Peconic Estuary Program 2017 Long-Term Eelgrass (*Zostera marina*) Monitoring Program

Progress Report 18

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

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Executive Summary

In 2017, the Peconic Estuary Program Long-term Eelgrass Monitoring Program (PEP LTEMP) underwent significant changes. With the approval of the PEP Natural Resources Committee, it was decided that 2017 would be the last year that LTEMP sites no longer supporting eelgrass (Northwest Harbor, Orient Harbor, Southold Bay, and Three Mile Harbor) would be removed from annual monitoring and, instead, moved to a monitoring schedule of every 3-5 years. In place of these four sites, four new sites, with extant eelgrass meadows, were selected as replacements. These sites included Coecles Harbor (Shelter Island), Fort Pond Bay (East Hampton), Napeague Harbor (East Hampton), and Sag Harbor Bay (East Hampton and Shelter Island). The start of LTEMP monitoring was delayed three weeks due to boat breakdown, and began on 7 September, 2017.

Light availability and water temperature continue to be important gauges of eelgrass health and data were collected at 7 of the original monitoring sites, as well as at the four, new monitoring sites in 2017. The light data for all sites showed that the summer of 2017 (July-September) experienced a higher than average number of overcast days, based on the Hcomp and Hsat data collected, and supported by National Weather Service data on precipitation. For July, six of 11 sites met Hcomp and two sites met Hsat requirements. August 2017 found only two sites met requirements for Hcomp and Hsat, while no sites met these minimum levels for September. The meadows fared better in regards to water temperatures. Coming off of two record, hot summers, the summer of 2017 recorded more moderate water temperatures. Seven sites recorded days with average temperatures ≥25°C, while only three sites experiencing an average daily temperature above 27°C. The only site that experienced a significant number of days above these two critical levels was Bullhead Bay.

Eelgrass shoot density is the primary parameter of the health of a meadow in the PEP LTEMP. The 2017 monitoring season reported two meadows that experienced significant declines, Orient Point and the new Three Mile Harbor sites, while Bullhead Bay recorded a significant increase in shoot density. The Gardiners Bay and Cedar Point saw no significant changes in shoot density. For the new LTEMP monitoring sites, 2017 provided a baseline from which future monitoring data will be compared. The Napeague Harbor meadow stood out with an average eelgrass shoot density of 806 shoots·m^2, the highest reported for an LTEMP meadow.

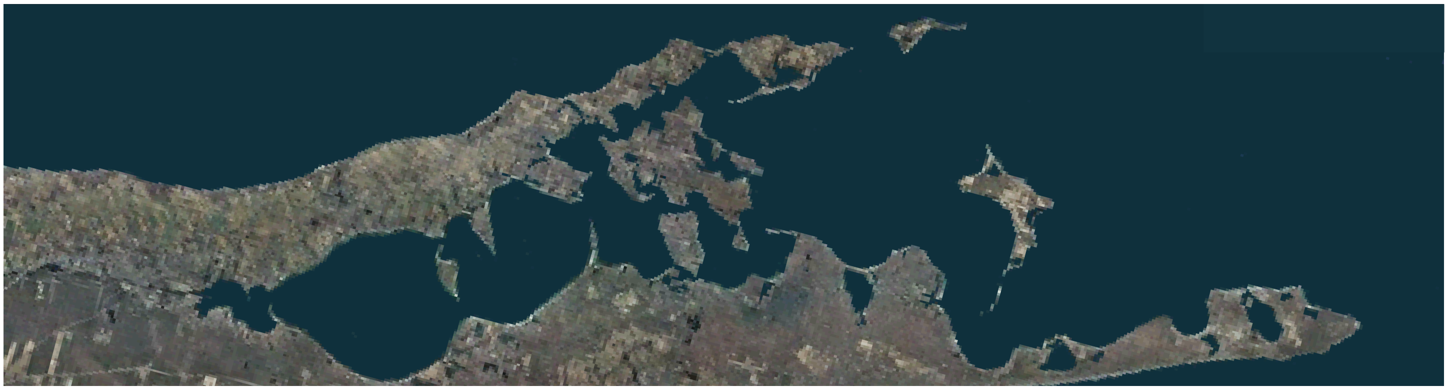
Macroalgae cover within the meadows provides a guage of competition and general water quality at each site. Macroalgae growing within eelgrass meadows and on eelgrass blades compete for nutrients and light. Macroalgae percent cover continued to be highly variable in 2017, both between years and between sites. Five of the original LTEMP monitoring sites (Bullhead Bay, Gardiners Bay, Orient Harbor, Cedar Point, and Orient Point) reported a significant decline in 2017, while only one site (Three Mile Harbor) saw an increase in macroalgae cover. Of the four new monitoring sites, only Coecles Harbor reported mcaroalgae coverage greater than 20%.

