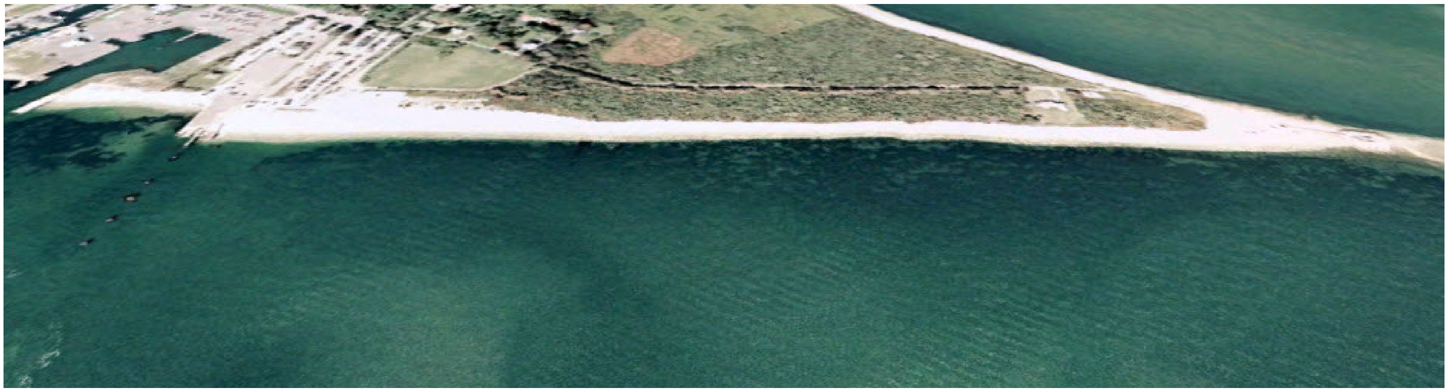
the photo-interpreter. Overall, based on this analysis, there has been no significant change to the areal cover of Cedar Point. The meadow has been labeled as "stable" in previous reports and this trend analysis supports that conclusion.

Conclusions

The Cedar Point site is a healthy meadow representative of what how eelgrass beds used to exist throughout the Peconic Estuary. Conditions at the site appear to be optimal for what we know is needed for eelgrass growth and spread. There is sufficient light at the site to support growth and expansion via both vegetative and sexual reproduction (i.e., seed production). Water temperatures during summer are low for the Peconics and in no way inhibit growth. The eelgrass coexists with the large population of *Sargassum filipendula* that grows attached to the boulders on the site, often with eelgrass growing around boulders supporting the macroalgae.

Erosional forces shape this meadow to a degree, but they do not have the impact on Cedar Point that is evident on the Gardiners Bay site. This may have to do with the rockier sediments and the wave-dampening effect of not only the eelgrass but the perennial *Sargassum*. The rocky nature of this site does discourage shellfishing and most boaters are prudent enough to follow the buoys, or risk encountering one of the many boulders that come almost to the waters surface.

In all, there is no concern regarding any aspect of this meadow’s health.



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." Figure OP-2 shows

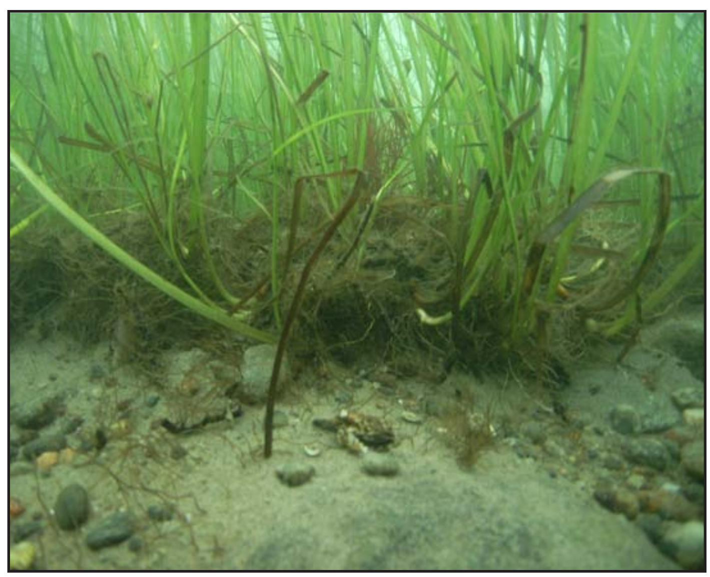


Figure OP-2. A side view of a "blowout" where a opening has been eroded in the meadow. The eelgrass is left to grow out over the edge where it is eventually dislodged. Also notice the coarse sediments left behind after the erosion.

