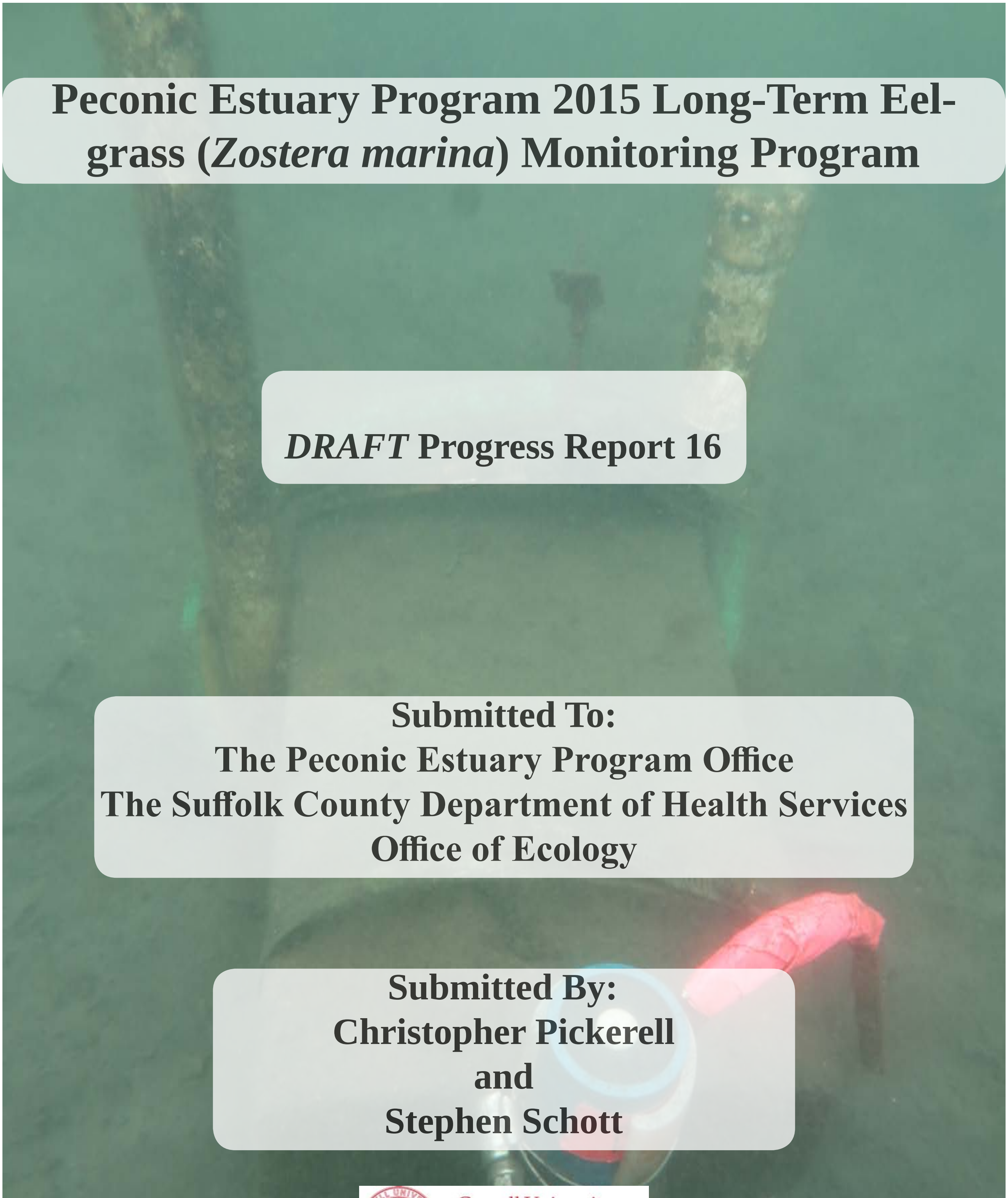

Peconic Estuary Program 2015 Long-Term Eel-grass (*Zostera marina*) Monitoring Program

DRAFT Progress Report 16

Submitted To:
The Peconic Estuary Program Office
The Suffolk County Department of Health Services
Office of Ecology

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Executive Summary

The 2015 Peconic Estuary Program Long-term Eelgrass Monitoring Program (PEP LTEMP) was initiated in June of 2015 with the set-up of the light and temperature monitoring stations and the deployment of water temperature monitoring equipment at six of the eight monitoring sites in the program. Eelgrass monitoring followed in August (20-28) with all eight sites visited by Cornell Cooperative Extension (CCE) divers, who collected eelgrass shoot density, macroalgae percent cover, and video archiving of each monitoring station within each of the sites. The data and observations collected during the 2015 monitoring effort are presented in this report and summarized below.

Light availability and water temperature are important gauges of eelgrass health and data were collected at 6 of the eight monitoring sites for both of these parameters. All of the sites that support extant eelgrass meadows were monitored, and in 2015, an additional site was added in Three Mile Harbor, where small beds were identified during the 2014 Peconic Estuary Aerial Eelgrass Survey. In general, light availability in the monitored meadows met or exceeded the daily requirements for healthy eelgrass meadows for July and August. By September, higher frequency of storms/wind, combined with shortening days find most meadows running slight deficits in light. Water temperatures exceeding 25°C (77°F) stress eelgrass, and research conducted by CCEsuggests that sites experiencing more than 30 days of water temperatures above 25°C can not support healthy eelgrass meadows. Three sites in 2015 exceeded the water temperature threshold, Bullhead Bay, Orient Harbor and Southold Bay. Neither Orient Harbor or Southold Bay currently support an eelgrass meadow. Bullhead Bay appears to be the exception to the high temperature threshold with the meadow having experienced 72 days over 25°C and 25 days at or exceeding 27°C, a temperature that has been reported as lethal to eelgrass for even short periods of time, yet the meadow has shown significant recovery since 2010, with 2015 reporting the highest eelgrass shoot density since in more than 10 years. Bullhead Bay's resistance to high water temperatures may be related to groundwater seepage in the meadow, a theory that is currently being investigated by CCE.

Eelgrass shoot density is the primary parameter of the health of a meadow in the PEP LTEMP. The general trend in recent years has been an overall decline in the extant meadows in the monitoring program. These declines have been facilitated by storm damage, climate change/sea level rise, bioturbation, and human impacts. In 2015, two of the monitoring meadows, Gardiners Bay and Cedar Point, recorded declines in average shoot density, with the decline at the Gardiners Bay site identified as significant, with the average shoot density falling below 100 shoots per square meter. The Orient Point meadow saw virtually no change from 2014, and Bullhead Bay experienced an increase in shoot density from 2014.

Macroalgae cover within the meadows provides a guage of competition and general water quality at each site. Macroalgae growing within eelgrass meadows and on eelgrass blades compete for nutrients and light. Typically, macroalgae percent cover has been highly variable, both between years and between sites. In 2015, Bullhead Bay, Orient Harbor and Three Mile Harbor saw significant increases in macroalgae percent cover from previous years. In Bullhead Bay, this increase was attributed to the recovery of the meadow supporting a larger macroalgae population. In Orient and Three Mile Harbors, macroalgal growth may be a filling of the niche left by the extinct eelgrass meadows in these sites.

For the four sites that still support eelgrass meadows, the changes in the areal extent of each of these eelgrass populations is reported annually, when aerial imagery is available. The delineations of these extent of these meadows allows for a comparison between years and can identify significant changes in each meadow and possibly indicate the cause(s) of that change. The general trend in the Peconic Estuary, since 2000, has been one of shrinking eelgrass meadows. With few exceptions, most meadows have lost acreage over the last 15 years. In

2015, one meadow, Cedar Point and the small bed in Three Mile Harbor, showed no change from 2014, while significant declines (>10 acres) were experienced in Bullhead Bay and Gardiners Bay. The Orient Point meadow showed a minor decline of 2.2 acres. While a percentage of the reported declines in extent of meadows may represent artifacts of sub-optimal imagery and the subjective nature of aerial delineation, significant declines, like those presented for Bullhead Bay and Gardiners Bay can not be dismissed as minor.

The PEP LTEMP has provided data since the late 1990s that allowed the resource managers at all levels of government to understand the trends in the eelgrass populations in the Peconic Estuary. Overall, eelgrass populations are in decline in the Peconic Estuary, and this is a trend shared with seagrasses globally. With the exception of Bullhead Bay, there are no eelgrass meadows growing west of Shelter Island. Environmental conditions, specifically light availability and water temperature, are no longer within the optimal range for eelgrass in this section of the estuary and, with global climate change and increasing population on the east end of Long Island, conditions may deteriorate in eelgrass meadows that are growing at the upper limits of their tolerance. Additionally, eelgrass meadows are subjected to more frequent and intense storms and increased disturbance by foraging animals and human activities, coupled with an inability to regenerate impacted areas at a rate to maintain population extent and integrity, which results in the continual decline observed in many of our eelgrass meadows. Eelgrass meadows growing under more favorable conditions in Gardiners Bay appear to be in good health and have changed little in the time between the 2000 and 2014 eelgrass surveys. While little can be done to minimize the impacts of climate change on eelgrass meadows, water quality issues and human disturbance can be addressed to limit the stress they exert on the meadows. Responding to impacts to eelgrass meadows requires "real-time" data. The 2014 aerial survey of the Peconics, while a valuable tool, ended a gap in knowledge spanning fifteen years. During that time, there was almost a fifty percent decline in eelgrass acreage in the Peconic Estuary. While it may not be economical to fly estuary-wide aerial surveys on an annual basis, a time-frame of 3-5 years should be considered. To suppliment the full-scale aerial surveys, drone technology could be utilized to provide more regular data for impacted meadows or gauge impacts from acute distubance events (e.g. storm/hurricanes, harmful algal blooms, etc.) and plan appropriate management responses. Funding research to better understand our remaining eelgrass meadows by examining their physical environments and population genetics could elucidate the potential responses of Peconic Estuary eelgrass populations to changing climate and water quality conditions and allow resource managers to develop plans to possibly mitigate these impacts, protecting this valuable resource. The impact of groundwater on the quality of the coastal waters in Suffolk County has been a priority topic, and studies focusing on how groundwater may influence the health of eelgrass meadows, both negatively (nitrogen and pesticide input) and positively (modifying water temperatures), could produce valuable information.

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 Long-term Eelgrass 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 (eight, in the case of Gardiners Bay) sampling stations within the bed.

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

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

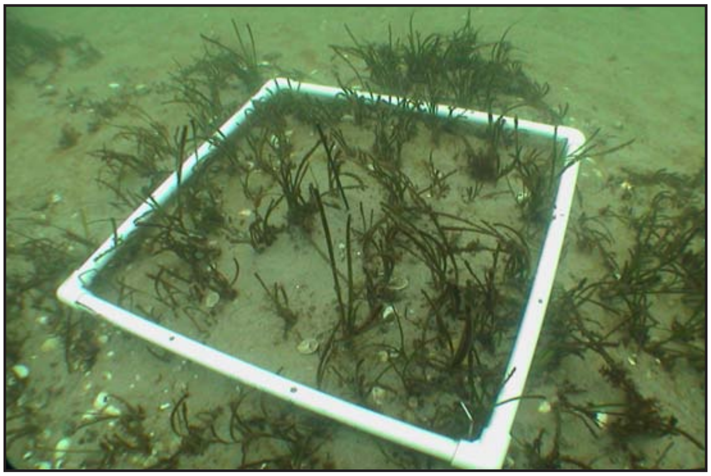


Figure Intro-1. A 0.10 meter^2 PVC quadrat used for eelgrass monitoring.

(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 increased 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.

Starting in 2012, two additional stations were added to the Gardiners Bay (Shelter Island) site due to the steady inshore migration of the eelgrass meadow. The stations (7 and 8) were selected to support eelgrass based on the March 6, 2012 aerial imagery presented in Google Earth. The location of these new stations is illustrated in Figure GB-1.

In 2014, three extant eelgrass beds were identified in the headwaters of Three Mile Harbor, East Hampton during the Eelgrass Aerial Survey. For 2015, the largest of the three beds was included in the monitoring with a diver completing 10 quadrat counts spread, randomly along its length. A light and temperature logger was also deployed in this bed for comparison against light and temperature data collected from the original Three Mile Harbor LTEMP site.

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 affects 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 species, 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.

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 at 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.

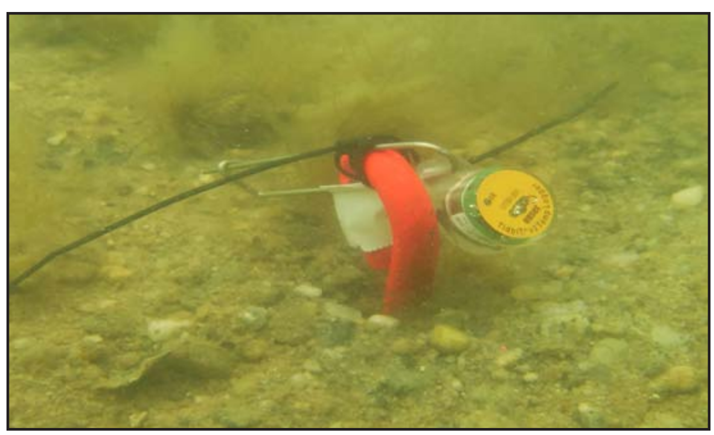


Figure Intro-2. A TidBit v2™ temperature logger attached to a screw anchor, deployed on-site.

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 is 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 (4 feet for this survey) 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. For the 2012 survey, a 1 week deployment was initiated for Three Mile Harbor in August to evaluate the light conditions at the site of the former meadow. The loggers were deployed 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 was then uploaded to and 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 12.3h period was adopted for the Peconic Estuary 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 2015 monitor began on 20 August and completed on 28 August. Sampling at each site was distributed among six stations that have been referenced using GPS, with the exception of the Gardiners Bay site, as mentioned above. At each of the six stations, divers conducted a total of 10 random, replicate counts of eelgrass stem density and macroalgae 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 minimally to genus level 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 MiniTab statistical software. The trends, within sites, were analyzed by comparing the current year's data with the data from the previous years.

Bed Delineation and Areal Extent

For the 2015 season, Google™ Earth aerial imagery (May 23, 2015) was used for current delineations. Trend analysis is presented using the results of the first eelgrass aerial survey (2000), the 2010 Suffolk County aerial (representing pre-Hurrican Sandy), the 2014 eelgrass aerial survey and the 2015 imagery. It should be noted that the Google Earth imagery and the Suffolk County aerials 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.

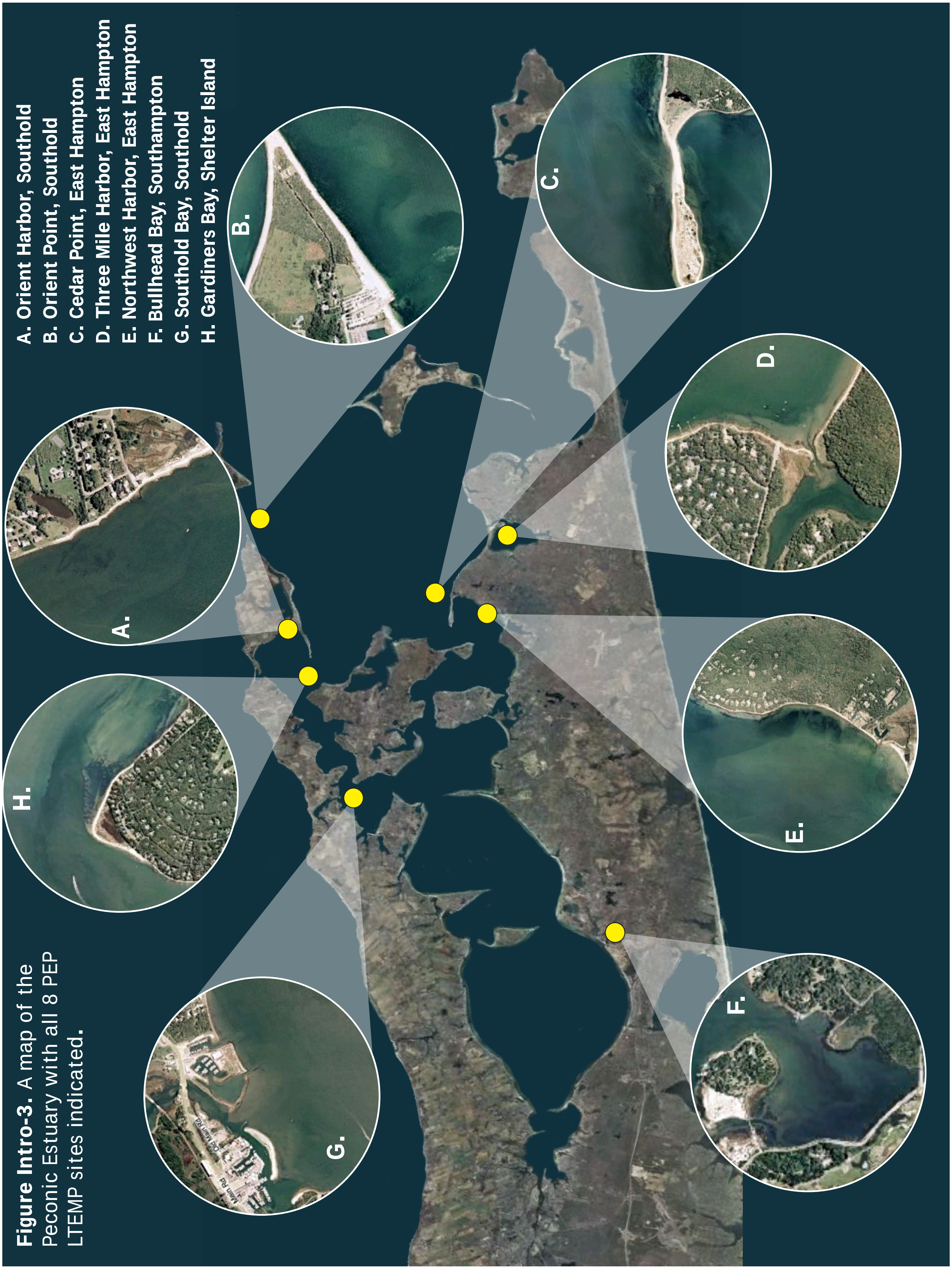


Figure Intro-3. A map of the Peconic Estuary with all 8 PEP LTEMP sites indicated.

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. When available, any GPS data describing a meadow’s extent was integrated into the final delineations presented.

Underwater Video

For the 2015 eelgrass monitoring, each diver was equipped with a GoPro Hero 2™ digital video camera in an underwater housing and video was taken to characterize each station at each of the eight PEP LTEMP sites.. The video clips were edited, combining footage from each station into a one to two minute video for each site. The videos can be found on YouTube at SeagrassLI’s video page.

Bullhead Bay 2015

Bullhead Bay is a small sheltered embayment located in the western Peconic Estuary and it is connected to Great Peconic Bay via Sebonac 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 Sebonac 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

Bullhead Bay 2015

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 for 2015.