For LTEMP 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 the 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. For the 2017 season the general trend in shrinking meadows continued, with the exception of Bullhead Bay. The Bullhead Bay eelgrass meadow expanded by almost 13 acres compared to its extent in 2016. In contrast, Gardiners Bay lost 8 acres, Cedar Point lost 13 acres and Orient Point also reported a loss of 3 acres. The four new meadows had delineations of their extent completed in 2017 and compared with the 2014 PEP Eelgrass Survey results. During the period from 2014 to 2017, none of the new monitoring sites declined by more than 9 acres.

Executive Summary

The 2017 monitoring season marks twenty years of eelgrass monitor in the Peconic Estuary. During that period of time, a better understanding of the factors influencing eelgrass meadow dynamics has been garnered. The program continues to research and refine our understanding of the importance of light availability and water temperature on the health and survival of eelgrass meadows, and research is continuing to fine tune our understanding of these factors in the Peconic Estuary. Over the last twenty years, the PEP LTEMP has witnessed the decline, and eventual loss of four eelgrass meadows in the program. Those meadows are being replaced with four new, healthy meadows, that will provide continued information allowing for the management and protection of the eelgrass resources across the Peconic Estuary. The Brown Tide blooms in the 1980s and 1990s provided the initial impetus to monitor eelgrass in the estuary. That threat has been replaced by global climate change which threatens the Peconic Estuary's eelgrass meadows with sea level rise, stronger/more frequent storms, and rising water tempreatures. The primary trend for eelgrass meadows in the Peconic Estuary over the last several decades has been a slow, but inevitable, eastward shift toward cooler, cleaner waters. The Bullhead Bay eelgrass meadow has been left behind, but its continued persistance provides a valuable model for eelgrass reslience that could assist in managing existing eelgrass meadows that are slowly being pushed to their edge of tolerance by environmental changes, like climate change. Future data collected from the Coecles and Napeague Harbor eelgrass meadows may provide added insights into resilience, bettering our understanding of how meadows, like Bullhead Bay, persist. The PEP LTEMP has increased our understanding of eelgrass ecology in the Peconic Estuary, and, the continuation of the program into the future will only expand this understanding.

Introduction and Methods



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 parameter 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

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)[1]	East Hampton
Orient Point (OP)[1]	Southold
Coecles Harbor (CH)[2]	Shelter Island
Fort Pond Bay (FP)[2]	East Hampton
Napeague Harbor (NAP)[2]	East Hampton
Head of Three Mile Harbor (HTMH)[3]	East Hampton
Sag Harbor Bay (SH)[2]	East Hampton and Shelter Island

[1] Added in 2008, [2] Added in 2017; [3] Added in 2015

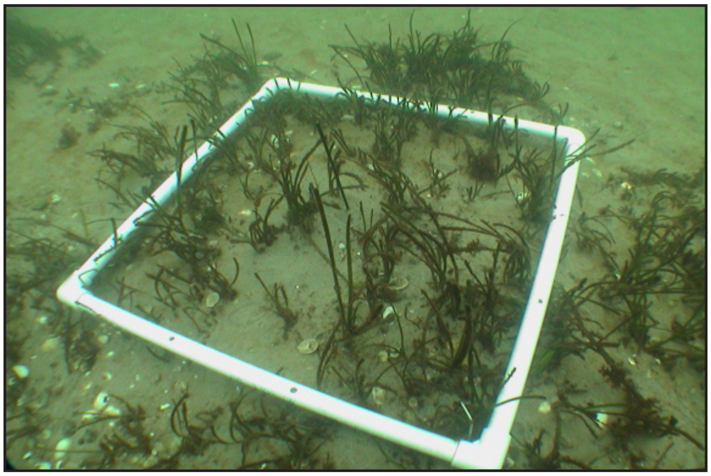


Figure Intro-1. A 0.10 meter^2 PVC quadrat used for eelgrass monitoring.

continued to utilize destructive sampling to collect data, however, sample size was increased to a total of twelve quadrats and there was a decrease in the size of the quadrats to 0.0625 m^2 (12.5 x 12.5 cm).

In 2000, the methodology for the monitoring program was amended to increase the statistical significance of the data collected. The adjustments reflected an increase in the number of sampling stations per site (from 3 to 6), the number of replicate samples per station (from 4 to 10) and the size of the quadrats. However, the 2000 methodology included an 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.

Two additional eelgrass meadows were added to the program in 2008. With the loss of eelgrass at four of the original meadows in the program, CCE proposed to take on Cedar Point, East Hampton and Orient Point, Southold as replacement sites. For each of the two new meadows, six monitoring stations were established following the protocols used for the original monitoring sites.

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.

The 2017 LTEMP season saw the inclusion of four new eelgrass meadows to the program. After consultation with the PEP's Natural Resources Subcommittee, Coecles Harbor (Shelter Island), Fort Pond Bay (East Hampton), Napeague Harbor (East Hampton), and Sag Harbor Bay (East Hampton and Shelter Island) were chosen as new monitoring sites (Figure Intro-4). Additionally, a second station was added to the monitoring effort at the head of Three Mile Harbor (East Hampton). For the 2017 monitoring season, it was agreed that all of the LTEMP sites, the original and new, would be monitored, but for future seasons, the LTEMP sites that no longer support eelgrass (Northwest Harbor, Orient Harbor, Southold Bay, and the original Three Mile Harbor) would be monitored once every 3 years.