Table OP-1. H_{comp}, H_{sat} and temperature data calculated from the deployment of Odyssey PAR loggers and TidBit temperature loggers in Orient Point over 7-days for each month, May-September, 2011.

Month	Ave. Daily H_{comp} (Hr)	Net Daily H_{comp} (Hr)	Ave. Daily H_{sat} (Hr)	Net Daily H_{sat} (Hr)	Ave. Monthly Temperature (°C)
May	13.8	+1.4	10.2	+1.7	14.8*
June	14.4	+2.0	12.1	+3.6	17.6
July	14.5	+2.1	12.2	+3.7	21.3
August	12.9	+0.5	10.1	+1.6	22.2
September	11.6	-0.8	8.5	0.0	21.0
October	9.2	-3.2	4.8	-3.7	17.2

**Represents the average water temperature for the last 12 days of May.*

a characteristic blowout found in the Orient Point meadow.

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%.

Light Availability and Temperature

The light logger and water temperature survey of the Peconic Estuary included Orient Point as its easternmost site on the North Fork. The data in Table OP-1 is a synthesis of the 7-day, monthly deployment of light loggers from May-October for Orient Point. As has been the general trend with all of the sites in this report that were included in the light and temperature survey, the worst months for Orient Point regarding H_{comp} and H_{sat} were September and October. Orient Point experienced the largest light deficit for both parameters of any of the meadows for October 2011. The last two days of the October deployment experienced high wind and storms that reduced both the period of H_{comp} and H_{sat} significantly, resulting in the net daily average deficits indicated in Table OP-1. Unlike Cedar Point, Orient Point's eelgrass meadow includes finer sediments that are easily stirred up and can take a long time to settle out, so the impact of bad weather would be drawn out for Orient Point. The deficits incurred by the poor weather in both September and October are likely made up by the surpluses over the previous months. Also to be considered is that the data represents only one week out of each of the months. Sunny days with low/no wind could have provided the eelgrass meadow with enough light to compensate for the recorded conditions.

The water temperature at Orient Point is more characteristic of the temperatures encountered in eastern LI Sound rather than the Peconic Estuary. The Orient Point eelgrass rarely faces temperatures exceeding 23°C, allowing the eelgrass at this site to maintain a lower metabolic rate than some of the warmer eelgrass meadows. This eelgrass meadow has historically been a prolific seed-producing bed and the high light/low temperature support the energy needed by these plants to produce flower shoots and seeds.

Table OP-2. 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
2011	279	+/-30

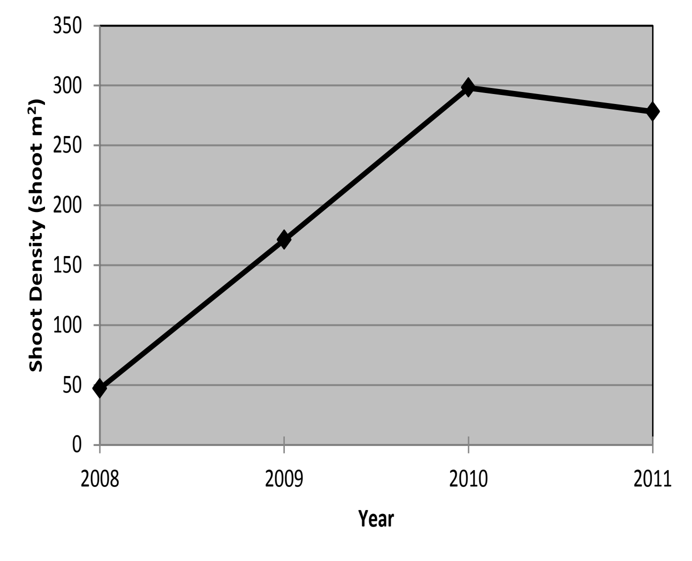


Figure OP-3. Graph of the annual mean eelgrass shoot density for Orient Point from 2008-2011.