Month	Ave. Daily H_{comp} (h)	Net Daily H_{comp} (h)	Ave. Daily H_{sat} (h)	Net Daily H_{sat} (h)	Ave. Monthly Temperature (°C)
July	13.7	+ 1.4	10.0	+2.0	26.3
August	12.1	-0.2	7.8	-0.2	26.8
September	10.3	-2.0	3.9	-4.1	23.9

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.

Light Availability and Temperature

Light loggers deployments were conducted monthly for seven days from July-September 2015, with the average Hcomp and Hsat for each month is presented in Table BB-1 above. Hcomp for July averaged 13.7h for the deployment, providing a surplus of light for the meadow to meet its basic metabolic needs. During July, the Hsat exceeded the basic daily requirement by 2h, averaging 10h of saturating light per day during the 10-day recording period. After July, water clarity experienced the normal seasonal decline that has been documented since light availability monitoring was initiated for the LTEMP. In August, both Hcomp and Hsat experienced a deficit of 0.2h, while September saw a greater decline in light availability with deficits of 2h for Hcomp and 4.1h for Hsat (Table BB-1).

The water temperature logger was deployed in early June. During the 2015 season, Bullhead Bay experienced comparable water temperatures to 2012, which had been the highest reported for LTEMP monitoring. The meadow was subjected to 72 days (52 days in 2014) of average water temperature exceeding 25°C and 25 days (2 days in 2014) of temperatures above 27°C. The first average daily water temperature above 25°C was recorded on 22 June 2015 with Bullhead Bay finally dropping below this threshold after 11 September 2015.

Eelgrass Shoot Density

The LTEMP monitoring was conducted in Bullhead Bay on 25 August, 2015. Eelgrass shoot density in Bullhead Bay showed no significant change between 2015 and previous two monitoring seasons (2013 and 2014) (Table BB-2; Figure BB-2a). The overall shoot density in the meadow increased slightly, however there was a conspicuous loss of eelgrass in the north-

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
2012	71	+/-12
2013	188	+/-20
2014	188	+/-12
2015	211	+/-27

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

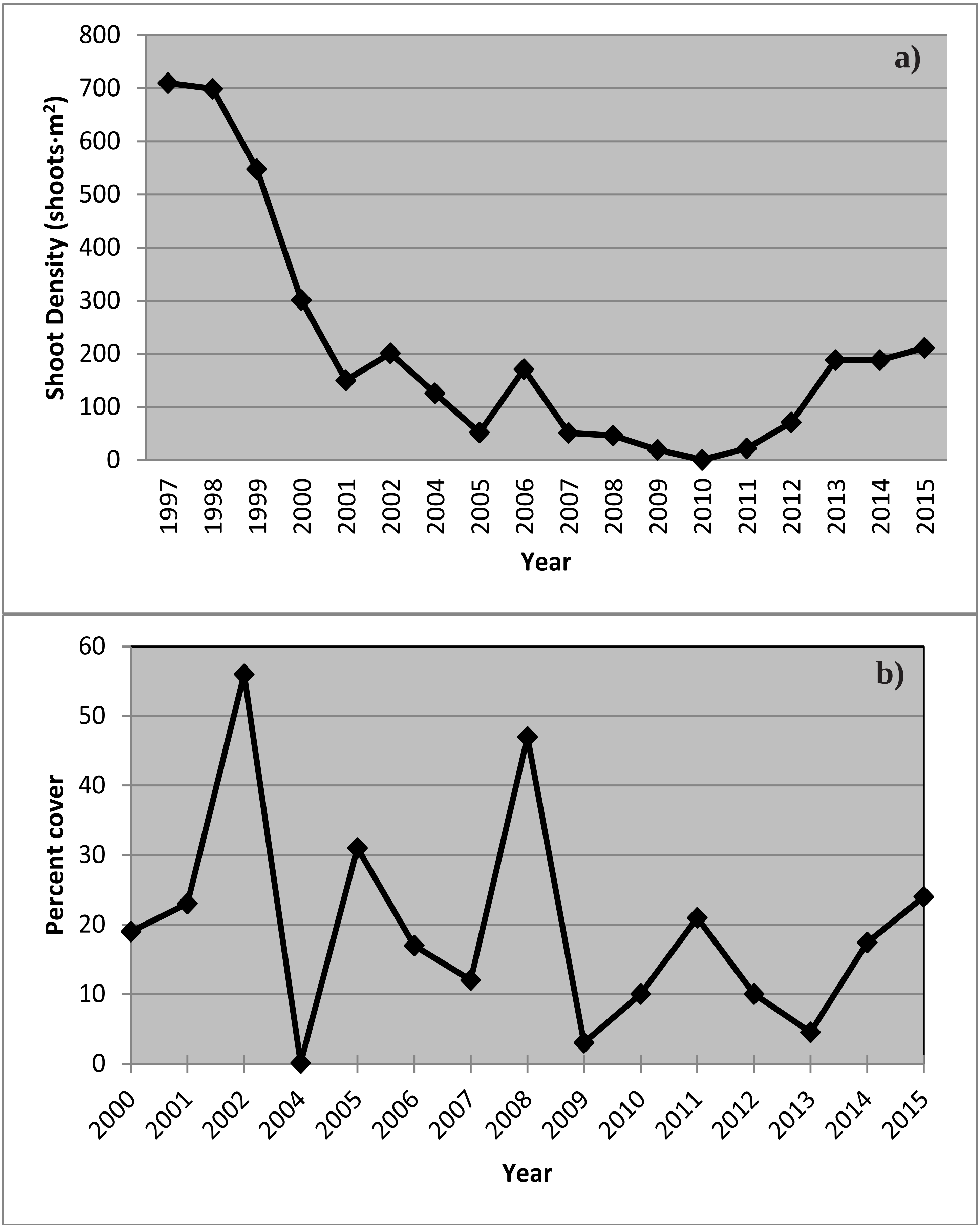


Figure BB-2. Graphs of average a) shoot density and b) macroalgae percent cover trends for all years of the PEP LTEMP conducted in Bullhead Bay.

Bullhead Bay 2015

Figure BB-3. The 2015 delineation of the Bullhead Bay eelgrass meadow.

ern section of the meadow encompassing Station 1 and part of Station 2 where there was almost a complete loss of eelgrass. Divers observed eelgrass rhizomes in, and emerging from the sediment throughout this area. Rhizome fragments were now brittle or black, suggesting that they may have recently been viable. Divers also observed large areas of disturbed sediment around Station 1 that suggests possible impact from ice during the previous winter. Widgeongrass (*Ruppia maritima*) has been almost entirely replaced by eelgrass throughout the monitoring area.

Macroalgae Cover

The 2015 monitoring season recorded increased macroalgae percent cover in Bullhead Bay (Figure BB-2b). Macroalgae took advantage of the loss of eelgrass around Stations 1 and 2, with *Spyridia filamentosa* and *Gracilaria* species forming expansive mats over the bottom in this area, accounting for the small increase in the average macroalgae percent cover from 2014. Macroalgal diversity was low, with only 5 species identified by divers. *Spyridia filamentosa* continued to be the most abundant macroalgae in 2015, but the green filamentous alga, *Chaetomorpha linum*, was observed growing entangled in large areas of the eelgrass canopy throughout Bullhead Bay. These mats of Chaetomorpha, while sometimes covering large areas, were not dense and likely presented little competition to the underlying eelgrass for light..

Bed Delineation and Areal Extent

When comparing the extent of the Bullhead Bay eelgrass meadow between 2014 Peconic Estuary aerial survey and delineation based on Google Earth images dated from May 2015, it appears that the harsh winter of 2015 may have had an impact. Comparison of the 2014 and 2015 areal coverage of eelgrass in Bullhead Bay found that the meadow suffered a loss of almost 17 acres of eelgrass over the winter (Table BB-3). Observations made by divers found that the northern section of the meadow (including areas around Stations 1 and 2) had sustained significant loss of eelgrass (Figure BB-4d), with rhizomes sticking out of or littering the bottom (Figure BB-5a). While the loss in acreage is not inconsequential, Bullhead Bay still maintains a large, continuous eelgrass meadow that represents an almost seven-fold increase from the 2010 meadow extent.

Conclusions

The 2015 eelgrass monitoring season found that the Bullhead Bay eelgrass meadow continues its recovery over most the bay, however the extremely cold winter of 2015, and the extended periods of thick ice it produced, appears to have negatively impacted the meadow. The shallow, northern section of the meadow suffered almost a complete loss of eelgrass near Station 1, with significant decline in the eelgrass surrounding Station 2 as well. Divers observed eel-

Table BB-3. Estimated areal coverage of the Bullhead Bay eelgrass meadow for select years from 2000-2015.

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.)
2012	30.50 acres (12.3 hect.)
2013	44.65 acres (18.07 hect.)
2014	56.92 acres (23.03 hect.)
2015	39.94 acres (16.16 hect.)

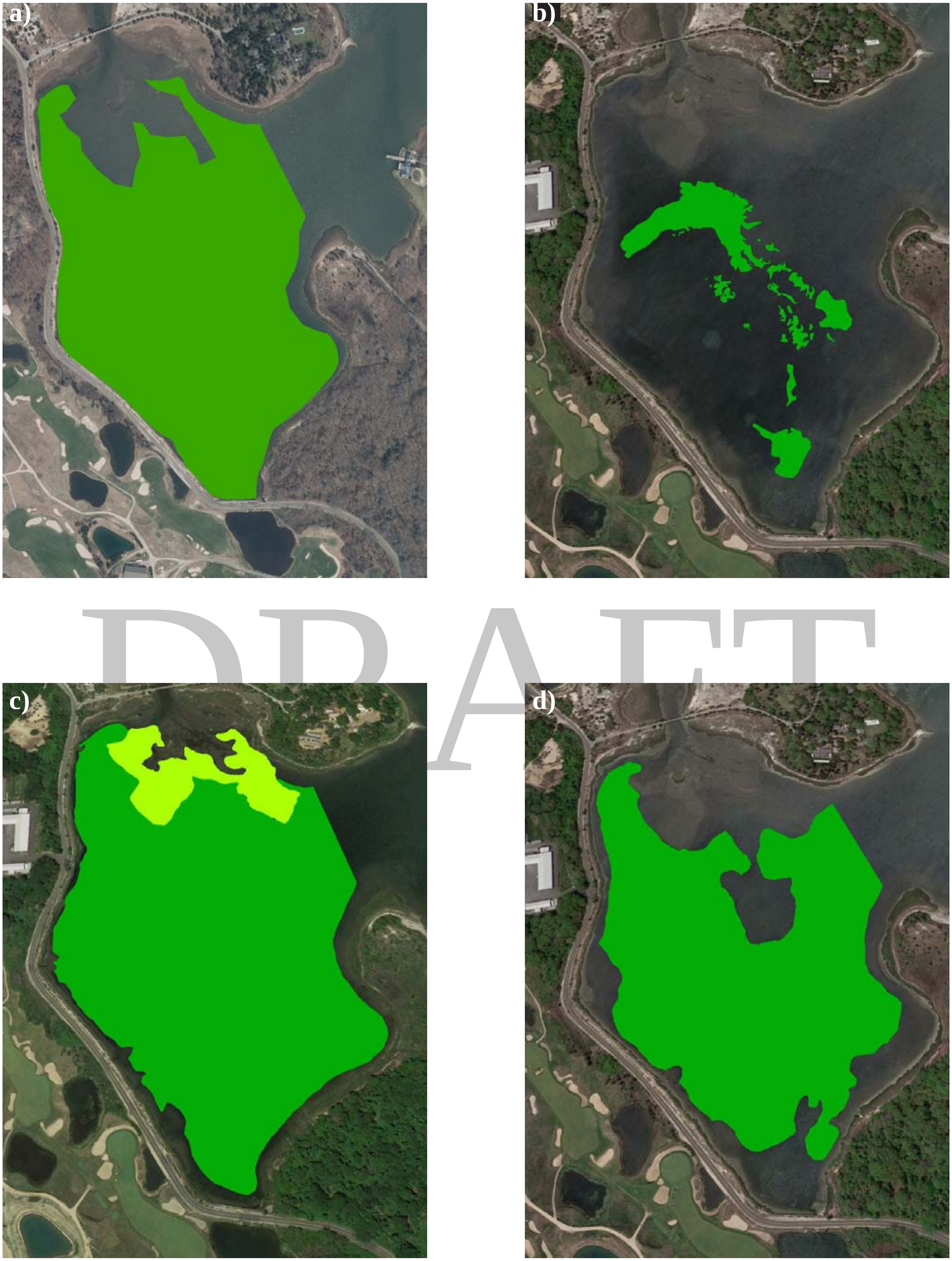


Figure BB-4. A series of aerial delineations of the Bullhead Bay eelgrass from 2000 through 2015. The years represented are a) 2000, b) 2010, c) 2014 and d) 2015.

Bullhead Bay 2015

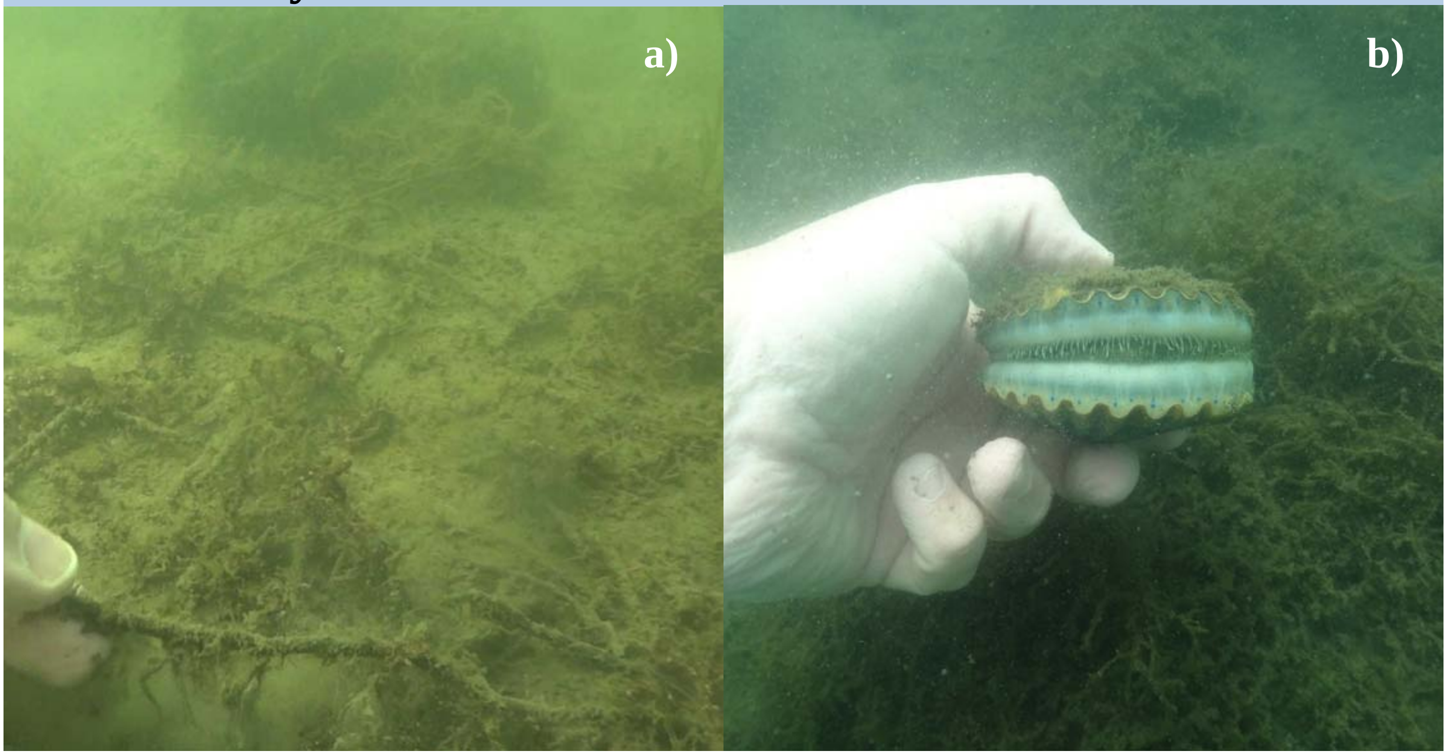


Figure BB-5. a) A photograph taken showing the exposed rhizomes in the area surrounding Station 1 in Bullhead Bay. b) CCE diver holds one of several adult bay scallops observed during the 2015 monitoring.

grass rhizomes standing up from the sediment into the water column (Figure BB-5a) or lying on the sediment surface as they had be washed, or pulled, out of the bottom. Unlike past die-offs that CCE divers have observed, the rhizomes were not not all black and brittle, with a large number maintaining some pliability and color that would be expected in living, or recently dead shoots. Several rhizomes were inspected closely and found to have lost the shoot end of the plant, suggesting that it was pulled upward until it broke from the rhizome. Without the meristem to generate new blades for photosynthesis, the rhizomes would slowly use up their storage carbohydrates and die, explaining the condition in which the divers found most of the exposed rhizomes. The loss of the above ground sections of the plant was likely due to the ice that formed in Bullhead Bay over the winter. The northern section of the meadow is shallow, but it also experiences the most tidal current due to the water flow under the bridge to the north. The eelgrass growing in shallow water would have been most susceptible to having its blades caught in the thickening ice. The eelgrass could have been pulled out by the ice moving up and down with the tides or when the ice started to break up in the spring, allowing individual ice floes to move back and forth with the tidal currents. The possibility that ice may have caused the damage to the meadow is further supported by observations of areas of the sediment that looked like they had been “bulldozed” throughout this area.

Water quality early in the season provided optimal water temperatures and an abundance of light that should have provided established shoots and developing seedlings the opportunity for growth and storage of reserves before the record-breaking heat of the summer increased plant stress in the bay. The eelgrass meadow was subjected to more than 70 days of temperatures over 25°C, which may not be lethal, would certainly stress the plants. That the Bullhead Bay meadow experience 25 days of daily average water temperature above 27°C is cause for concern, and, while no deleterious effects to the meadow were observed during fall 2015 observations, the effects of heat stress may be evident during the 2016 growing season. Light availability remaining relatively high likely mitigated some of the heat stress the plants endured. Also, preliminary study of water temperatures at several sites and at different levels of the water column within Bullhead Bay found significant differences in temperature between the eelgrass canopy and just below the sediment surface, especially near areas that were identified by Stark et al. (2012) to have high rates of groundwater seepage. Groundwater seepage throughout the eelgrass meadow may be moderating temperatures enough to reduce stress on the plants, especially in the meristem region just below the sediment surface. A summary of the preliminary temperature study will be released in the Spring 2016 with plans to conduct a more comprehensive study during the summer of 2016.