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

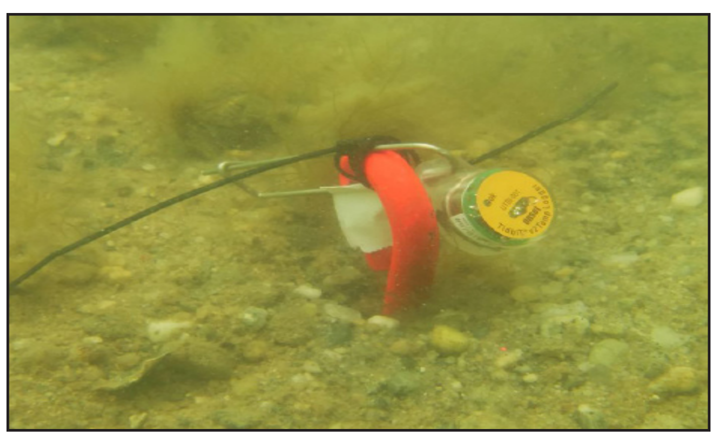


Figure Intro-2. A TidBit v2™ temperature logger attached to a screw anchor, deployed on-site.

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.

Water temperature loggers were deployed at seven of the original LTEMP monitoring sites (Bullhead Bay, Cedar Point, Gardiners Bay, Orient Point, Southold Bay, Three Mile Harbor and Three Mile Harbor-New), as well as the four new LTEMP sites (Coecles Harbor, Fort Pond Bay, Napeague Harbor and Sag Harbor Bay) for the 2017 season. The water temperature results for the above listed sites will be used in conjunction with the light data collected at the sites.

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 collected primarily at the vegetated sites within the PEP LTEMP including: Cedar Point, Gardiners Bay, Orient Point, and Three Mile Harbor-New, Coecles Harbor, Fort Pond Bay, Napeague Harbor, and Sag Harbor Bay. The Southold Bay and Three Mile Harbor sites (extinct eelgrass meadows) were also included in the survey. The loggers were deployed for 10 days of recording. The logger measured the quantity of PAR at set intervals throughout each day. The loggers were retrieved after at least 7 days, with most deployments being 10 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 µmols·m^{-2}·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 µmols·m^{-2}·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.

For the 2017 season, Odyssey PAR loggers were deployed at seven of the original LTEMP monitoring sites (Bullhead Bay, Cedar Point, Gardiners Bay, Orient Point, Southold Bay, Three Mile Harbor and Three Mile Harbor-New), as well as the four new LTEMP sites (Coecles Harbor, Fort Pond Bay, Napeague Harbor and Sag Harbor Bay).

Eelgrass Monitoring

The 2017 monitoring began on 11 September and completed on 2 October. The delay in the 2017 monitoring was due to a boat breakdown suffered on the intended first day of monitoring (21 August, 2017). Additionally, the expanded number of monitoring sites to visit (12 versus 8), and the extra work to scout and