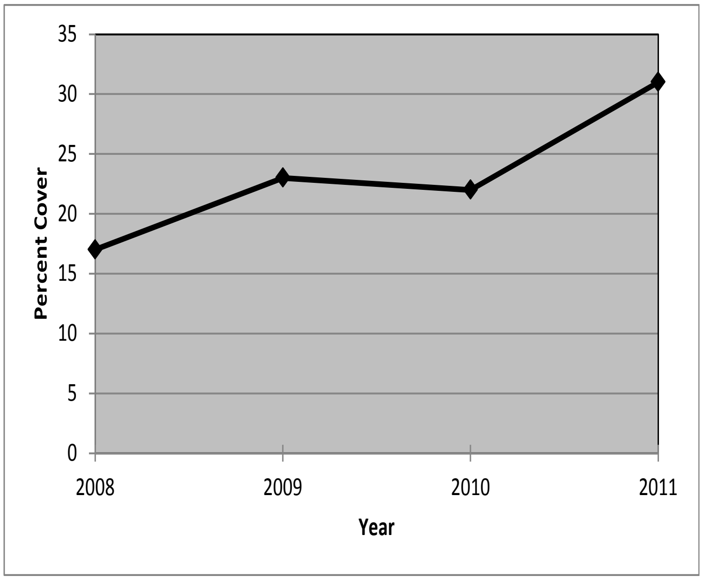


Figure OP-4. The annual mean macroalgae percent cover for Orient Point from 2008-2011.

Eelgrass Shoot Density

The 2011 eelgrass survey is the fourth year of monitoring that has occurred at this site. Based on the data represented in Table OP-2 and Figure OP-3, the meadow has continued to recover from the storm damage it experienced in 2006. While 2011 saw a small decrease in the average shoot density from 2010, the change was statistically not significant. The meadow has still not recovered to the pre-2006 density of 400-500 shoots per square meter, but after 5 years of recovery, the meadow has made considerable gains. Most of the recovery has been observed in the inshore areas of the meadow. The off-shore areas suffered the brunt of the storm damage and have continued to absorb damage from subsequent storms resulting in a much slower recovery.

Macroalgae Cover

Macroalgae is showing a similar recovery to that of eelgrass in the Orient Point meadow. Since the storm of 2006 reduced the eelgrass population at the site, sand movement has exposed rocky sediment for macroalgae to colonize. The increase in percent cover in the meadow is illustrated in Figure OP-4. The greatest increase in macroalgae was observed at Stations 5 and 6 (Figure OP-1) where the damage from the storm was greatest and, initially, the eelgrass meadow was not very dense. This area is also subject to relatively high currents and these currents have added to the sand movement and exposure of once buried boulders that have been readily colonized by *Sargassum filipendula* and turf-forming red algae (e.g., *Chondrus crispus*, *Phyllophora pseudoceranoides*, etc.).

Table OP-3. Trend analysis of the estimated area of the Orient Point meadow as determined from aerial photographs from 2000 to 2010.

Year	Estimated Area
2000	*7.59 acres (3.07 hect.)
2004	62.24 acres (25.19 hect.)
2007	55.80 acres (22.58 hect.)
2010	31.39 acres (12.70 hect.)

Bed Delineation and Areal Extent

For Orient Point, CCE has long known that the meadow's deep edge was over 1000 feet from the MLW line, but it consisted of low density patches that were not always obvious in aerial photography. Also, the meadow's edge was close to the path that the Cross Sound Ferry takes when leaving the dock and the ferries tend to stir up the water column, which would further obscure the presence of eelgrass at the site. Even with all that considered, the 2000 eelgrass survey grossly underestimated the acreage of the meadow (Table OP-3) when compared to the area of eelgrass for the later photosets. The 2006 storm damage is not as evident in the 2007 aerials as the damage thinned patches of the meadow and fragmented larger

Figure OP-5. Eelgrass growing in the shallow, near-shore area of the Orient Point meadow in April, 2012.

patches, but it did not necessarily result in the direct loss of eelgrass area. However, the fragmentation of the meadow and the reduced shoot densities in patches has likely contributed to the continued contraction of the meadow into shallower water that is evident in the 2010 aerials. In some areas of the meadow, the eelgrass has retreated inshore several hundred feet from the 2004 (pre-storm damage) meadow. The continued loss of meadow should start to slow as it has converged on areas that were not hit hard by the 2006 or subsequent storms. These areas are not patchy so erosional forces have less exposed meadow edge to work on.

Conclusions

Orient Point continues to take the brunt of storms that hit the east end of Long Island. Its exposed nature, especially to winds out of the east, make it susceptible to damage from winter storms. The initial observed loss in 2006-2007 has still not recovered, in terms of area once occupied by eelgrass, however, the eelgrass that did endure the damage has seen significant improvement. The deeper portions of this meadow experienced the worst damage and as a consequence far behind the eelgrass in the shallower sections of the bed. The discrepancy in recovery is likely attributable to lower light levels in the deeper waters and the initial lower density of plants and greater patchiness along the deep edge of the meadow.