The monitoring data from 2015 indicates that the Bullhead Bay eelgrass meadow continues to recover. Shoot densities increased in 2015, even though no eelgrass was recorded in Station 1 and around most of Station 2, suggesting that the rest of the meadow is filling in. While the initial recovery of the meadow was attributed to recruitment from seed, the meadow has reached a population level in which vegetative reproduction has become the dominant mode of spread, except in those areas where eelgrass was lost in 2015. Recovery around Stations 1 and 2 will likely be from seed and observations of these areas in Spring 2016 will identify the presence of seedlings versus vegetative spread. Widgeongrass may become established in these open areas in 2016 due to lack of competition from eelgrass, however, as the eelgrass slowly reestablishes itself, it will push out the widgeongrass, like it has done in the rest of the meadow over the past few years. The recovery of the Bullhead Bay eelgrass meadow has benefitted the macroalgae community. Macroalgae has trended up since 2013, with species like *Spyridia filamentosa* and *Gracilaria* taking advantage of the increase eelgrass canopy as anchorage from which to spread.

Another encouraging observation while working in Bullhead Bay in 2015 was the resurgence of wildlife. Adult bay scallops were observed throughout the bay and a CCE diver also recorded a bug scallop attached to an eelgrass blade. During several visits to Bullhead Bay, large schools of menhaden were encountered finning on the surface. With the recovery of the meadow, there seems to be an increase in the stickleback population as nests were frequently observed in the eelgrass around the monitoring stations.

There is much to learn from the Bullhead Bay eelgrass meadow to understand how it continues to survive and thrive in an area of the estuary where the rest of the once abundant eelgrass meadows have gone extinct. Identifying how this eelgrass population deals with high water temperatures may provide better insight for restoration in similar systems. At the very least, the loss of eelgrass from the northern sections of the bay will provide an opportunity to identify and observe the likely mechanisms that lead to the recovery of the meadow from near extinction to its current state.

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 nutri-

Gardiners Bay 2015

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 for 2015.

Month	Ave. Daily H_{comp} (h)	Net Daily H_{comp} (h)	Ave. Daily H_{sat} (h)	Net Daily H_{sat} (h)	Ave. Monthly Temperature (°C)
July	13.6	+1.3	10.0	+2.0	23.1
August	12.5	+0.2	9.7	+1.7	24.9
September	11.6	-0.7	8.8	+0.8	23.2

ent 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, like Brown-Tide.

Light Availability and Temperature

Light loggers were deployed to Gardiners Bay eelgrass meadow for one week each month, July-September 2015. The average for Hcomp and Hsat was calculated for each month's deployment and they are presented in Table GB-1. The Gardiners Bay eelgrass meadow continues to have high water clarity with both Hcomp and Hsat meeting minimum requirements for most of the sampling period. By September, Hcomp missed meeting the 12.3h threshold by less than one hour, but the site still managed to meet Hsat. Overall, the meadow experienced a good season in regards to light.

Until 2015, water temperature stress had not been considered a potential issue for the Gardiners Bay eelgrass meadow. With the record-breaking heat of the summer of 2015, eighteen days were recorded where the daily average water temperature was above 25°C. This was an increase from previous years where 2013 experienced seven days and 2014 saw no day above 25°C. The highest recorded temperature for the Gardiners Bay meadow was 26.55°C, which came late in the season on 25 August 2015. The 2015 season differed from previous years in that July was relatively cool, but the August temperatures averaged almost 1.5°C above July, which is unusual.

Eelgrass Shoot Density

The Gardiners Bay eelgrass meadow was visited on 28 August, 2015 and, as in previous three seasons, only three monitoring stations within the survey area supported eelgrass (Stations 6, 7, and 8). For the 2015 monitoring, the eelgrass shoot density decreased significantly from 2014 to 2015 (Table GB-2; Figure GB-2a), with the average shoot density averaging 70 shoots·m^2 in 2015 for the site. When only the three

Table GB-2. The average annual eelgrass shoot density for Gardiners Bay from 1999 to 2015, 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
2012*	74	+/-15
2013	99	+/24
2014	106	+/-22
2015	70	+/-15

**Two new stations established (total=8).*

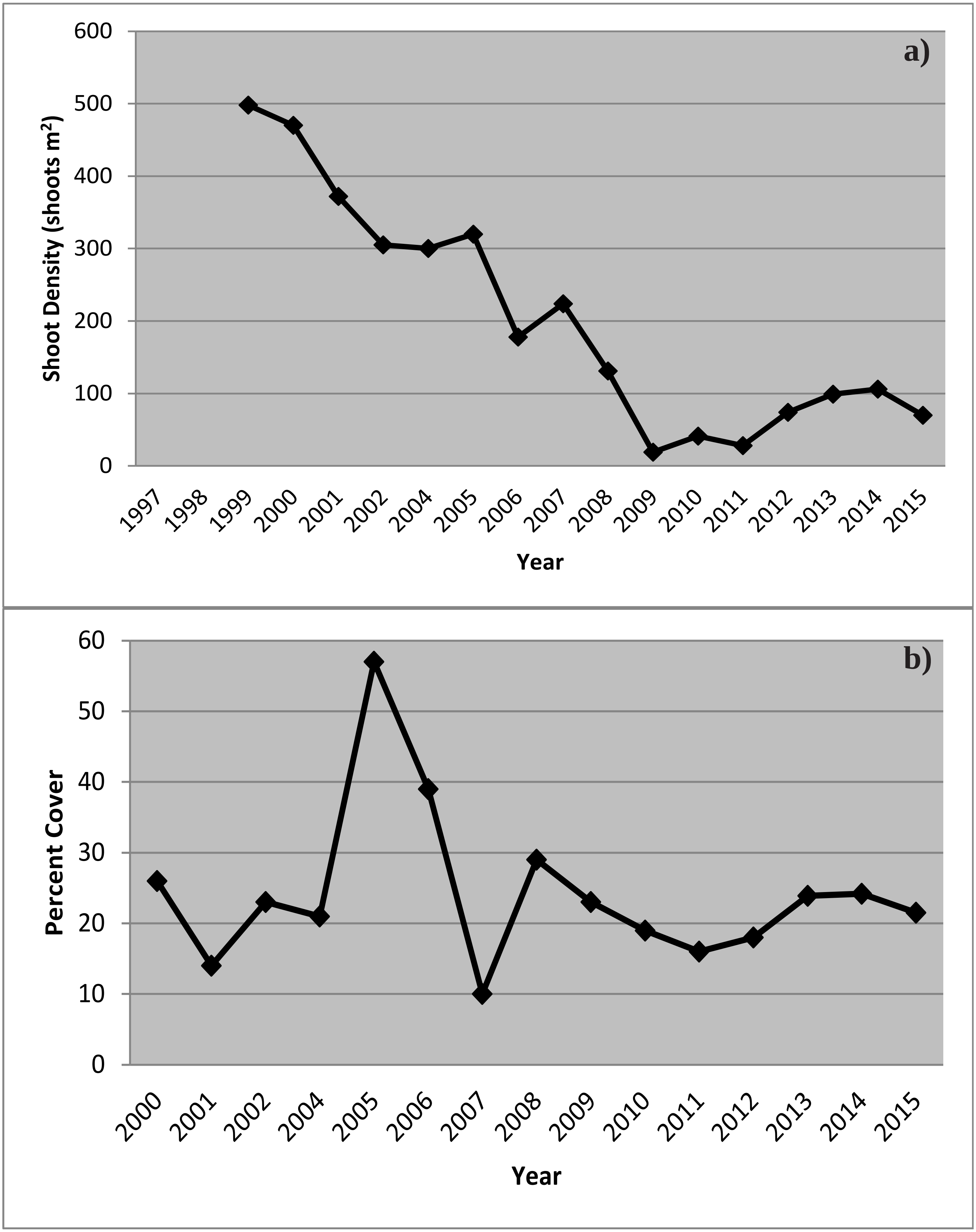


Figure GB-2. Graphs of average a) shoot density and b) macroalgae percent cover trends for all years of the PEP LTEMP conducted at the Gardiners Bay site.

Figure GB-3. The 2015 areal delineation of the Gardiners Bay eelgrass meadow of the northeast shore of Shelter Island, NY.

vegetated stations are considered, the shoot density was 181 shoots·m^2, a decline in 86 shoots·m^2 from 2014 for these same three stations. Much of this decline was due to increased patchiness of the meadow at this site and was likely influence by the harsh winter and, possibly the ice that was prevalent throughout the estuary.

Macroalgae Cover

The 2015 monitoring of the Gardiners Bay Site identified 11 species of macroalgae. *Spyridia filamentosa* was reported as the primary species, with *Sargassum filipendula* also a common species, especially nearshore on cobble and boulders. Macroalgae declined slightly in 2015 from 2014 (Figure GB-2b), but was not found to be a significant change in percent cover for the site. Other species reported for this meadow *Codium fragile*, *Ceramium* species, *Dasya baillouviana*, *Gracilaria* species and the relatively recent introduced red alga, *Grateloupia turuturu*, which was reported for the first time at this site.

Bed Delineation and Areal Extent

Table GB-3. The estimated areal coverage of the Gardiners Bay eelgrass meadow from 2000-2015.

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.)
2012	35.62 acres (14.42 hect.)
2013	24.79 acres (10.03 hect.)
2014	37.65 acres (15.24 hect.)
2015	27.25 acres (11.03 hect.)

The 2015 bed delineation was completed using Google™ Earth imagery taken on 23 May, 2015. The imagery over the Gardiners Bay site had waves and sun glare, making the detailed precision from previous years' delineations difficult to achieve. However, the general delineation (Figure GB-3) provided an estimated area for the meadow of 27.25 acres (11.03 hectares) (Table GB-3). This represents a loss of more than 10 acres from the 2014 delineation of the site. While this appears to be a significant loss in one year, the delineations in 2014 were more coarse, likely resulting in an over-estimated area, especially when considering the estimate from 2013. When the 2013 and 2015 delineations are compared, there is not a significant change between years.

Conclusions

The Gardiners Bay eelgrass suffered a minor decline from the previous two monitoring seasons. While shoot density was down from 2014, the areal extent of the meadow had not significantly changed from 2013. The winter of 2015 with its numerous storms and the formation of nearshore ice likely impacted the meadow. Shallow sections of the meadow would have been subjected to ice scour resulting in loss of eelgrass and increased patchiness. These new open areas in the meadow would be susceptible to the erosional forces presented by the currents and waves at the site, further expanding open areas within the meadow. In this case, the normally protected inshore edge of the meadow suffered the most loss, as evidenced by the decrease in shoot density at the three vegetated monitoring stations. With global climate change presenting the region with warmer summer temperatures and colder, stormier winters, the Gardiners Bay eelgrass meadow

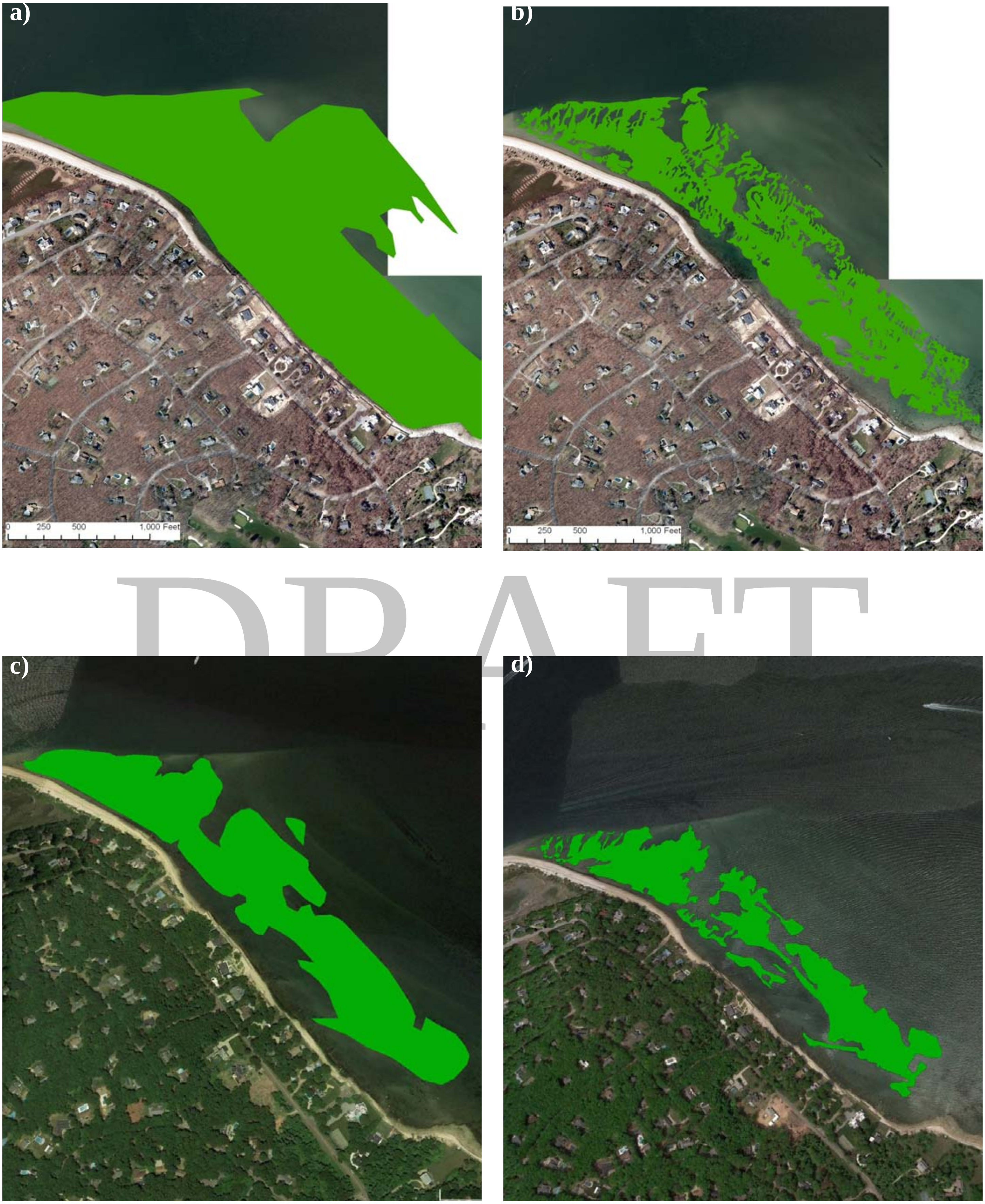


Figure GB-4. A series of aerial delineations of the Gardiners Bay eelgrass from 2000 through 2015. The years represented are a) 2000, b) 2010, c) 2014 and d) 2015.

Figure GB-5. The edge of an eelgrass patch at the Gardiners Bay LTEMP site. The clam in the foreground was washed out of the edge of the eroded patch and is unable to rebury itself due to its large size.

may be subjected to increased pressure, resulting in future significant losses.

Some of the pressure and stress on the meadow could be alleviated if anthropogenic disturbance could be reduced or eliminated from the site. Boating traffic continues to traverse the meadow, resulting in additional erosion and prop scarring of the meadow. Boater eduction and/or signage could deter people from crossing the meadow. Alternately, an addition navigational marker (i.e., buoy) could be placed closer to Hay Beach Point on the Greenport side of the meadow to identify the proper channel. Whichever, if any, of these options are considered, something needs to be implemented to reduce the overall impact on this meadow.

Northwest Harbor is a 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 mate-

Northwest Harbor 2015

Table NWH-1. The average annual eelgrass shoot density for Northwest Harbor from 1997 to 2015, 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
2012	0	+/- 0
2013	0	+/- 0
2014	0	+/- 0
2015	0	+/- 0

Figure NWH-2. One of Northwest Harbor's scallops hiding under a small mat of the red alga, *Spyridia filamentosa*.

rial can be suspended, reducing visibility to a few feet.

Eelgrass Shoot Density

The Northwest Harbor LTEMP was monitored on 28 August, 2015 with no eelgrass reported for the site (Figure NWH-3; Table NWH-1). No other eelgrass was identified in Northwest Harbor in the 2014 PEP Eelgrass Aerial Survey, so monitoring could not be shifted to an extant eelgrass meadow at this site.

Macroalgae Cover

The macroalgae community in the Northwest Harbor LTEMP site continued to maintain a percent cover under 10% in 2015. While the percentage was up slightly from 2015 (Figure NWH-4), the bottom remains relative featureless and provides limited structure for fish and other animals.

Conclusions

With the updated aerial survey of eelgrass completed in 2014 and no extant meadows identified in Northwest Harbor, there is minimal possibility that eelgrass will ever spontaneously recover at this site. And, without knowing the initial cause of the decline of the meadow and whether those conditions still exist, restoration would be ill-advised and likely result in failure at this site.

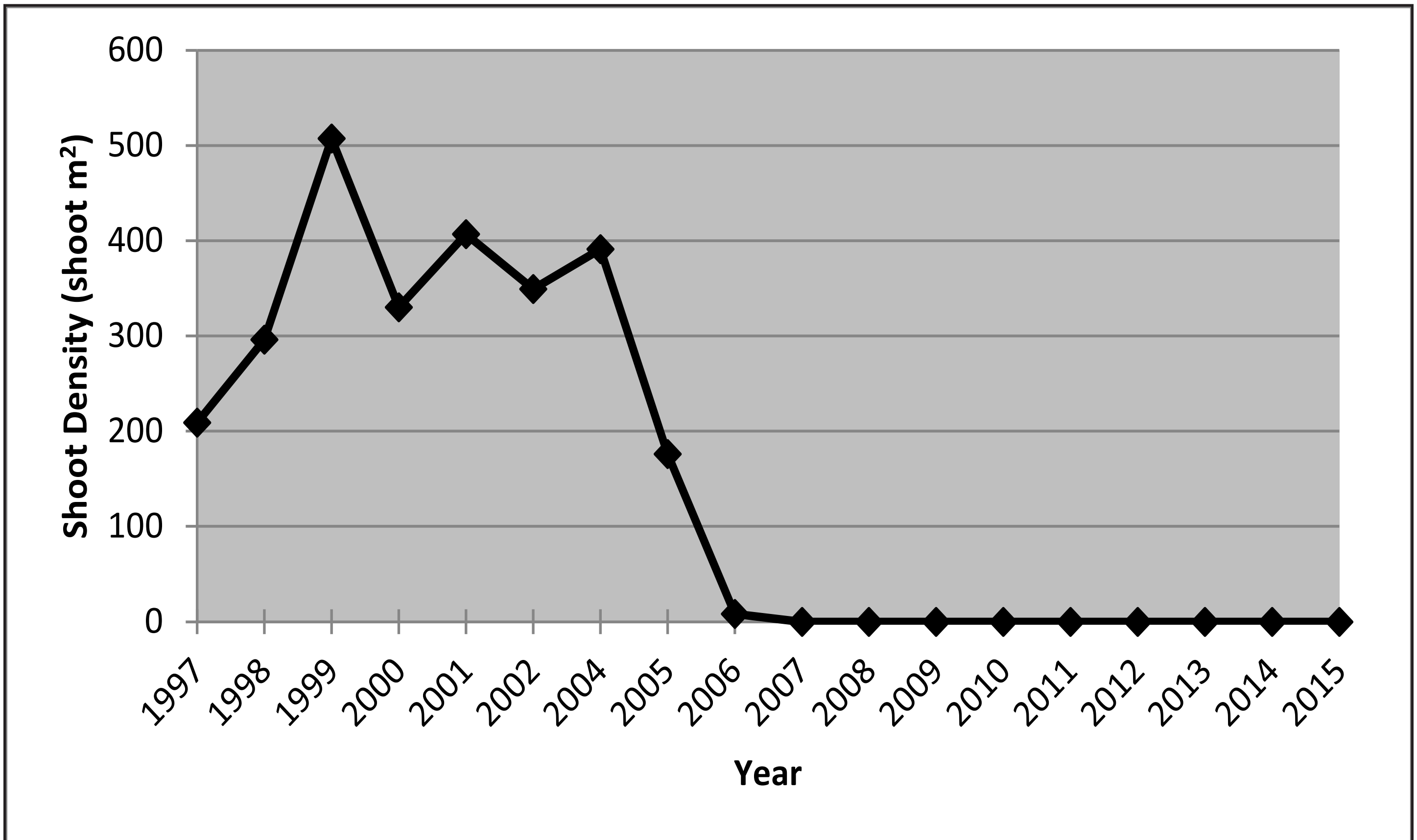


Figure NWH-3. Average annual eelgrass shoot density for Northwest Harbor, East Hampton.