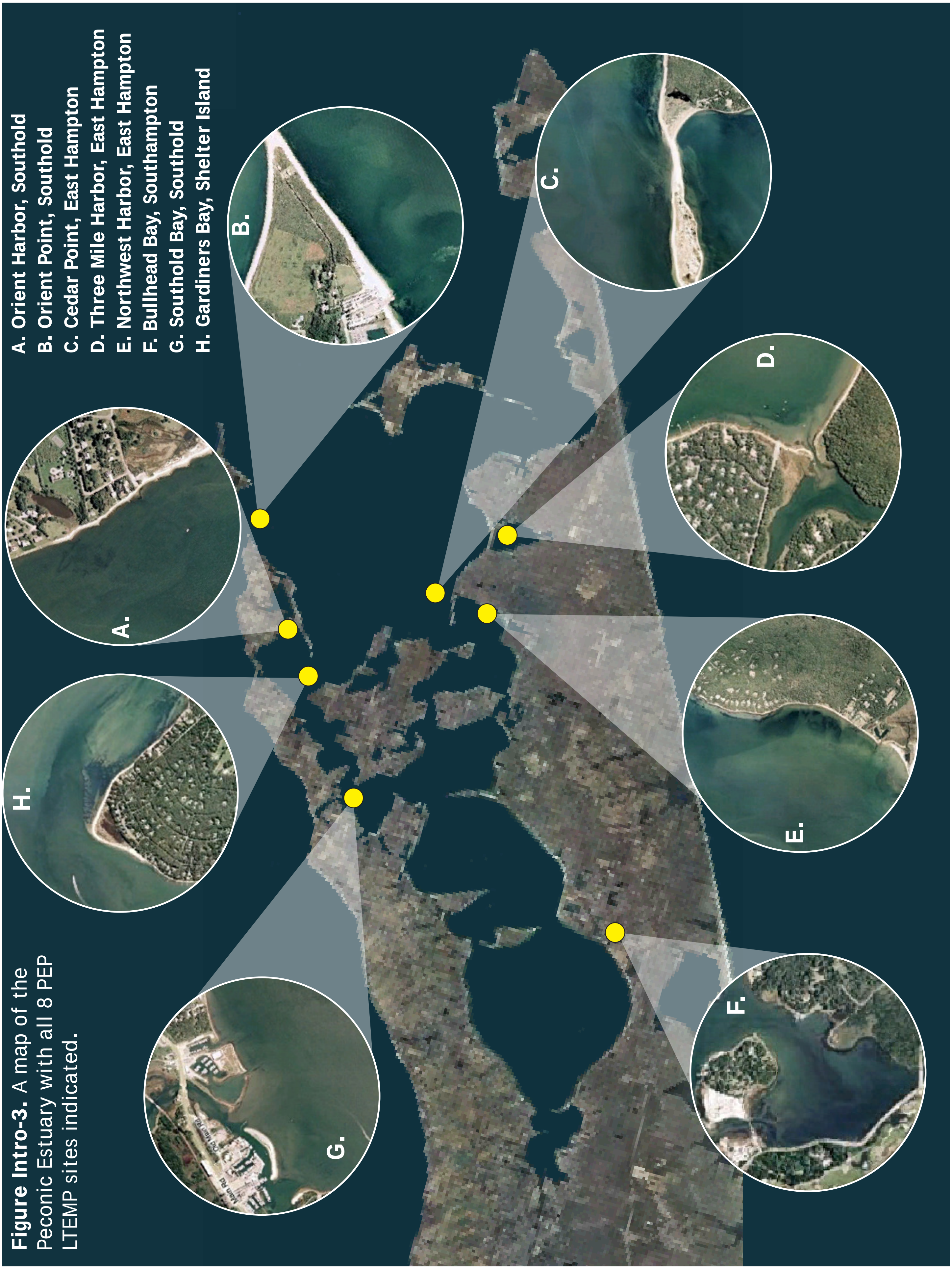


Figure Intro-3. A map of the Peconic Estuary with all 8 PEP LTEMP sites indicated.