Besides the storm damage, the data collected during the light and water temperature survey indicated that Orient Point meets or exceeds the needs of eelgrass in terms of the amount and quality of light available to eelgrass for most of the year. However, as the September and October data shows, wind and storms can significantly reduce the light reaching the eelgrass at this site. The temperature of the site is similar to that of LI Sound, where eelgrass seems to thrive in its eastern bounds, so the Orient Point meadow is expected to remain healthy and continue its recovery from the 2006 storm.

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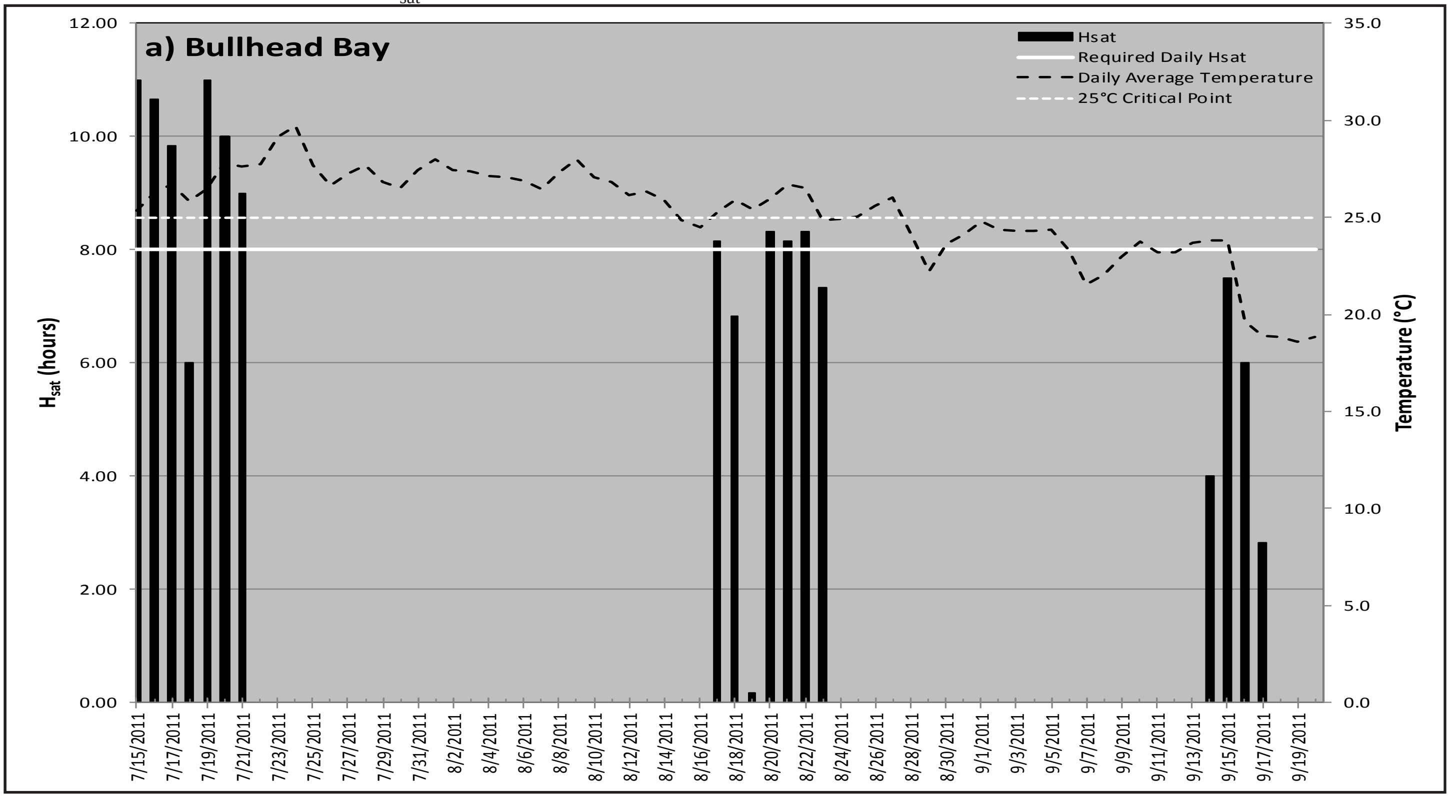
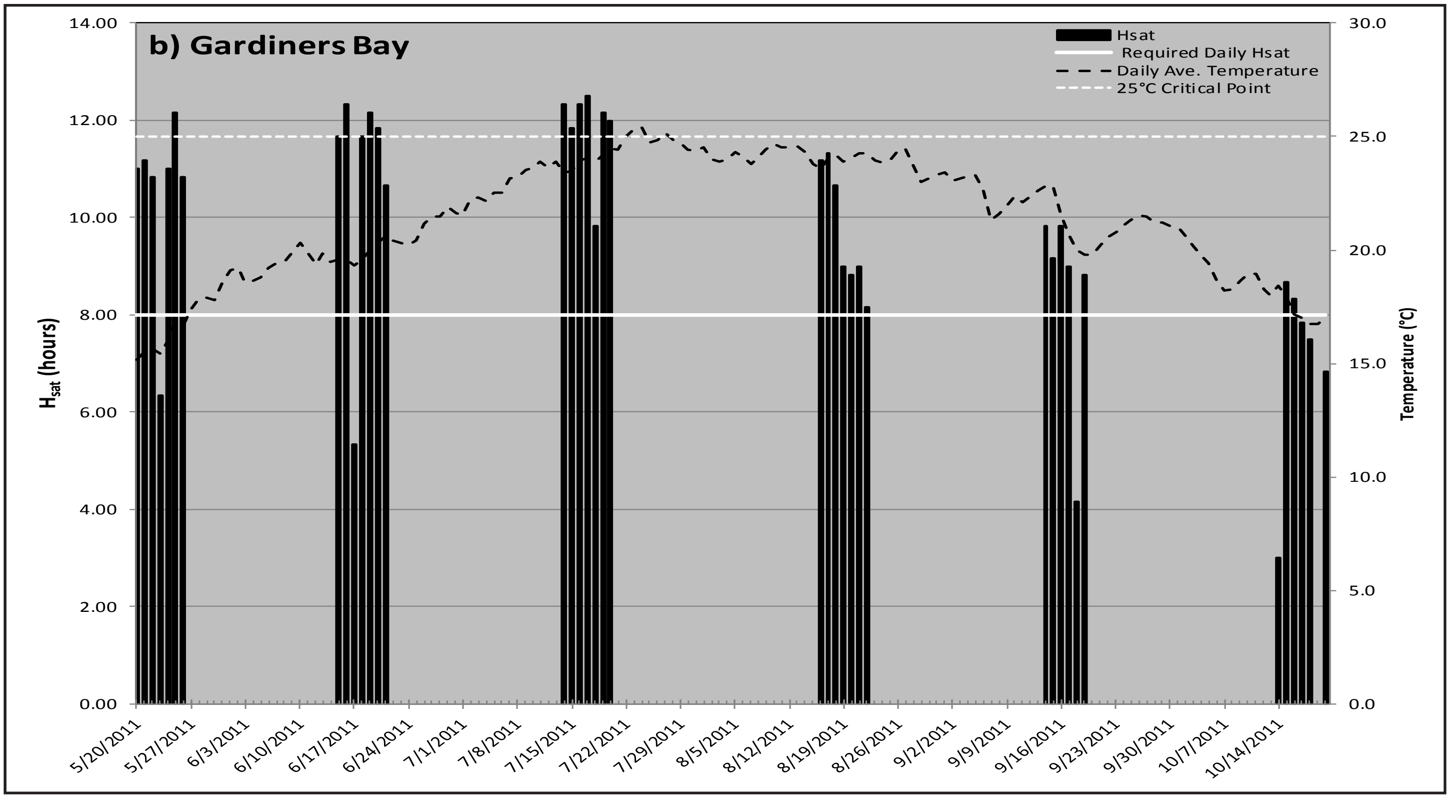
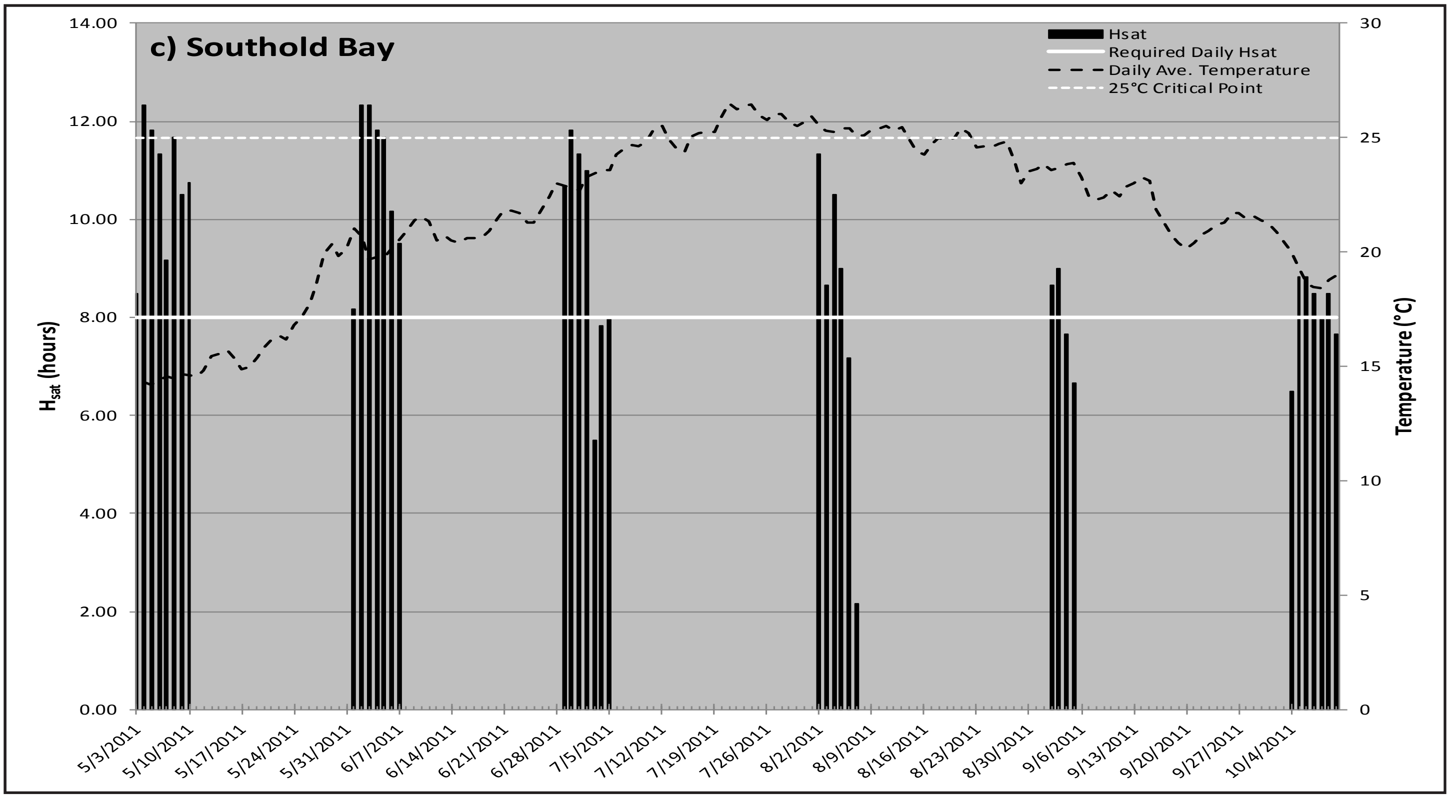
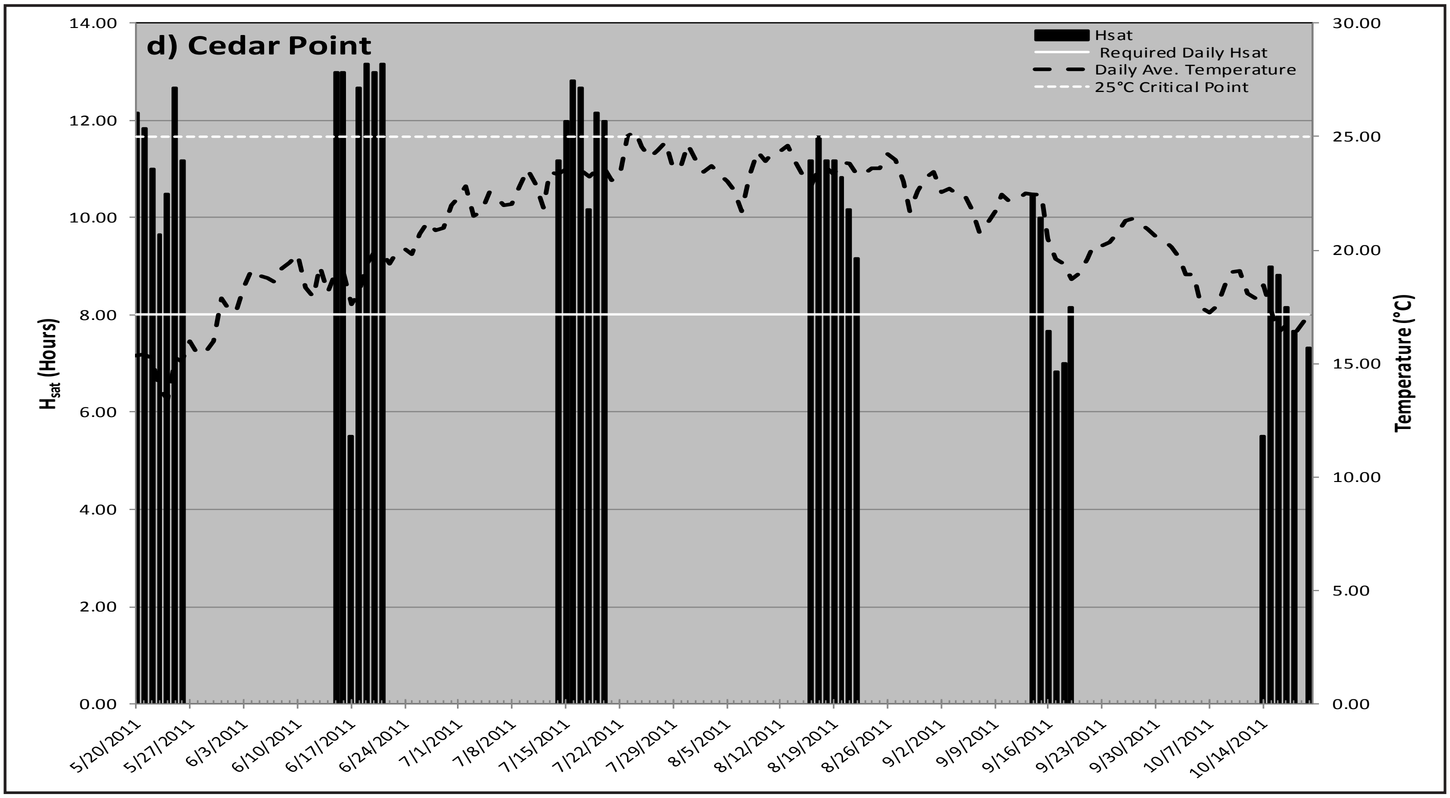
Appendix 1a-e. Graphs representing the collected light and water temperature data for the five LTEMP meadows included in the light logger survey in 2011. The graphs include the H_{sat} recorded for each of the monthly logger deployments and daily average temperature. Reference lines were drawn at 8h and 25°C, indicating the minmum required H_{sat} and critical water temperature, respectively.