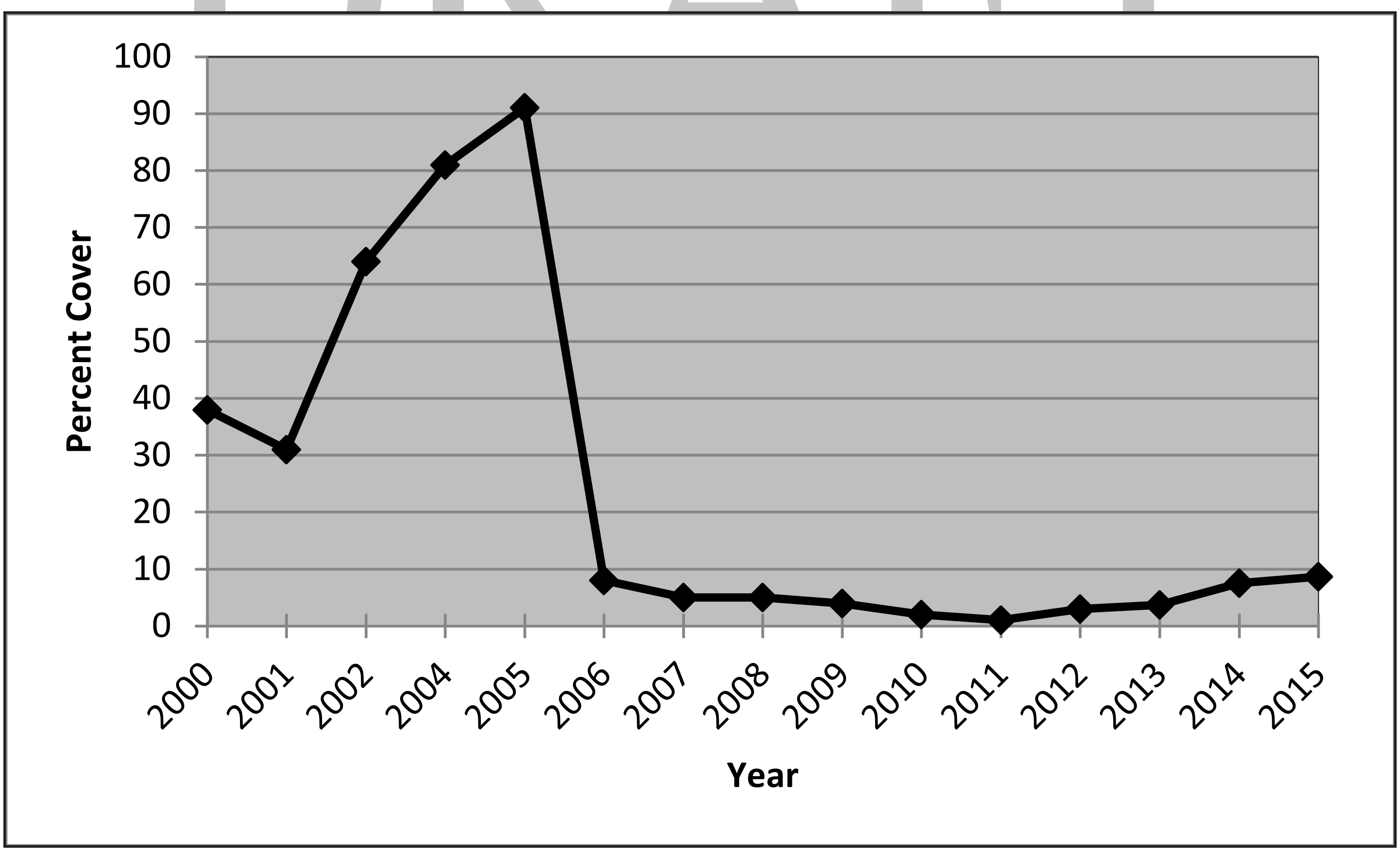


Figure NWH-4. Annual mean macroalgae cover for Northwest Harbor, East Hampton from 2000 to 2015.

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, once situated on the eastern shore of Orient Harbor (Figure OH-1), was 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 site are relatively low.

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

Site Characteristics

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.

Temperature

CCE has not deployed temperature logging equipment in Orient Harbor since the complete loss of the meadow at the LTEMP site. However, the USGS has a water quality monitoring buoy deployed in Orient Harbor (USGS 01304200 Orient Harbor at Orient, NY) which collects a suite of water quality data and reports in real time. As the summer of 2015 was a record-breaking with high temperatures, the data collected from the buoy was downloaded and analyzed to provide monthly averages and "Days ≥ 25°C" for Orient Harbor (Table OH-1). Based on the buoy data, Orient Harbor's average water temperature for the month of August was 25.3°C. Over the course of the summer, the harbor experienced 33 day with temperatures exceeding 25°C. If there was extent eelgrass in Orient Harbor, these conditions would have stressed the population. It should be noted that 2015 was an abnormal year for high temperatures, but with global climate change, this may become the norm, causing conditions in Orient Harbor to become less hospitable to potential recolonization or restoration of eelgrass.

Table OH-1. The monthly average water temperatures take by the USGS water quality buoy stationed in Orient Harbor for May-September 2015. Also noted is the total days that daily average water temperatures met or exceeded 25°C.

Month	Ave. Water Temperature (°C)	Days ≥ 25°C
May	15.4	0
June	19.4	0
July	23.6	3
August	25.3	22
September	23.4	8

Table OH-2. The average annual eelgrass shoot density for Orient Harbor from 1997 to 2015, 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
2012	0	+/- 0
2013	0	+/- 0
2014	0	+/- 0
2015	0	+/- 0

Eelgrass Shoot Density

The 2015 eelgrass monitoring in Orient Harbor was conducted on 26 August, 2015. As with the previous seven seasons, no eelgrass was reported within the LTEMP site or its stations (Figure OH-2; Table OH-2). Observations from walking a section of the beach bordering the monitoring area during the summer and fall of 2015 noted minimal eelgrass wrack, suggesting that there is unlikely an unidentified eelgrass meadow present in Orient Harbor. This is also supported by the 2014 PEP Eelgrass Aerial Survey, which identified no extant eelgrass in the harbor.

Macroalgae Cover

Macroalgae saw a significant increase in percent cover from 2014 with percent cover reaching 45% in 2015 (Figure OH-3). *Spyridia filamentosa* was, by far, the most common species reported in Orient Harbor, forming large bed-like mats over the bottom throughout the LTEMP area (Figure OH-4). While *Spyridia* may not be as complex and valuable of a habitat as eelgrass, many animal species were observed using it for refuge, including bay scallops, small crabs and

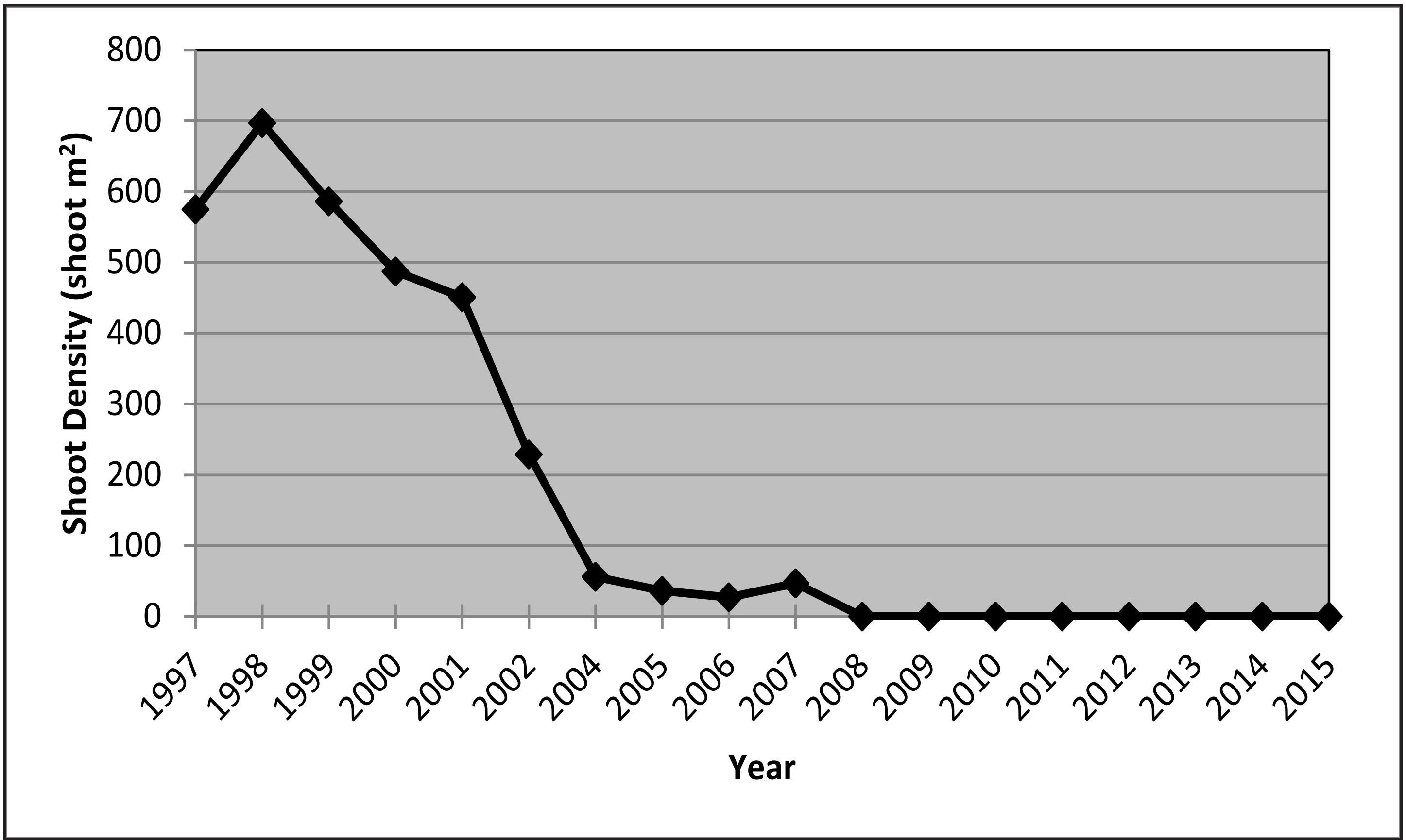


Figure OH-2. Average annual eelgrass shoot density for Orient Harbor, Southold.

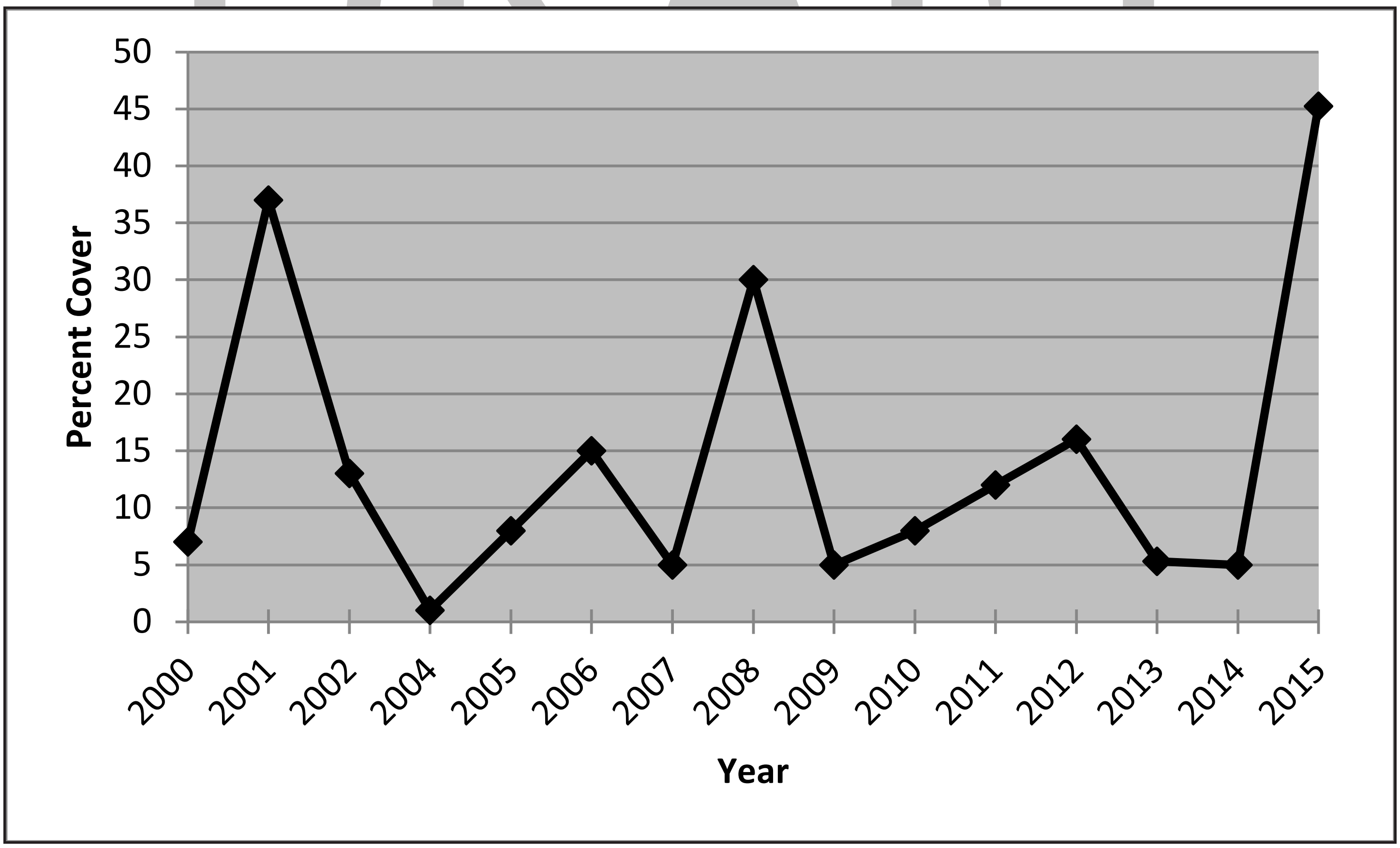


Figure OH-3. Annual mean macroalgae cover for Orient Harbor, Southold from 2000 to 2015.

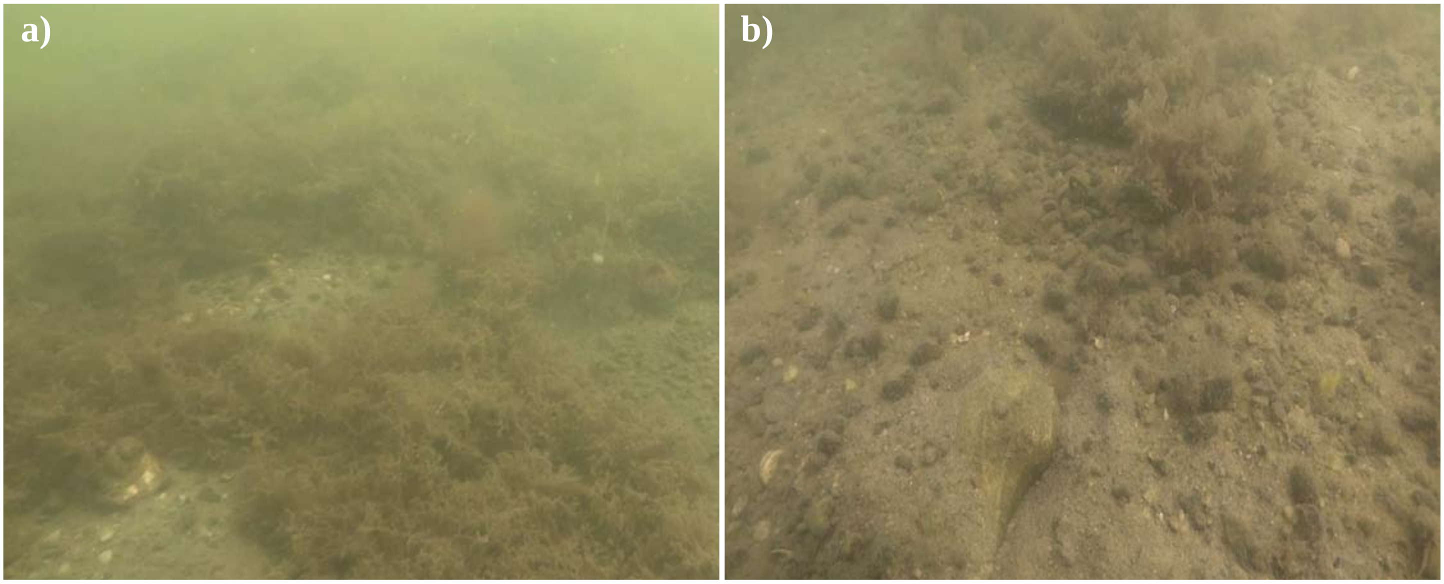


Figure OH-4. Photographs illustrating bottom conditions in Orient Harbor in 2015 at a) Station 1 and b) Station 2. The coarse sediment texture and mats of *Spyridia filamentosa* are evident at both sites. Also in b) is a partially buried knobbed whelk hunting for clam, but also found to be a significant predator of bay scallops.

even juvenile sea bass, cunner and tautog.