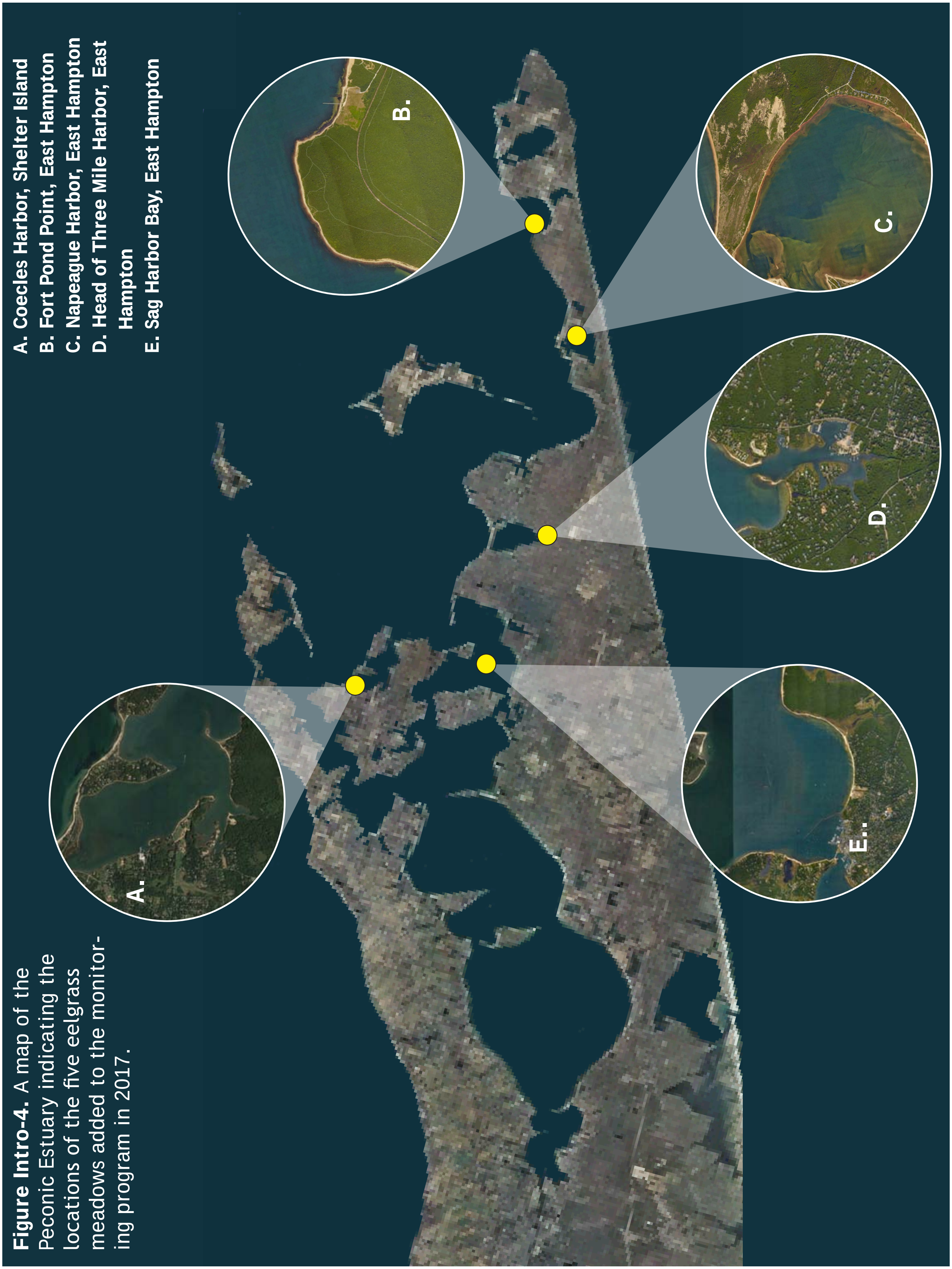


Figure Intro-4. A map of the Peconic Estuary indicating the locations of the five eelgrass meadows added to the monitoring program in 2017.

set up monitoring stations at the new sites, required more time commitment than previous monitoring seasons. Sampling at each site was distributed among six stations that have been referenced using GPS, with the exception of the Gardiners Bay site, which now supports eight stations. At each of the 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 2017 season, Google™ Earth aerial imagery 1 October, 2017) 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. 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 2017 eelgrass monitoring, each diver was equipped with a GoPro Hero 3™ 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 will be edited, combining footage from each station into a one to two minute video for each site. The videos will be posted on YouTube at SeagrassLI's video page.

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%. The follow-up sediment analysis conducted in 2017 found similar results, with an average organic content of 7.2%. Locally, sediment organics exceeded 12% in the 2017 analysis. 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 2017

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 2017. *Light logger was lost due to tampering with site.

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	13.1	0.8	7.9	-0.1	26.2
August*	ND	ND	ND	ND	25.1
September	7.8	-4.5	2.6	-5.4	21.9

Bullhead Bay also supports significant populations of mute swans and Canada geese that not only add nutrients from their droppings, but also impact the bed by their grazing on eelgrass. Even though there are several significant potential sources of nitrogen loading to Bullhead Bay, the eelgrass continues to populate this system. One factor that may reduce the impact of poor water quality in Bullhead Bay may be its overall shallow profile. With the eelgrass growing at depths of 6 feet or less at MLW, light is not attenuated to a point where it is insufficient for eelgrass photosynthesis.