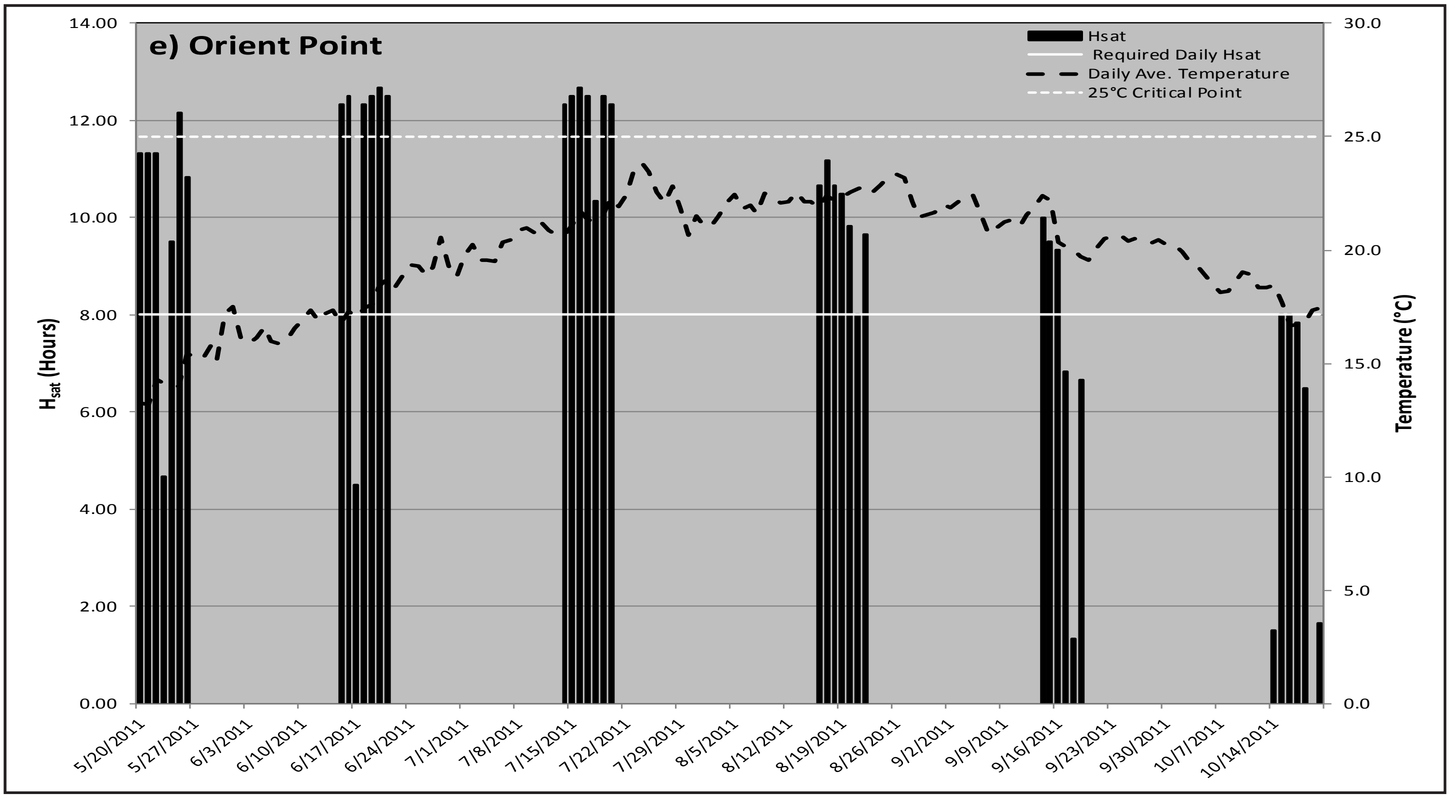




Appendices


c) Southold Bay
Hsat
Required Daily Hsat
Daily Ave. Temperature
25°C Critical Point
H sat (hours)
Temperature (°C)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
30
25
20
15
10
5
0
5/3/2011
5/10/2011
5/17/2011
5/24/2011
5/31/2011
6/7/2011
6/14/2011
6/21/2011
6/28/2011
7/5/2011
7/12/2011
7/19/2011
7/26/2011
8/2/2011
8/9/2011
8/16/2011
8/23/2011
8/30/2011
9/6/2011
9/13/2011
9/20/2011
9/27/2011
10/4/2011


d) Cedar Point
Hsat
Required Daily Hsat
Daily Ave. Temperature
25°C Critical Point
H sat (Hours)
Temperature (°C)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
5/20/2011
5/27/2011
6/3/2011
6/10/2011
6/17/2011
6/24/2011
7/1/2011
7/8/2011
7/15/2011
7/22/2011
7/29/2011
8/5/2011
8/12/2011
8/19/2011
8/26/2011
9/2/2011
9/9/2011
9/16/2011
9/23/2011
9/30/2011
10/7/2011
10/14/2011


e) Orient Point
Hsat
Required Daily Hsat
Daily Ave. Temperature
25°C Critical Point
H_{sat} (Hours)
Temperature (°C)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
30.0
25.0
20.0
15.0
10.0
5.0
0.0
5/20/2011
5/27/2011
6/3/2011
6/10/2011
6/17/2011
6/24/2011
7/1/2011
7/8/2011
7/15/2011
7/22/2011
7/29/2011
8/5/2011
8/12/2011
8/19/2011
8/26/2011
9/2/2011
9/9/2011
9/16/2011
9/23/2011
9/30/2011
10/7/2011
10/14/2011

Appendix 2a-k.

2a. Bullhead Bay eelgrass meadow in 2004.

2b. Bullhead Bay eelgrass meadow in 2010.

2c. Gardiners Bay eelgrass meadow in 2004.

2d. Gardiners Bay eelgrass meadow in 2007.

2e. Gardiners Bay eelgrass meadow in 2010.

2f. Cedar Point eelgrass meadow in 2004.

2g. Cedar Point eelgrass meadow in 2007.

2h. Cedar Point eelgrass meadow in 2010.

2i. Orient Point eelgrass meadow in 2004.

2j. Orient Point eelgrass meadow in 2007.

2k. Orient Point eelgrass meadow in 2010.