Conclusions

There has still been no sign of eelgrass recovery/reestablishment in Orient Harbor, inside or outside of the LTEMP area, since its last report more than 5 years ago. The bottom macroalgal mats of primarily *Spyridia* have increased in size and scope, which has been uncharacteristic of other LTEMP site that have lost eelgrass (e.g. Northwest Harbor and Southold Bay). Orient Harbor, unlike these other sites, has a coarser sediment with gravel and some cobble that provide macroalgae, like *Spyridia*, anchor points that are not available in sandy sites like Northwest Harbor. This coarse sediment may also be an impediment to recruitment of eelgrass seeds that may be transported into the site via floating flower shoots from nearby meadows. While the probability of an natural restoration of eelgrass in Orient Harbor is very low, there has been some encouraging, but as yet unsubstantiated, reports of new eelgrass meadows growing in the mouth of adjacent Hallock Bay. There have been other anecdotal reports of eelgrass "popping up" in areas where it has not been seen in several years as well, but these accounts will need to be investigated. If this new information proves to be accurate, there may be an increase in the probability of a natural recruitment event in some area of Orient Harbor. Also, if eelgrass is coming back in areas where it had been lost, this may indicate that the conditions/events that led to the initial loss are no longer limiting eelgrass.

One concern which may limit any recovery of an eelgrass meadow in Orient Harbor, and even the region, is the effect on global climate change and its effect on summer water temperatures. The buoy data in Orient Harbor reported over 30 days of daily average water temperatures above 25°C, which is outside the norm for this site in past years. If these conditions become prevalent in the future, this may further impact the potential for this site to support eelgrass in the future.

With "new" eelgrass meadows being reported in Orient Harbor, and other areas, the 2016 LTEMP will attempt to identify and groundtruth new meadows in and around the Orient Harbor and other LTEMP sites. If these reports prove to be accurate, then potential restoration test plantings could be considered for these areas that were once healthy eelgrass meadows.

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 was 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 former Southold Bay eelgrass bed was sheltered from most prevailing winds, so wave exposure was generally low to moderate. However, some storm events 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 Boat yard 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.

Southold Bay 2015

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 for 2015.

Month	Ave. Daily H_{comp} (h)	Net Daily H_{comp} (h)	Ave. Daily H_{sat} (h)	Net Daily H_{sat} (h)	Ave. Monthly Temperature (°C)
July	12.7	+0.4	7.0	-1.0	24.2
August	12.4	+0.1	9.1	+1.1	25.7
September	11.3	-1.0	8.4	+0.4	23.7

The waters that the Southold Bay meadow receive from the flushing of Hashamomack Pond not only influence temperature, as noted above, but also exposed the site to nutrient-laden water that has been found to negatively impact eelgrass meadows by indirectly reducing eelgrass growth due to a decrease in light availability caused by increased phytoplankton and macroalgae biomass at the site.

Light Availability and Temperature

Light loggers were placed at the Southold Bay site for one week each month, July through September, 2015, and the average Hcomp and Hsat for each month's deployment are presented in Table SB-1, above. Water clarity in 2015 was markedly better than in previous years with both parameters running deficits in only two separate months (Hcomp in September and Hsat in July). The lack of rain in 2015 was a probable factor in the high water clarity, with limited nutrients and suspended sediments impairing water quality in Southold Bay and Hashamomack Pond which flushes through the site twice daily.

Water temperatures in Southold Bay for 2015 were found to meet the expectations of such a warm summer, with the site experiencing 40 days with temperatures above 25°C over the course of the summer. Since 2010, when light and temperature monitoring has been consistently conducted at the site, this is the highest number of days exceeding this threshold. Water temperatures did not break the 27°C mark in 2015, as the highest temperature recorded was 26.6°C on 25 August, 2015.

Eelgrass Shoot Density

The Southold Bay site was visited for monitoring on 25 August, 2015. There was no eelgrass observed on the site (Figure SB-2; Table SB-2) during the 2015 season. This was the tenth year this site has been without eelgrass.

Macroalgae Cover

Macroalgae cover dropped below 10% in 2015 (Figure SB-3). Eight species of macroalgae were identified on the site and included, in order of prevalence: *Sargassum filipendula* (primarily attached to boulders in Station 1), *Spyridia filamentosa*, *Gracilaria* species, and *Codium fragile* (on boulders in Station 1 and on shell throughout the site). The other species observed represented very low cover.

Conclusions

Southold Bay continues to be devoid of eelgrass growth for the tenth season, with water quality conditions, specifically water temperature being suboptimal for eelgrass growth. Water clarity was much improved over previous years, likely resulting from the lack of

Table SB-2. The average annual eelgrass shoot density for Southold Bay from 1997 to 2015, 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
2012	0	+/- 0
2013	0	+/- 0
2014	0	+/- 0
2015	0	+/- 0

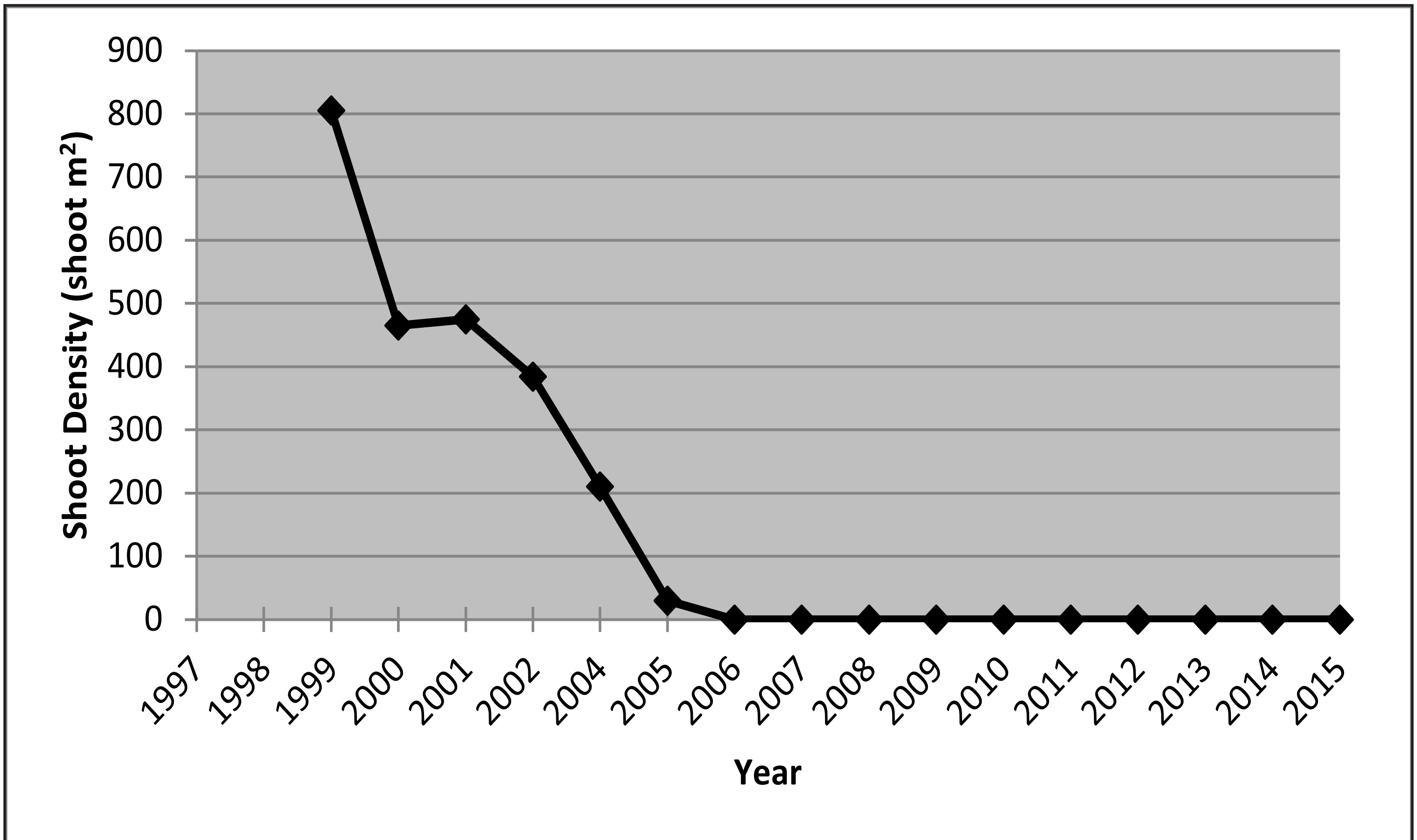


Figure SB-2. Average annual eelgrass shoot density for Southold Bay, Southold.

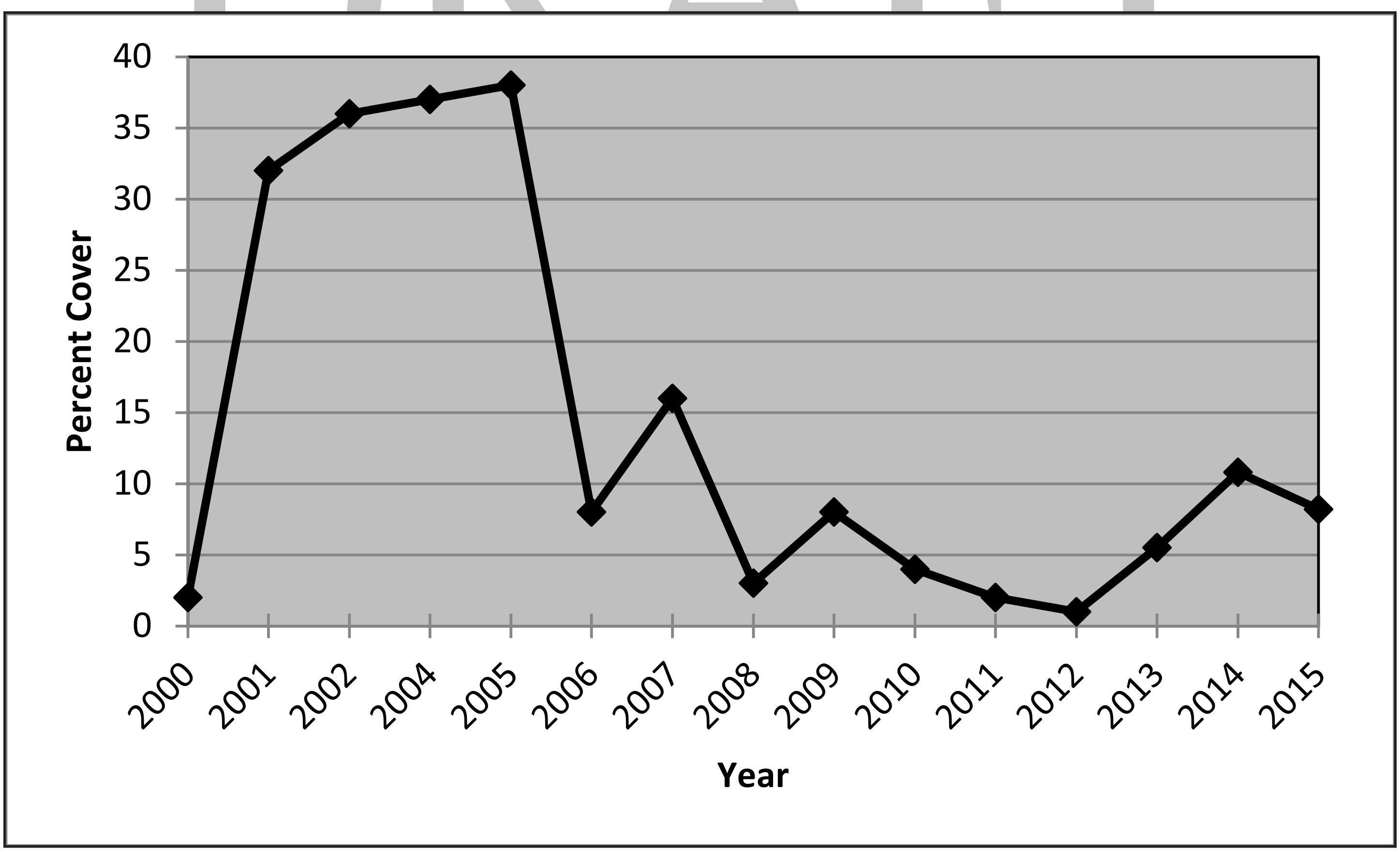


Figure SB-3. Annual mean macroalgae cover for Southold Bay from 2000 to 2015.

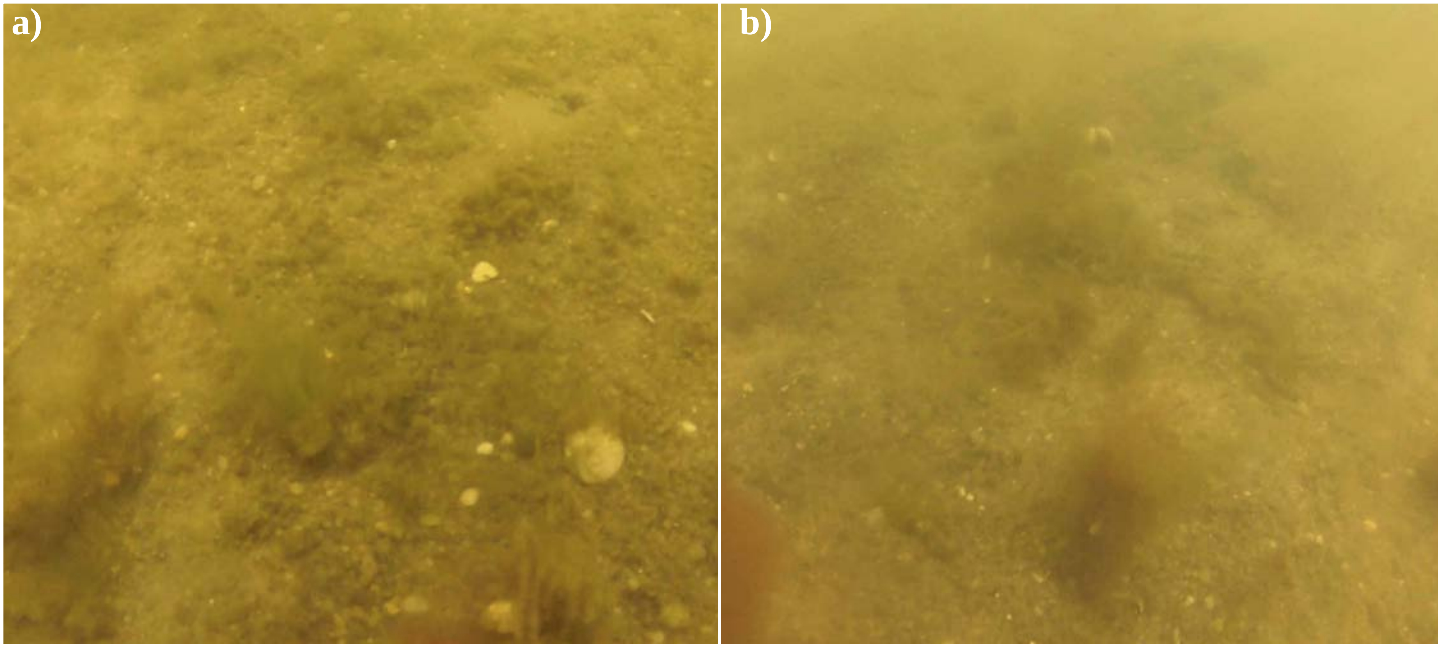


Figure SB-4. Photographs of the bottom conditions at the Southold Bay LTEMP site taken during the 2014 monitoring visit by divers.

rain the region had received for the season. Overall, conditions at the Southold Bay site have remained static since the loss of eelgrass in 2006.

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).

During the 2014 Peconic Estuary Eelgrass Aerial Survey, there were three, extant eelgrass meadows near the headwaters of Three Mile Harbor that were identified (Figure TMH-2). During the 2015 monitoring season, one of these meadows (indicated in Figure TMH-2 within the white oval) had temperature and light loggers deployed to it and ten quadrat counts were completed along its length.

Site Characteristics

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

Figure TMH-2. An aerial view of the headwaters of Three Mile Harbor showing the three extant beds of eelgrass discovered during the 2014 aerial survey.

Three Mile Harbor 2015

Table TMH-1. H_{comp}, H_{sat} and temperature data calculated from the deployment of Odyssey PAR loggers and TidBit temperature loggers for two sites in Three Mile Harbor for 2015.

Month	Ave. Daily H_{comp} (h)	Net Daily H_{comp} (h)	Ave. Daily H_{sat} (h)	Net Daily H_{sat} (h)	Ave. Monthly Temperature (°C)
Three Mile Harbor LTEMP Site					
August	12.7	+0.4	10.1	+2.1	25.6
September	11.7	-0.6	8.7	+0.7	23.0
Three Mile Harbor New Meadow					
August	12.6	+0.3	9.7	+1.7	25.8
September	11.6	-0.7	8.7	+0.7	23.4

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.

Light Availability and Temperature

Light loggers were deployed at both the Three Mile Harbor LTEMP site and the larger of three "new" meadows in the harbor's headwaters for August and September 2015 (Table TMH-1). The light data (Hcomp and Hsat), when compared between sites, found no significant difference in light availability for the periods sampled in 2015. Both sites experienced the typical decline in light availability for September, with Hcomp dropping below the 12.3h threshold. The Hsat for the site declined from August to September for both sites, but still remained about the minimal requirement of 8h.

Water temperature loggers weren't deployed to the site until mid-August 2015. Due to this late deployment, water temperatures were already above 25°C, and the LTEMP site averaged above 27°C on its first full day of deployment. Comparing water temperatures between the two sites found the LTEMP experienced 14 days with temperatures exceeding the 25°C threshold, while the "new" meadow recorded 21 days. The LTEMP site recorded the only daily average temperature above 27°C and the highest temperature recorded for both sites of 27.7°C. While a full season of water temperature was not captured for either site in 2015, the data collected shows that water temperatures do cross the 25°C threshold and suggests that these conditions could last for extended periods during the summer months. Also, the deployment only managed to record one day at the LTEMP site with temperatures greater than 27°C, and with the record air and water temperatures reported for the region, it is highly probable that one, or both of the sites, experienced more days at these potentially lethal temperatures.