Light Availability and Temperature

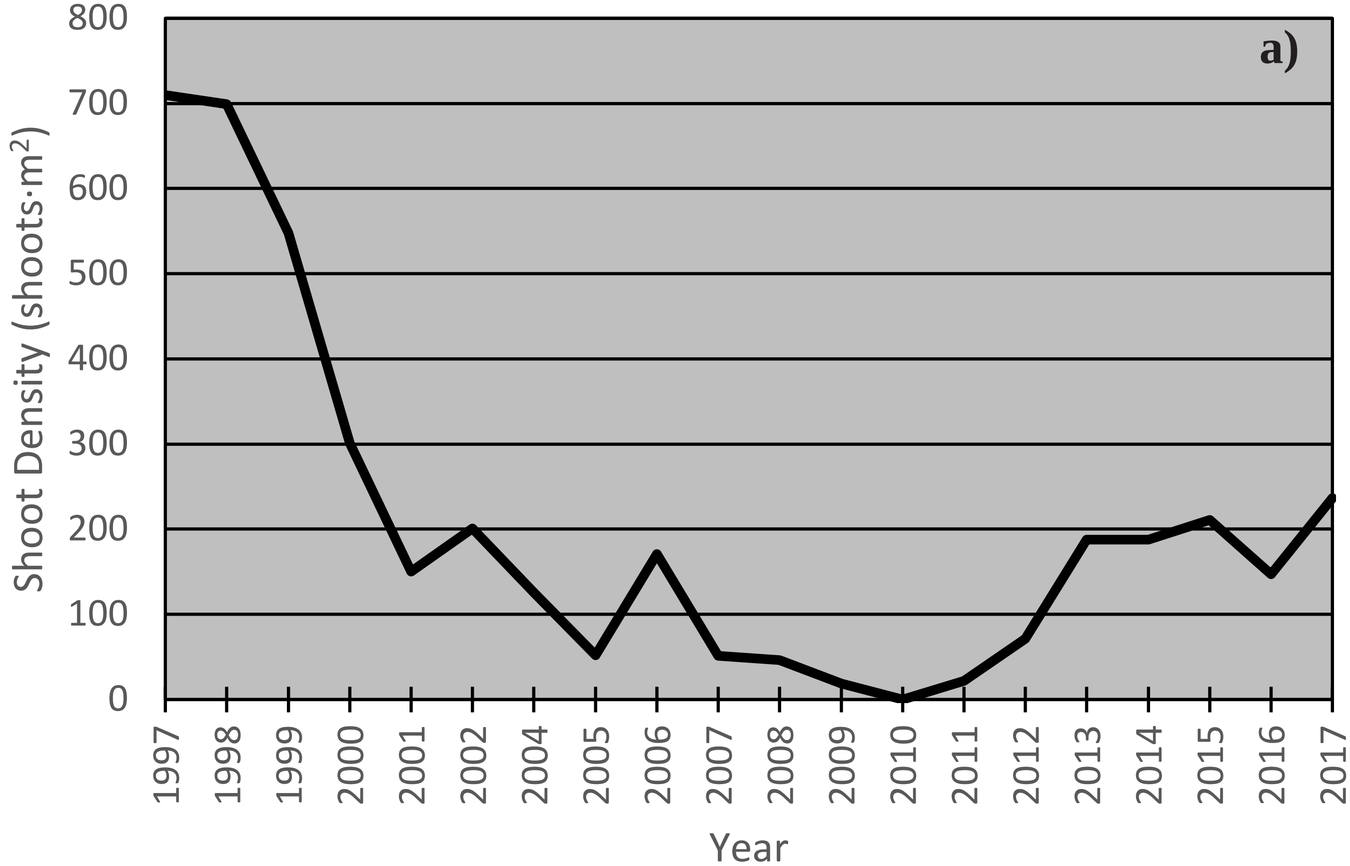
Light logger deployments were conducted monthly for ten days from July-September, 2017, with the average Hcomp and Hsat for each month presented in Table BB-1 above. Overall, water clarity was observed to be extremely good within the meadow during several visits throughout the season to deploy/retrieve loggers. There was an issue with the 2017 light monitoring in Bullhead Bay, however. As indicated in Table BB-1, the light logger was lost during the August deployment. On the visit to recover the logger after its deployment, it was discovered that someone had dragged one of the site marker buoys more than 100ft from its original position. It is believed that the light logger hooked onto the buoy line while it was dragged and was deposited (possibly taken) somewhere away from the site. An extensive search was conducted by CCE divers, but the logger was not found. The remaining light data for July and September found that Hcomp met the 12.3 hour requirement in July, but the meadow ran a deficit of light for Hcomp in September and Hsat for both July and September. These low light conditions were likely due to the prevailing weather pattern affecting the region during the summer of 2017. According to the National Weather Service, from June-September 2017, there were more than 30 days with measureable precipitation. The low reported light levels were also found at other sites throughout the monitoring area, suggesting that this was a widespread event resulting from overcast conditions.

Water temperature loggers were deployed in Bullhead Bay from early June through the end of September. The loggers recorded that the meadow experienced 49 days averaging above 25°C and 11 days above 27°C. The monthly average temperatures for July and August were both above the 25°C threshold (Table BB-1). The highest reported water temperature for the 2017 season was 30.44°C recorded on 21 July, 2017. While

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
2016	147	+/-25
2017	236	+/-32