Eelgrass Shoot Density

Table TMH-2. The average annual eelgrass shoot density for Three Mile Harbor from 1997 to 2015, 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
2012	0	+/- 0
2013	0	+/- 0
2014	0	+/- 0
2015	0	+/- 0

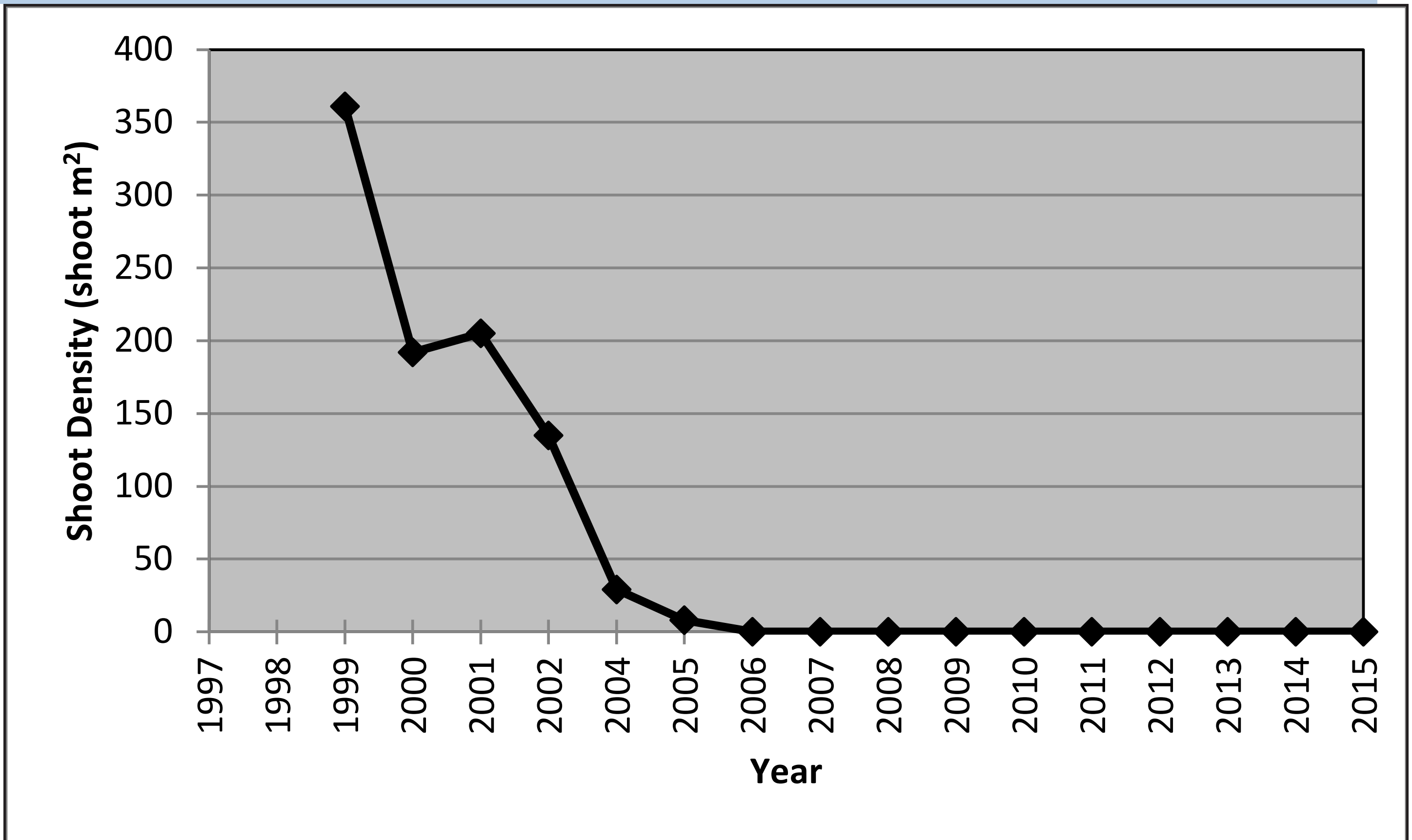


Figure TMH-2. Average annual eelgrass shoot density for Three Mile Harbor, East Hampton.

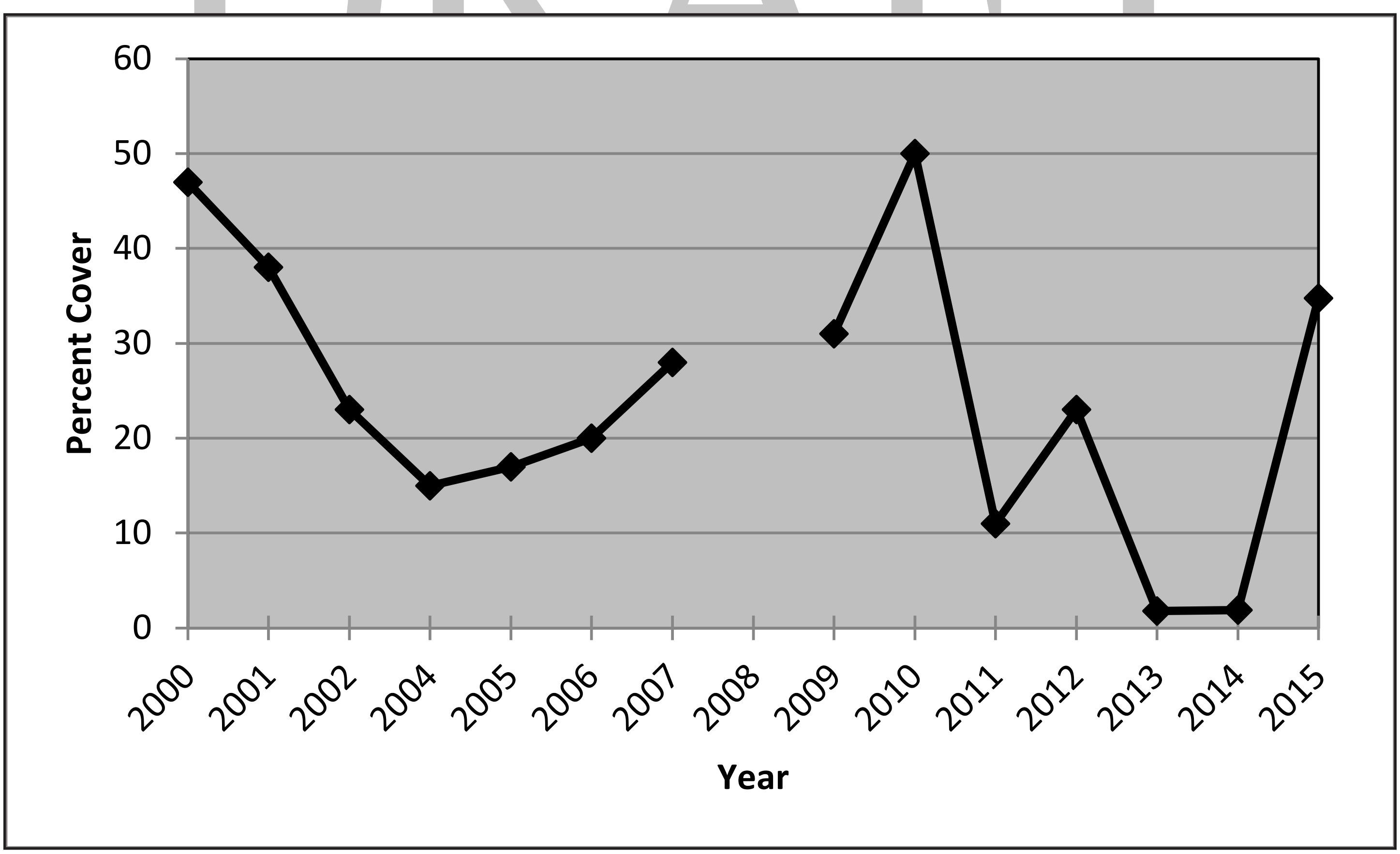


Figure TMH-3. Annual mean macroalgae cover for Three Mile Harbor from 2000 to 2015.

Three Mile Harbor 2015

Figure TMH-4. A photograph from the “new” meadow in Three Mile Harbor characterizing the high macroalgae cover, specifically *Spyridia filamentosa*, but healthy eelgrass.

Monitoring of both the LTEMP site and “new” meadow was completed on 20 August, 2015. No eelgrass was observed at the LTEMP site, as has been the trend since 2006 (Figure TMH-2; Table TMH-2). For the “new” meadow, 10 quadrat counts were randomly spaced along its length. Nine out of the ten quadrats contained eelgrass and the “new” meadow averaged 177 shoots·m^2 and Widgeongrass (*Ruppia maritima*) was observed in relatively high densities along the nearshore edge of the meadow.

Macroalgae Cover

The Three Mile Harbor LTEMP site saw a spike in macroalgae percent cover in 2015. Macroalgae cover averaged 34.7% over all the stations and represented a more than 30% increase over the covers from 2013 and 2014 (Figure TMH-3). The primary species identified for the LTEMP site was *Spyridia filamentosa* with subordinate species including *Codium fragile*, *Gracilaria* species, and *Ulva* species.

The “new” meadow presented an almost monoculture of *Spyridia filamentosa* growing entangled in the eelgrass canopy. *Spyridia* was growing so dense around the bottoms of eelgrass shoots, that in some sections of the meadow, only the very tops of the eelgrass shoots were visible (Figure TMH-4). This dense growth resulted in 100% cover in all quadrats sampled for this site, and represents some of the densest growth of macroalgae reported during LTEMP monitoring. Other species reported for the “new” meadow included the green, filamentous species *Chaetomorpha linum* and *Cladophora* species, *Codium fragile,* and *Gracilaria* species.

Bed Delineation and Areal Extent

Delineation of the “new” meadow from the 23 May, 2015 Google^{TM} Earth aerials found only a nominal change in areal extent from 2014, and the difference in the two delineations could be within the error inherent in a subjective analysis such as aerial interpretation.

Conclusions

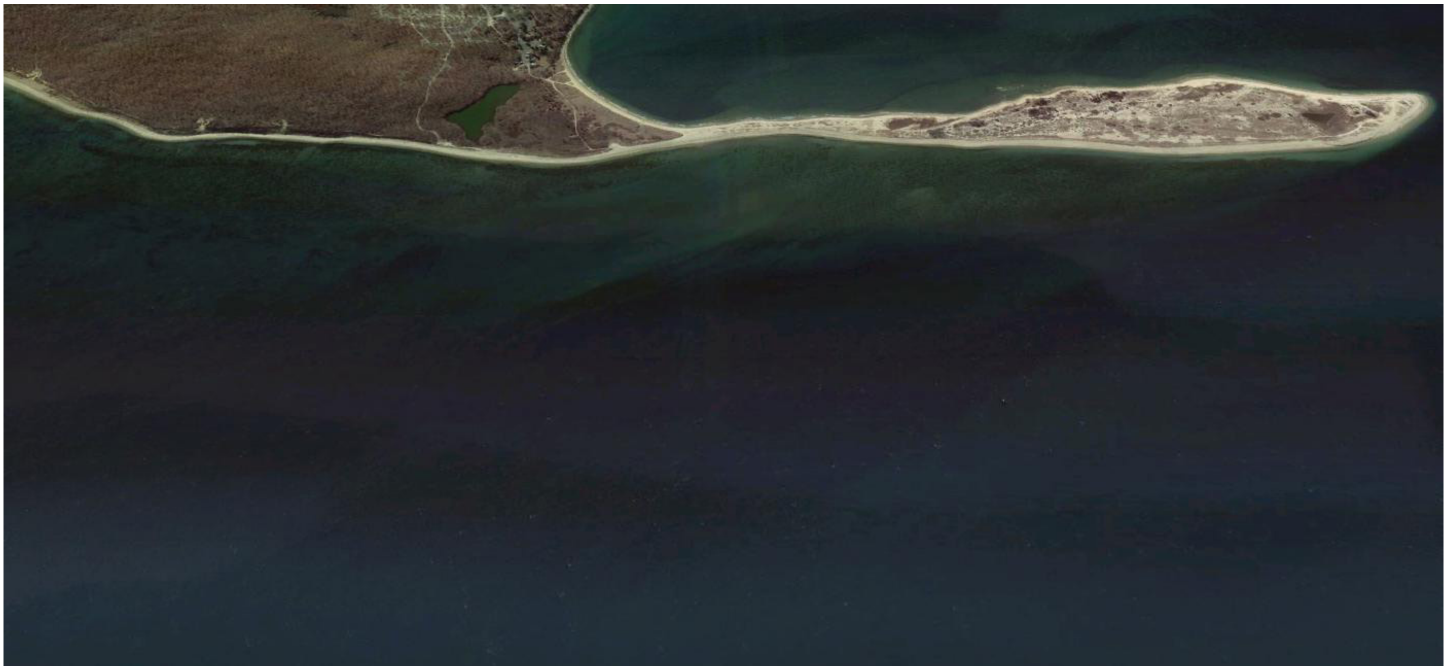
The identification of extant eelgrass meadows in Three Mile Harbor has provided a unique opportunity to compare environmental conditions between an extinct and extant meadow, occupying a semi-enclosed system, in an attempt to narrow down potential factors that may have led to the decline of the extinct meadow. Although the light and temperature loggers were deployed late in the season, their data suggests that light availability, at least for August and September 2015, was not limiting at either site.

Water temperature recorded from both sites showed that they both exceed 25°C for extended periods during summer months, however, while the “new” meadow experienced a longer period of high temperatures, the LTEMP site data suggests that it may reach higher temperatures. An interesting observation tied to water temperature was made by a CCE diver. The diver found a live, banded-chink snail (*Lacuna vincta*), which is common in eelgrass meadows throughout the region from the winter through the early summer, but typically only persists through the summer at sites that rarely exceed temperatures of 22°C. The presence of one of these snails in the “new” meadow site in August may indicate that there may be groundwater influence in the meadow similar to what has been reported for Bullhead Bay.

Previous LTEMP reports have suggested that eelgrass restoration in the Three Mile Harbor LTEMP site could be possible if another extant meadow could be located within the harbor complex to be used as a baseline to determine if the LTEMP site's current environmental parameters would support eelgrass growth. The 2016 LTEMP monitoring will deploy temperature loggers in the spring to capture the seasonal rise, then decline of water temperatures into the fall. Light loggers will be deployed monthly at each site starting in June through September. Sediment samples will be taken from the "new" meadows, as well as the LTEMP meadow to characterize differences that could impact potential restoration at the site (e.g. high organic content).

Finally, with the permission and cooperation of the East Hampton Trustees, a small-scale restoration seeding may be attempted at the LTEMP site in 2016 using CCE's buoy-deployed seeding (BuDS) system. The deployment of the BuDS system will depend on the flower shoot density in the "new" meadows and the cooperation of the Trustees in providing protection around the test planting site.

Cedar Point 2015



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.

Site Characteristics

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

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. Observations made during the eelgrass monitoring survey and other activities suggested that the overall sediment texture will 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 to Gardiners Bay. The water should be relatively low in nutrients (specifically nitrogen) and the summer high water temperatures are similar to Orient Point. Cedar Point was included in the Peconic Estuary Light and Water Temperature Survey conducted from May-October, 2015, and that data is presented below.

Light Availability and Temperature

Light loggers were deployed for one week, monthly, from July-September, and the TidBit temperature logger was deployed from late May-early October 2015. Light availability at Cedar Point for the 2015 season was very good with only the Hcomp for September showing a deficit (Table CP-1). Observations made in the field throughout the season reported water column

Cedar Point 2015

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, for 2015.

Month	Ave. Daily H_{comp} (h)	Net Daily H_{comp} (h)	Ave. Daily H_{sat} (h)	Net Daily H_{sat} (h)	Ave. Monthly Temperature (°C)
July	13.8	+1.5	11.1	+3.1	22.4
August	12.5	+0.2	9.9	+1.9	24.2
September	11.5	-0.8	8.3	+0.3	22.7

visibilities at or exceeding 10 feet when traversing the site by boat. Water temperatures at Cedar Point while averaging slightly higher than previous years, was not as impacted by the above average summer temperatures of 2015. The site only recorded two days with average water temperatures greater than 25°C and the high temperature for the site was 26.1°C, almost 2°C warmer than 2014's high temperature.

Eelgrass Shoot Density

Cedar Point was visited on 27 August, 2015 for the annual monitoring. Eelgrass shoot densities were down slightly in 2015 from the previous year with density averaging over the site at 331 shoots·meter^2 (Figure CP-2; Table CP-2). This does not represent a significant change from 2014.

Macroalgae Cover

The Cedar Point eelgrass meadow continues to be dominated by the brown seaweed, *Sargassum filipendula*. *Sargassum* takes advantage of the rocky sediment and abundant boulders at this site to provide anchorage. This species is also better suited to higher wave energy sites than more fragile species, like *Spyridia*, which tend to be the primary species in more protected meadows. The overall macroalgae cover for Cedar Point showed virtually no change from 2014 (Figure CP-3) with species composition similar between years as well.

Bed Delineation and Areal Extent

The aerial delineation of the Cedar Point meadow was completed using Google™ Earth imagery taken on 23 May, 2015. Based on those aerials, the meadow showed little overall change in area, covering an area of almost 85 acres in 2015 (Table CP-3). When compared to the delineations from the 2014 Eelgrass Aerial Survey, it appears that there was some loss along the meadow's inshore edge in 2015, which may be attributed to winter storm or ice damage in the shallow areas of the meadow (Figure CP-5).

Conclusions

Cedar Point continues to be one of the healthiest, and the largest eelgrass meadow in the monitoring program. While the meadow has suffered some decline in recent years, due to storm and erosional loss in the mid-section of the meadow, overall, the eelgrass population has maintained the highest average density of any of the LTEMP sites. The gap between the western and eastern halves of the meadow appears to have widened from 2014 to 2015 (Figure CP-5c and

Table CP-2. The annual average eelgrass shoot density for Cedar Point for 2008 and 2015, including standard error.

Year	Mean Density	S.E.
2008	285	+/-28
2009	385	+/-34
2010	500	+/-34
2011	389	+/-19
2012	348	+/-31
2013	195	+/-26
2014	382	+/-39
2015	331	+/-31

Table CP-3. The estimated cover of the eelgrass meadow at Cedar Point for 2000, 2004, 2010, and 2012, 2013, 2014, and 2015.

Year	Estimated Area
2000	35.20 acres (14.25 hect.)
2004	164.18 acres (66.44 hect.)
2007	224.46 acres (90.84 hect.)
2010	144.96 acres (58.66 hect.)
2012	127.27 acres (51.50 hect.)
2013	96.55 acres (39.07 hect.)
2014	85.76 acres (34.71 hect.)
2015	84.80 acres (34.32 hect.)