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



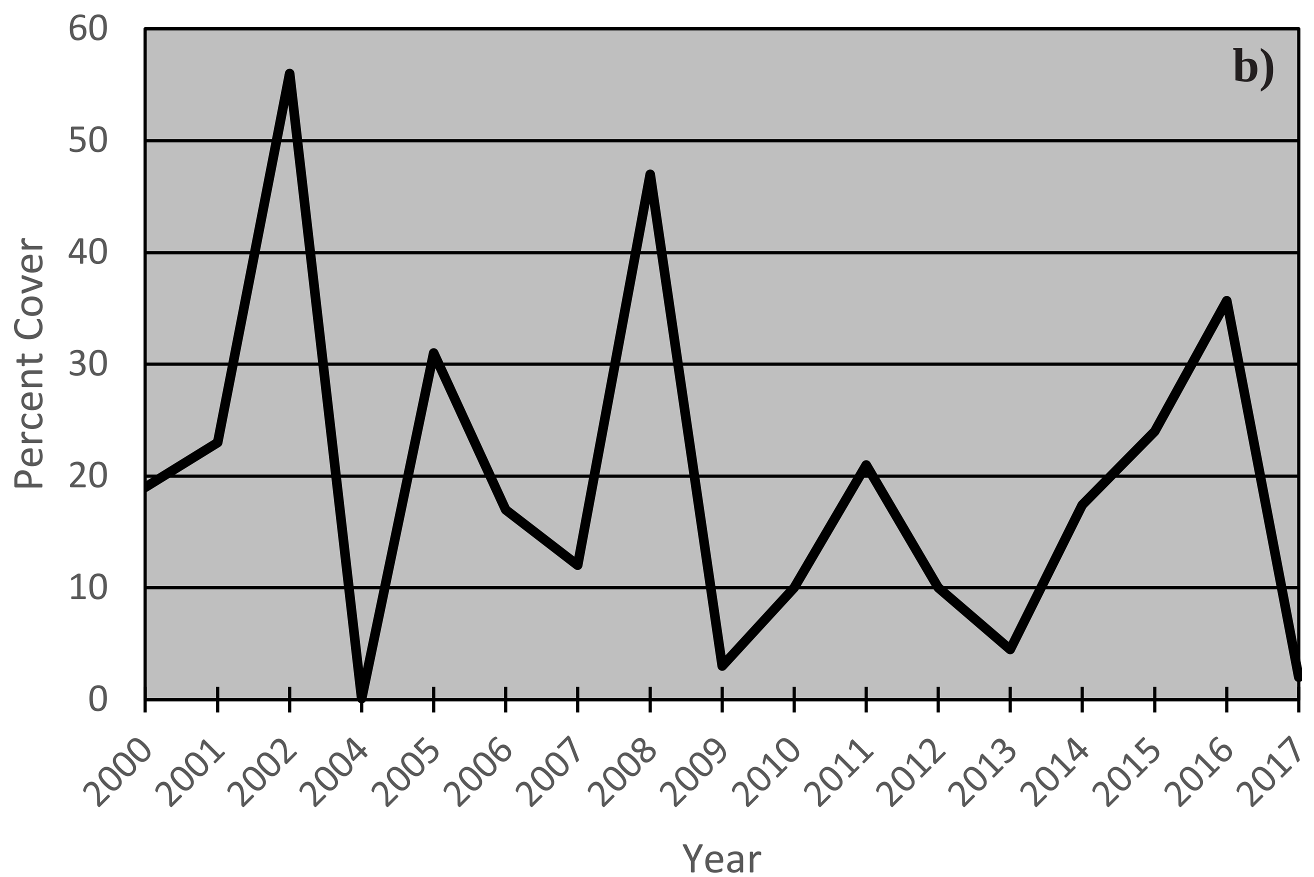


Figure BB-2. Graphs of average a) shoot density and b) macroalgae percent cover trends for all years of the PEP LTEMP conducted in Bullhead Bay.

Bullhead Bay 2017

Figure BB-3. The 2017 delineation of the Bullhead Bay eelgrass meadow.

2017 will certainly be one of the warmest seasons for water temperature with almost 50 days above 25°C, however it falls short of the 2017 season with 72 days, and potentially the 2016 season, if the complete 2016 season data had not been lost.

Eelgrass Shoot Density

The Bullhead Bay monitoring visit was conducted on 11 September, 2017. Eelgrass shoot density was found to have significantly increased from 2016 levels (Table BB-2 and Figure BB-2a). The average eelgrass density for Bullhead Bay in 2017 was 236 shoots·m^2, the highest shoot density recorded for the meadow since 2000 (Table BB-2; Figure BB-2a). Not all monitoring stations recorded eelgrass in their quadrat counts. Monitoring Station 1 had no reported eelgrass within the vicinity of the station.

Macroalgae Cover

Macroalgae was notably absent from much of the Bullhead Bay eelgrass meadow in 2017. With only 2% cover and only 2 species (*Spyridia filamentosa* and *Gracilaria* sp.) observed, 2017 was the second lowest biomass year reported for Bullhead Bay.

Bed Delineation and Areal Extent

Delineation of the Bullhead Bay eelgrass meadow was completed using aerial imagery from Google Earth™ taken on 1 October, 2017. The quality of the imagery was sufficient to provide an accurate assessment of the areal extent of the meadow. In 2017, the meadow expanded from its 2016 area to cover 47 acres of the bay, representing an increase in almost 13 acres from 2016 (Table BB-3; Figure BB-3 and 4f). The meadow filled in areas in the north-central sections of the meadow that were unvegetated in 2016 and expanded to the northeast toward Sebonac Creek.

Conclusions

Bullhead Bay continues to support a healthy, and in 2017, expanding eelgrass meadow. With the significant recovery from the decline in shoot density and area reported in 2016, the meadow is slowly expanding, approaching levels of eelgrass density and areal extent not seen in the meadow since 2000. This recovery all comes as the meadow is experiencing the highest water temperatures and longest periods of exposure to these typically lethal temperature conditions.

Factors contributing to this recovery may include the limited human impact to the site, as shellfishing, with the exception of crabbing, is no longer allowed in the bay and powerboating is minimal. In 2017, there was a decrease in the number of resident swans observed

Table BB-3. Estimated areal coverage of the Bullhead Bay eelgrass meadow for select years from 2000-2017.

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.)
2016	34.21 acres (13.84 hect.)
2017	47.0 acres (19.02 hect.)