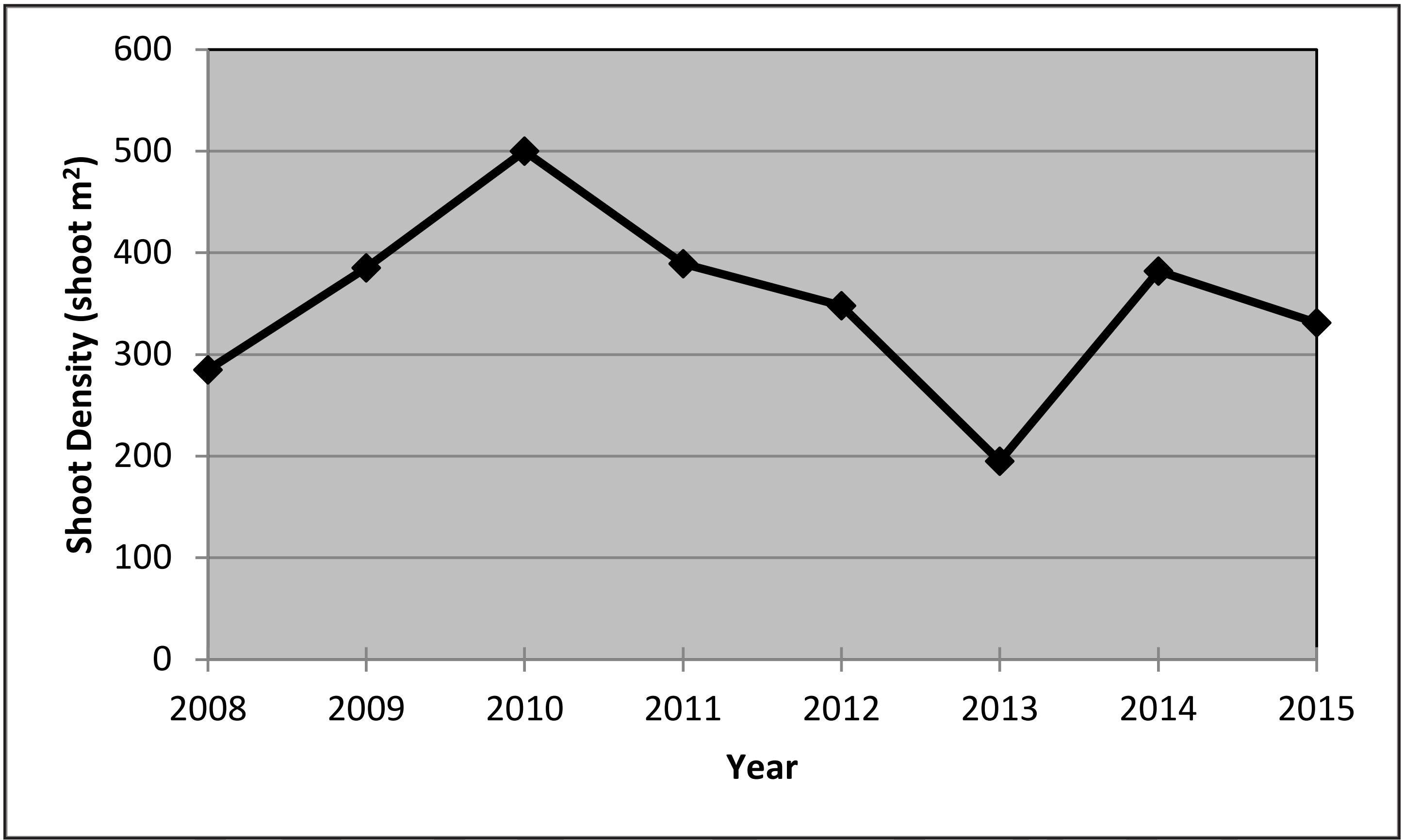


Figure CP-2. The average annual eelgrass shoot density for Cedar Point for 2008-2015.

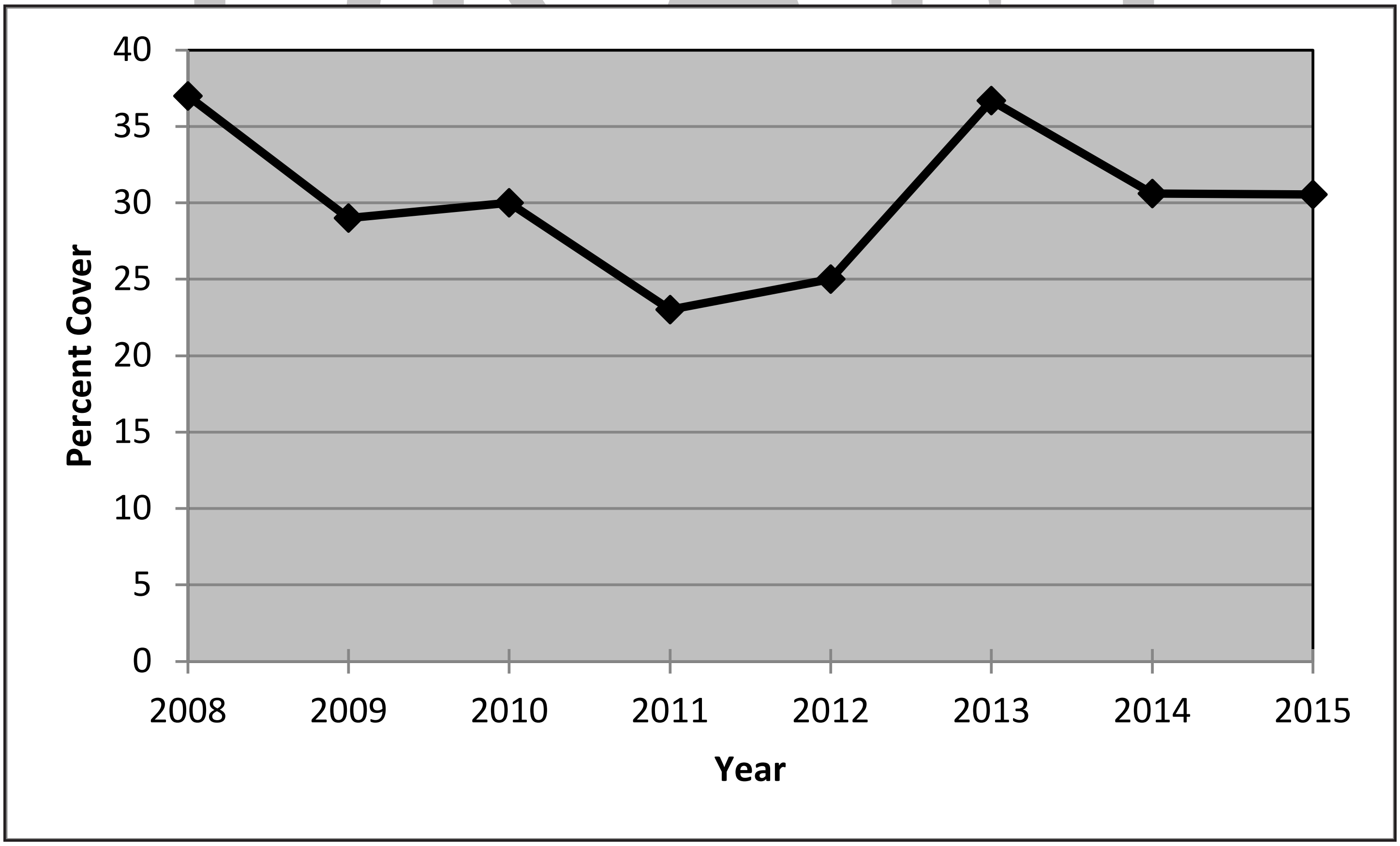


Figure CP-3 Annual mean macroalgae cover for Cedar Point, East Hampton from 2008 to 2015.

Cedar Point 2015

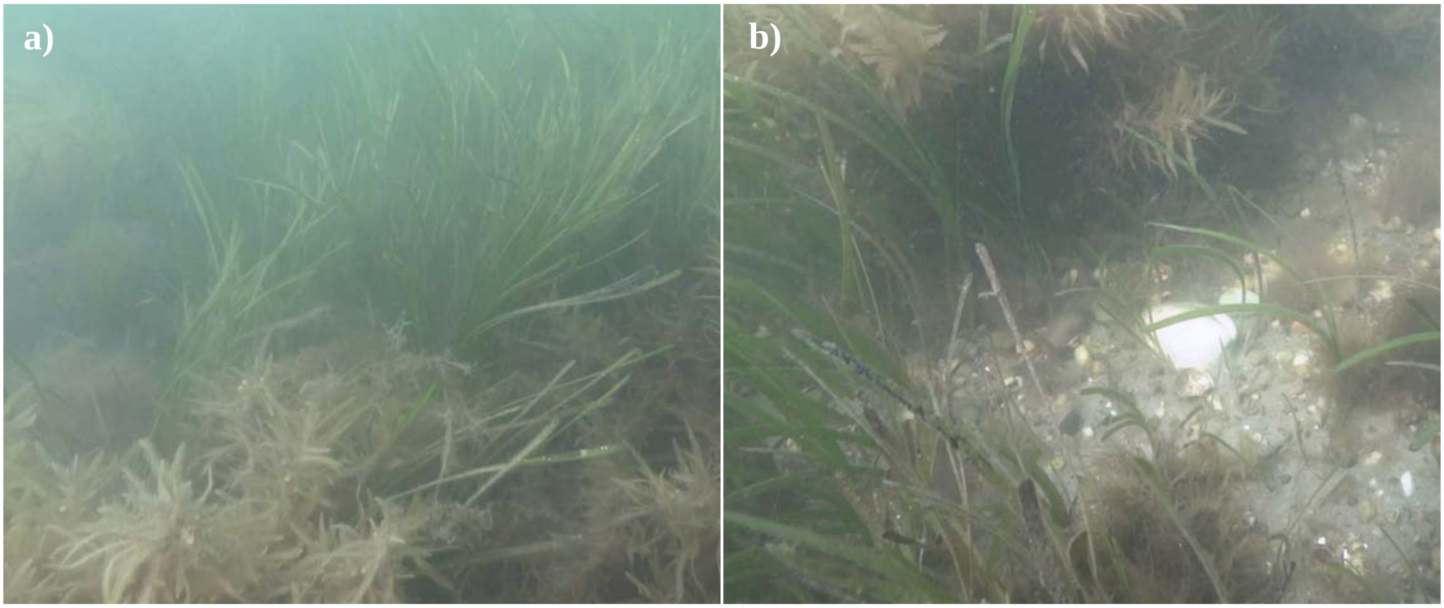


Figure CP-4. Underwater photographs taken in the Cedar Point eelgrass meadow in 2015 showing a) the coexistence of eelgrass and *Sargassum* (foreground) and b) a hard clam that had taken advantage of an open patch within the eelgrass meadow.

d), and this area will be monitored closely in the future to identify further changes.

If the summer of 2015 is an indication of the future temperature changes the region will experience, then it appears that the Cedar Point meadow should not be affected by these changes for some time. With the hottest summer on record in 2015, the meadow experienced two days above the 25°C threshold. Increase frequency and severity of storms appear to be more of a threat from global climate change than increases in water temperature for this site. Water clarity continues to be above average at this site. With the drought conditions during the 2015 season, water clarity was the highest reported by divers for during the summer season.

The Cedar Point eelgrass meadow is a unique community. The site is co-dominated by eelgrass and the brown alga, *Sargassum filipendula* (Figure CP-4a), which is an area within the Peconic Estuary with high structural complexity that is utilized by all manner of marine organisms, but especially finfish and shellfish (Figure CP-4b). With the LTEMP area representing only a part of the entire meadow (the meadow extends along more than 2 miles of shoreline to the east), this site should be considered one of the more important meadows in the estuary to monitor and protect.

Figure CP-5. Delineations of the Cedar Point eelgrass meadow from aerial photographs for a) 2004, b) 2010, c) 2014, and d) 2015 (continued on next page).

Cedar Point 2015

Figure CP-4. Continued.

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. 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 ends at a drop off of several inches to one foot. The edge of the meadow is often left hanging over the "blow-out."

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 sedi-

Orient Point 2015

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 2015.

Month	Ave. Daily H_{comp} (h)	Net Daily H_{comp} (h)	Ave. Daily H_{sat} (h)	Net Daily H_{sat} (h)	Ave. Monthly Temperature (°C)
July	13.8	+1.5	10.4	+2.4	20.9
August	12.5	+0.2	9.5	+1.5	22.9
September	11.0	-1.3	6.8	-1.2	22.1

ment was found to be relatively low at an average of 0.86%.

Light Availability and Temperature

Light logger deployment for the 2015 season began in July and continued through September. Light loggers collected seven days of light data each month during this period with average daily values presented above in Table OP-1. The data for both Hcomp and Hsat followed normal trends for Orient Point, with values for both parameters exceeding minimal requirements in July and August, but slowly declining into the fall. This cycle has been presented in previous LTEMP reports for Orient Point and is considered the norm for this site for light in an average year.

Water temperature loggers were deployed in the beginning of June 2015. Even with 2015 being the warmest summer on record for the region, the Orient Point meadow did not experience any days with water temperature exceeding 25°C. The highest reported daily average temperature was 24.3°C, with the highest water temperature reading for the summer recorded as 26.3°C (almost 3°C higher than 2014). Given this data, it appears that high water temperatures are not an imminent threat to the Orient Point eelgrass meadow, even when the effects of global climate change have identified at other LTEMP sites.

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
2012	175	+/-22
2013	201	+/-40
2014	229	+/-30
2015	224	+/-30

Eelgrass Shoot Density

Eelgrass monitoring in the Orient Point eelgrass meadow was conducted on 27 August, 2015. Shoot density for the site was reported to have declined slightly from 2014 (Figure OP-2; Table OP-2), from 229 shoots·m^2 to 224 shoots·m^2. The offshore monitoring stations (Stations 2,4, and 6) continue to recover from storm damages incurred by Superstorm Sandy and the last two stormy winters. Station 6 had not reported eelgrass in the quadrats randomly sampled, however, divers have reported small, isolated patches of eelgrass growing in areas adjacent to this station, presenting the possibility that there may be recruitment occurring along the deep edge of the meadow. As reported in the 2014 LTEMP report, the inshore sections of the meadow continue to thrive, especially Station 5, where shoot density averaged almost 500 shoots·m^2 in 2015.

Macroalgae Cover

The sediment characteristic of Orient Point, with bottom types ranging from fine sandy (and some exposed ancient peat) to small boulder fields, allows the Orient Point site to maintain a healthy and diverse macroalgae population. The macroalgae population experienced a slight increase in 2015 with the average percent cover of 19.5% (Figure OP-3). Twelve species of macroalgae were identified during quadrat sampling, with *Sargassum filipendula* (brown) and *Chondrus crispus* (red) being two of the more common species. Also reported for the site were the non-native, invasive species *Codium fragile* and *Grateloupia turuturu*.

Bed Delineation and Areal Extent

The 2015 eelgrass bed delineation for Orient Point was completed using Google™ Earth aerial imagery dated 23 May, 2015. Based on this imagery and groundtruthing conducted during the monitoring visit, the 2015 extent of the meadow included 19.40 acres (7.85 hectares) of eelgrass (Table OP-3). This repre-

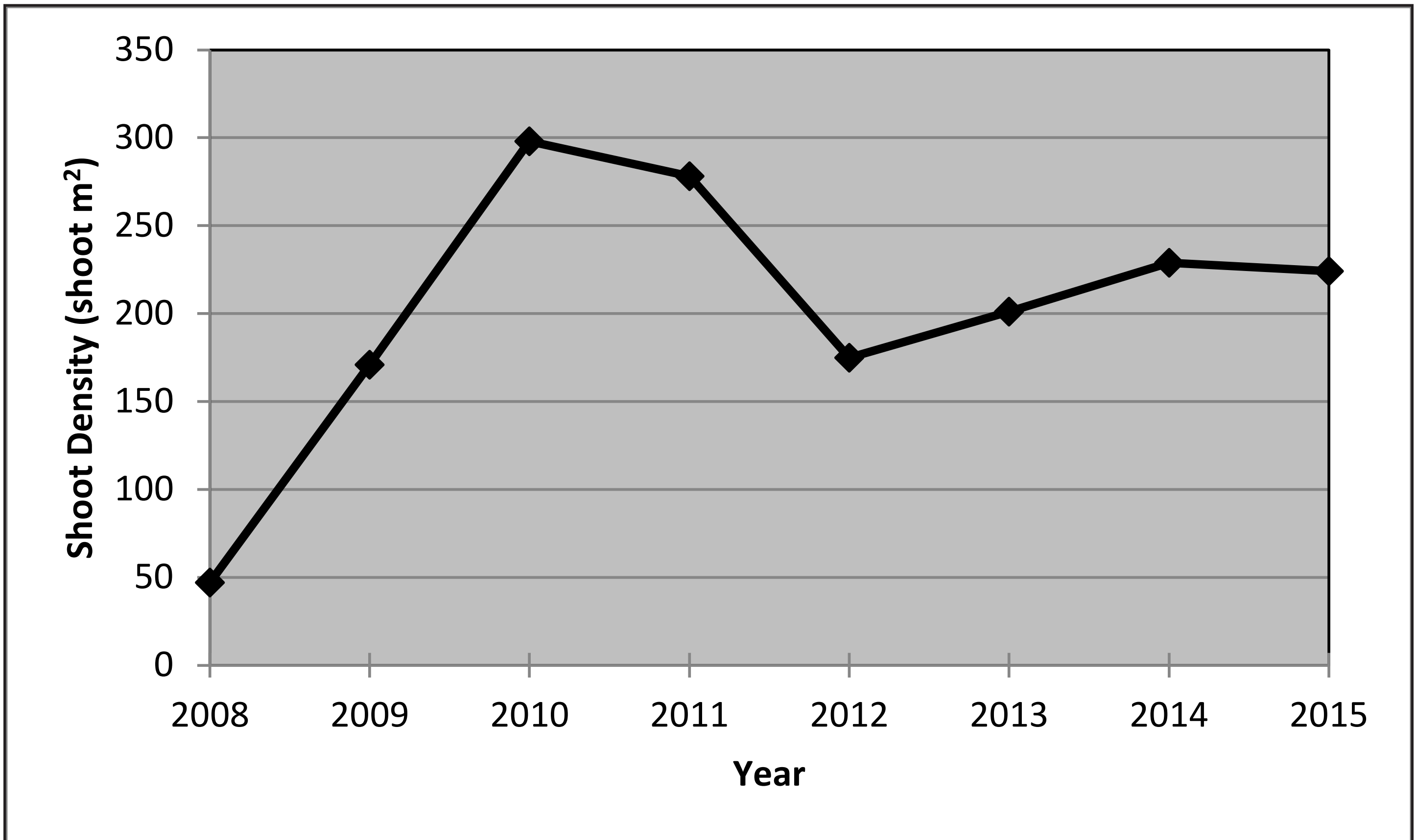


Figure OP-2. Graph of the annual mean eelgrass shoot density for Orient Point from 2008-2015.

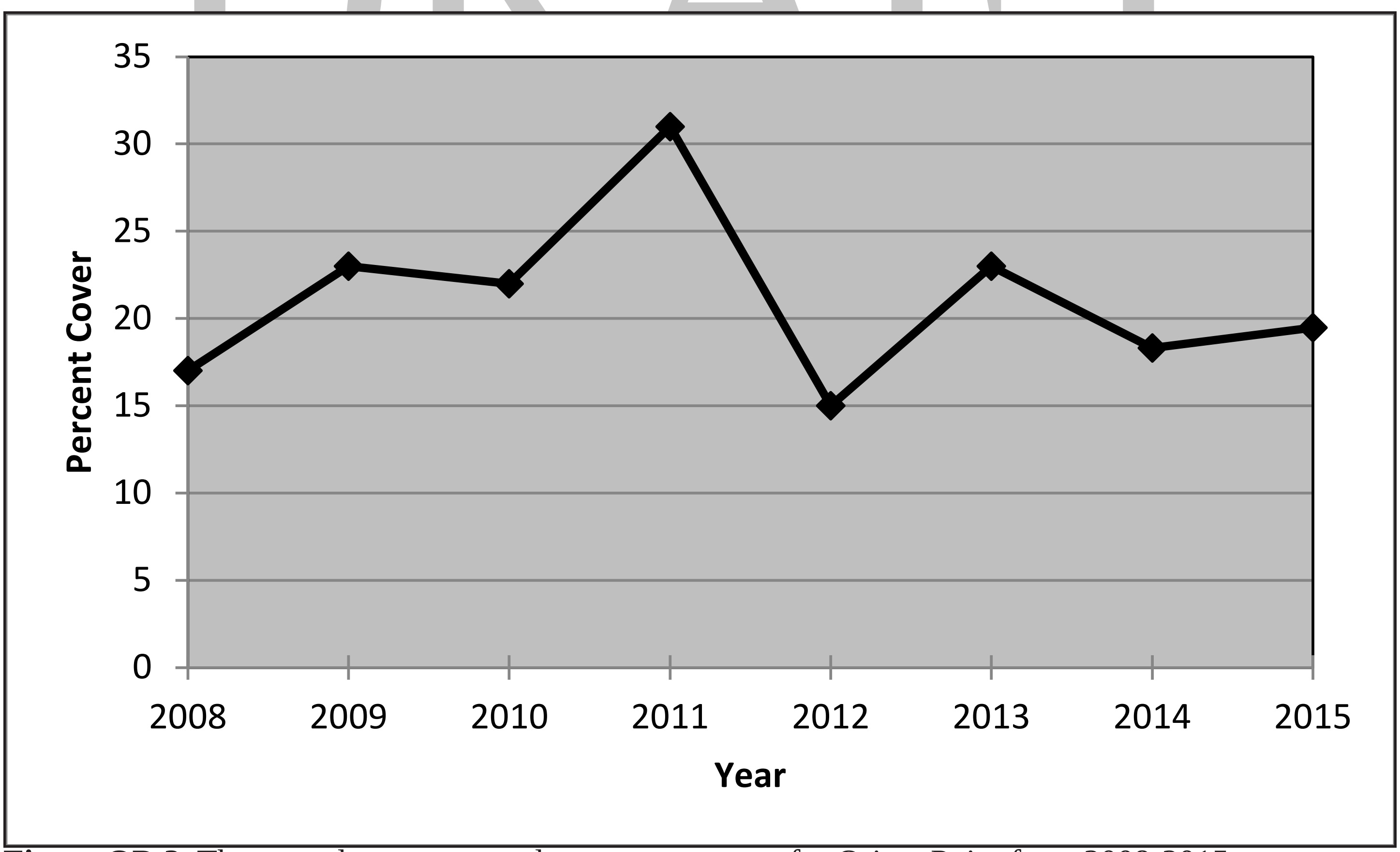


Figure OP-3. The annual mean macroalgae percent cover for Orient Point from 2008-2015.

Table OP-3. Trend analysis of the estimated area of the Orient Point meadow as determined from aerial photographs from 2000 to 2015.

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.)
2012	17.18 acres (6.95 hect.)
2013	16.40 acres (6.64 hect.)
2014	21.60 acres (8.74 hect.)
2015	19.40 acres (7.85 hect.)

sents a little more than a 2 acre loss from the 2014 Eelgrass Aerial Survey. This loss (approx. 10%) could be within the error associated with conducting this type of subjective delineation, suggesting that there was little change in the meadow's extent between the two years. Comparing the 2014 and 2015 delineations (Figure OP-5), it appears there was some loss in meadow along the offshore edge near the middle and northern sections.

Conclusions

Even with the harsh winter and hot summer of 2015, the Orient Point eelgrass meadow remains healthy. This has been aided by continued high water clarity and moderate water temperatures during the growing season. Eelgrass shoot densities showed little change from 2014, however, loss along the offshore edge was evident from low shoot densities at Stations 4 and 6, and the aerial delineation of the meadow. These losses in the deeper sections of the meadow have been offset with the inshore eelgrass flourishing in recent years. For the second season in a row, divers have counted quadrats with densities that calculated to more than 800 shoots·m^2 in the inshore sections of the meadows. The meadow continues to have high seed production and reports of small, isolated patches of eelgrass shoots near Station 6, suggests that there has been some recruitment of these seeds into areas of the meadow lost in recent years.

Barring future, significant damage from storms, the eelgrass meadow should continue its recovery. Unlike some other species of seagrass, natural recovery can be a slow, long-term process for eelgrass. Continued disturbance, from storms, bioturbation, or human activities, will slow the pace or recovery, but, as long as water quality and temperature remain within the optimal range for eelgrass, the meadow should show progress toward reestablishing lost areas.

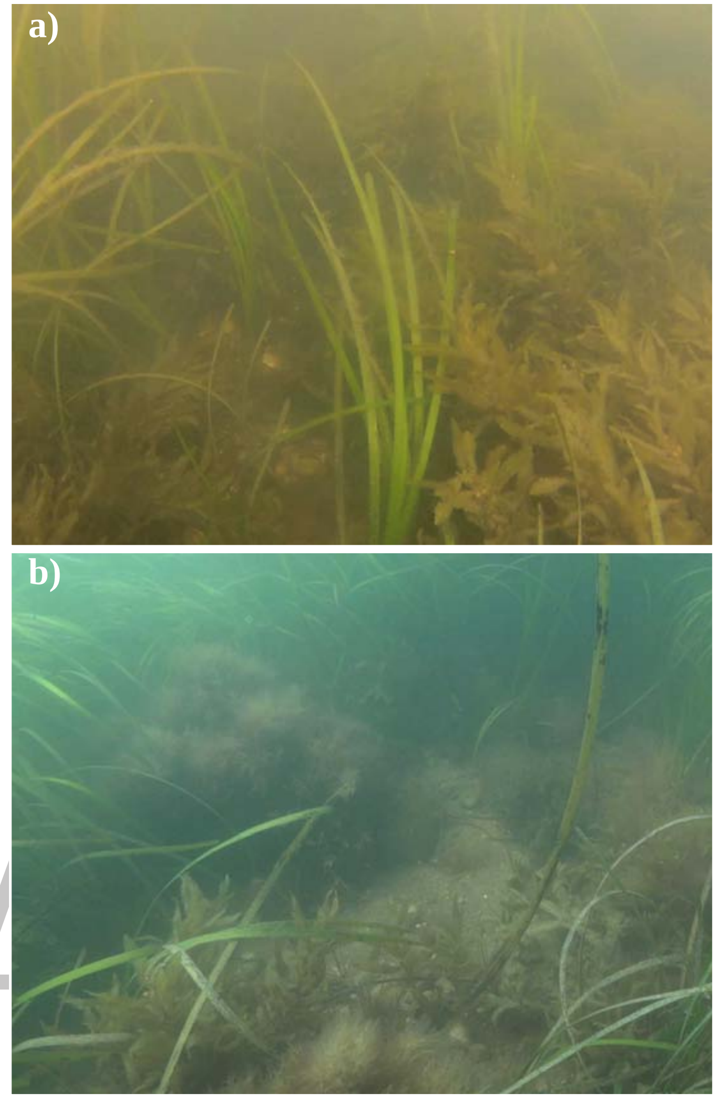


Figure OP-4. Underwater photographs illustrating conditions within the Orient Point eelgrass meadow at a) Station 1 and b) Station 5 during the 2015 monitoring visit.

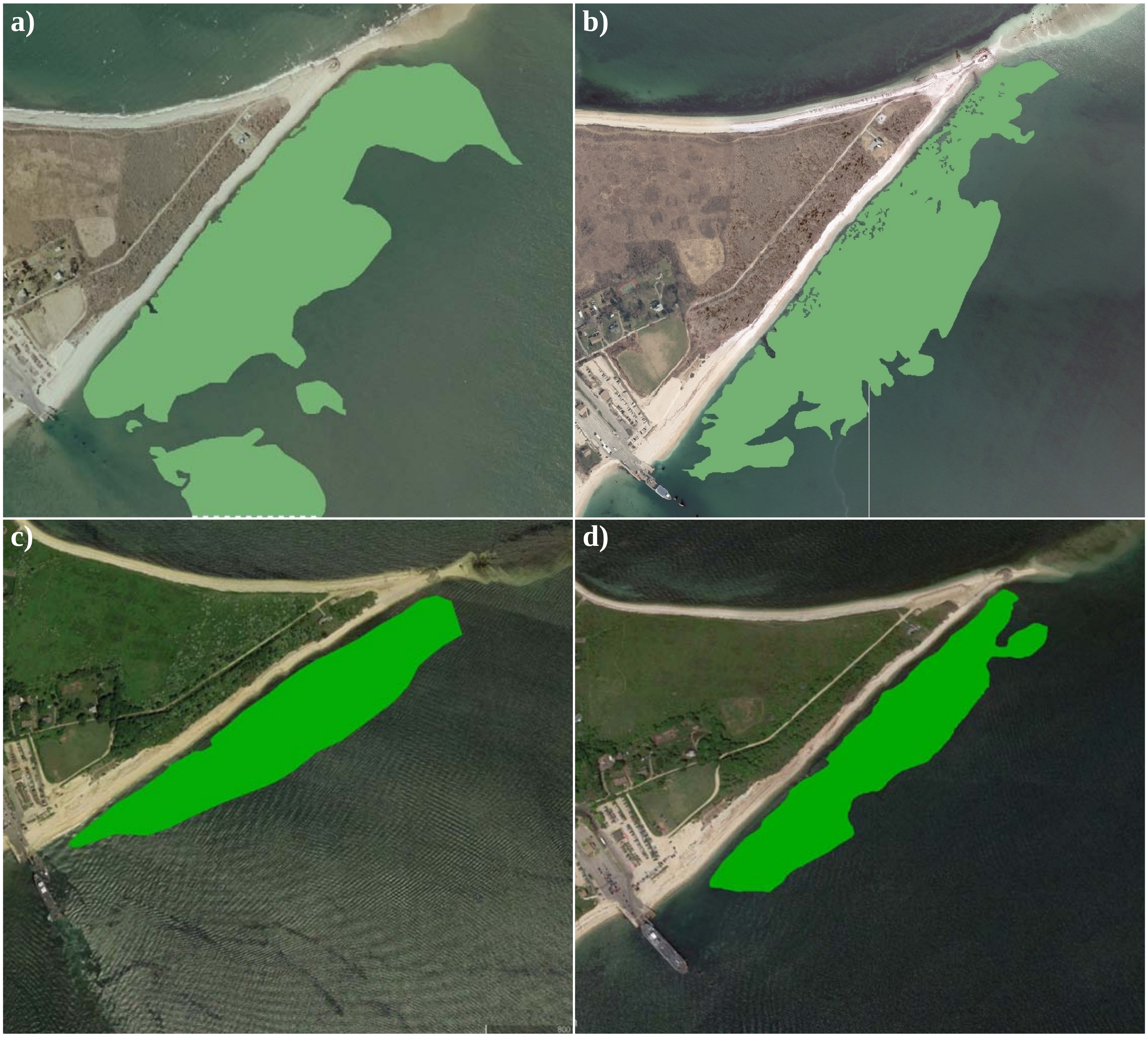
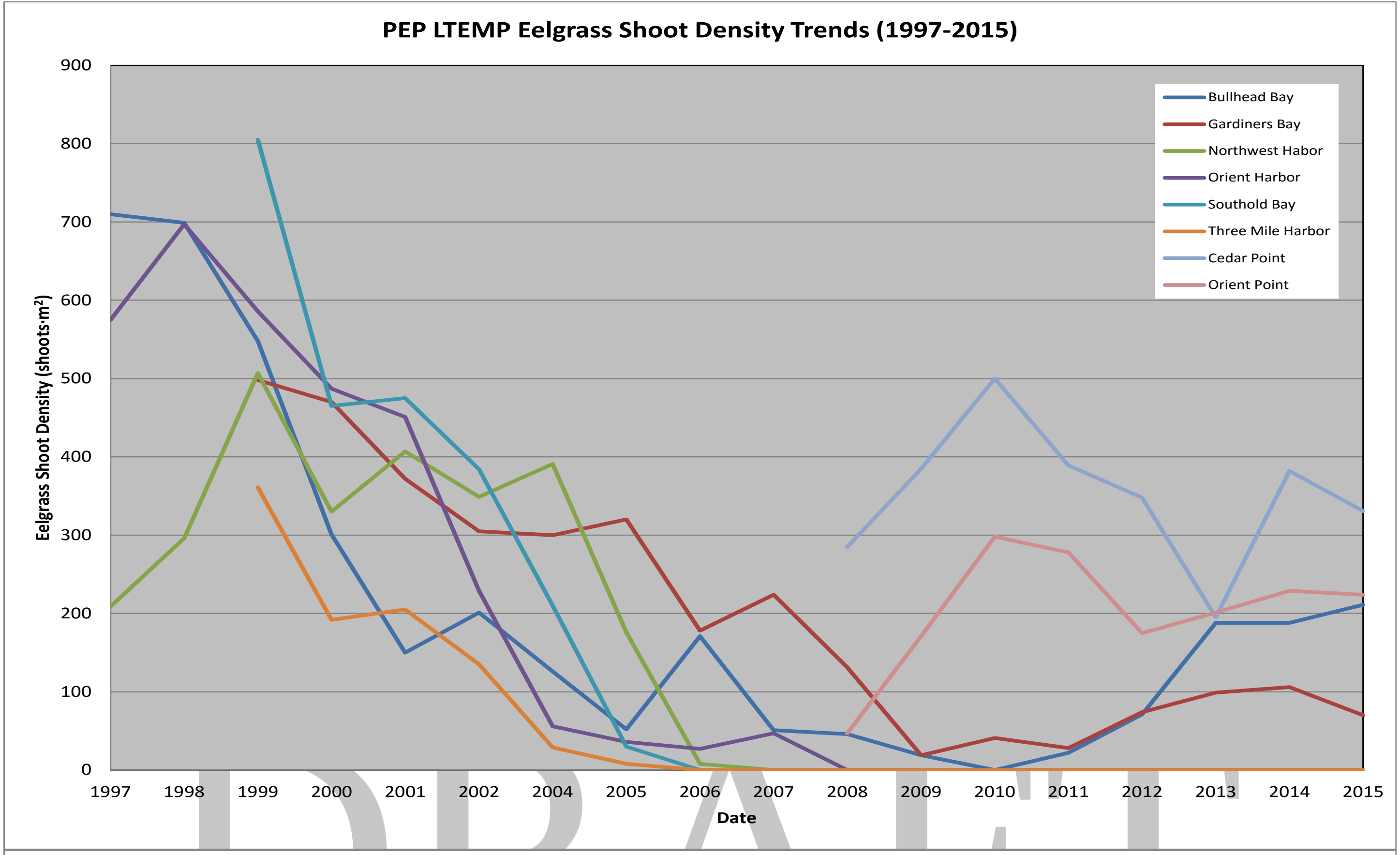
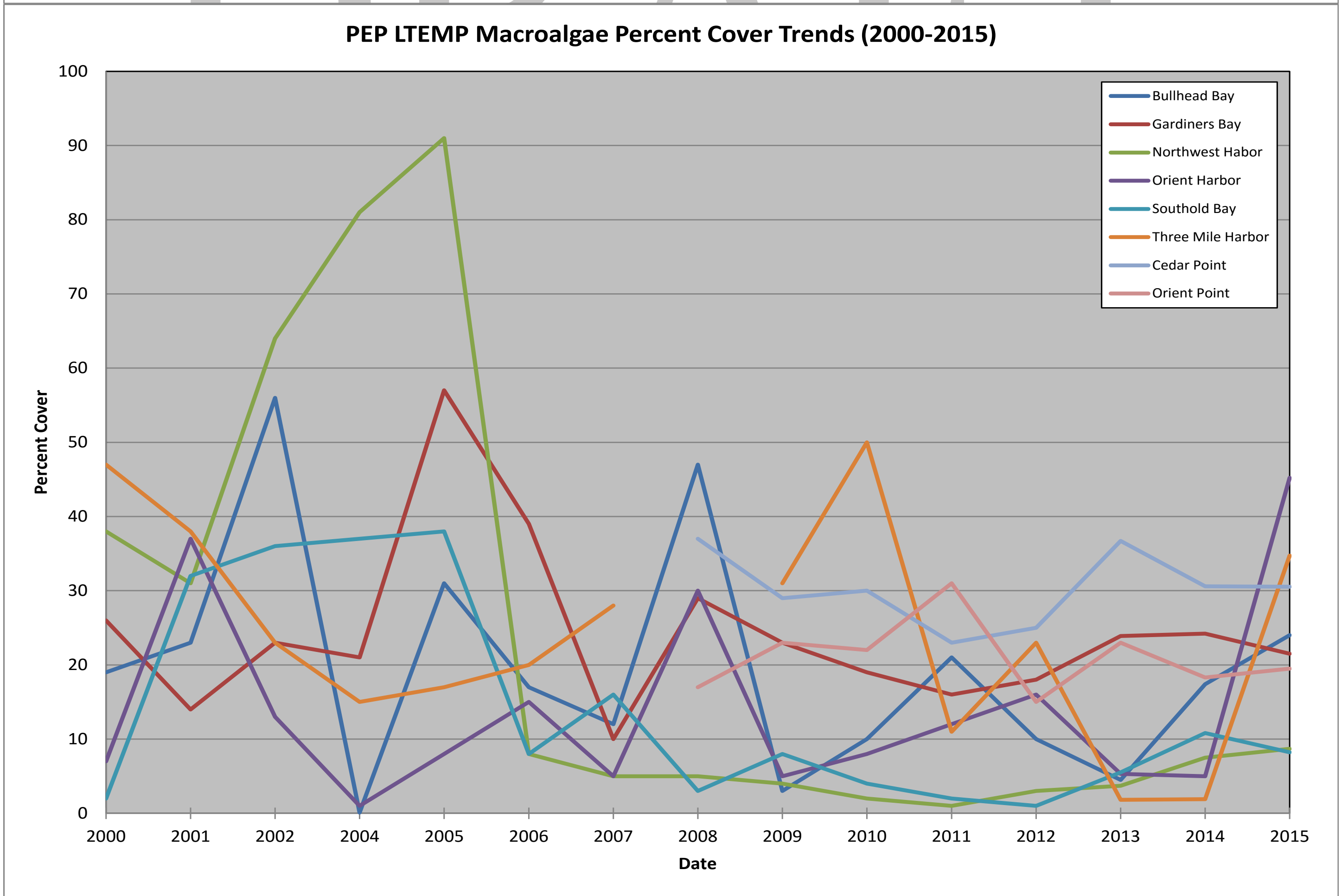


Figure OP-5. Delineations of the Orient Point, Southold, NY eelgrass meadow from aerial imagery for a) 2004, b) 2010, c) 2014 and d) 2015.

Appendix

Appendix 1: Eelgrass Shoot Density and Macroalgae Percent Cover Trends for all years.





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