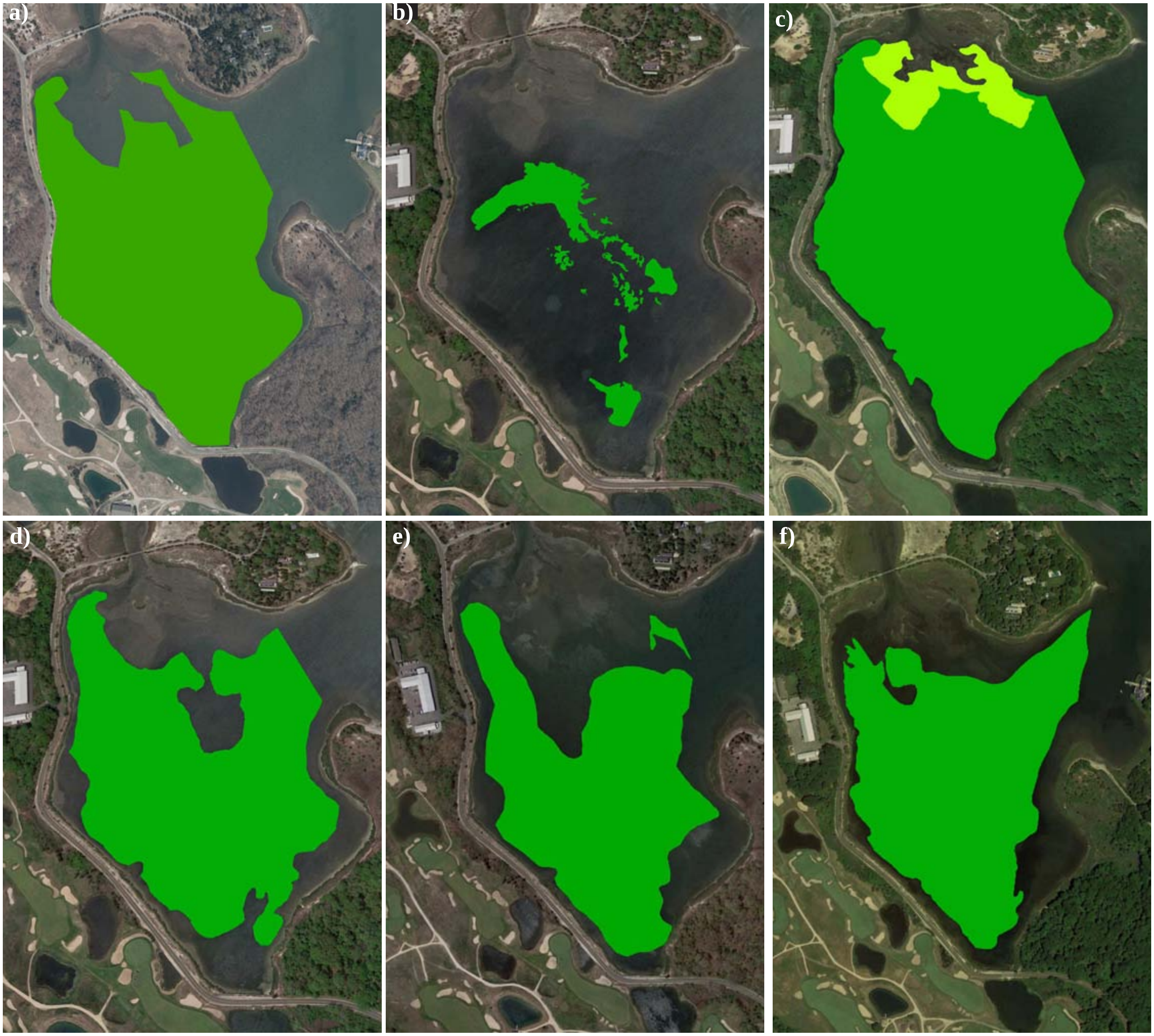


Figure BB-4. A series of aerial delineations of the Bullhead Bay eelgrass from 2000 through 2016. The years represented are a) 2000, b) 2010, c) 2014, d) 2015, e) 2016, and f) 2017.

in the bay, compared to the 2016 numbers reported. Water clarity was very good in 2017 and, combined with very low biomass of macroalgae in the meadow, would greatly benefit the growth and expansion of the meadow.

Even with the gains reported above, the meadow still has opportunities for further recovery. Monitoring Station 1 was devoid of eelgrass, and recruitment to this area in 2018, without losses in other areas, would serve to further improve meadow shoot density. Areal extent of the meadow has not reached the levels reported in 2000 and 2014, with room for recolonization still remaining in the southeast section of Bullhead Bay and a small area in the northern section (Station 1). Based on the 20 years of monitoring data collected in this meadow, there are still questions regarding the the simple existence of a persistent eelgrass community growing in conditions (i.e. high water temperatures) that have lead to the loss of other meadows in the Estuary. The importance of understanding factors allowing eelgrass to survive, and recently, thrive under these suboptimal conditions could provide important information in managing other extant meadows in the Estuary, as well as identifying potential sites for future eelgrass restoration. The suggestion that more research

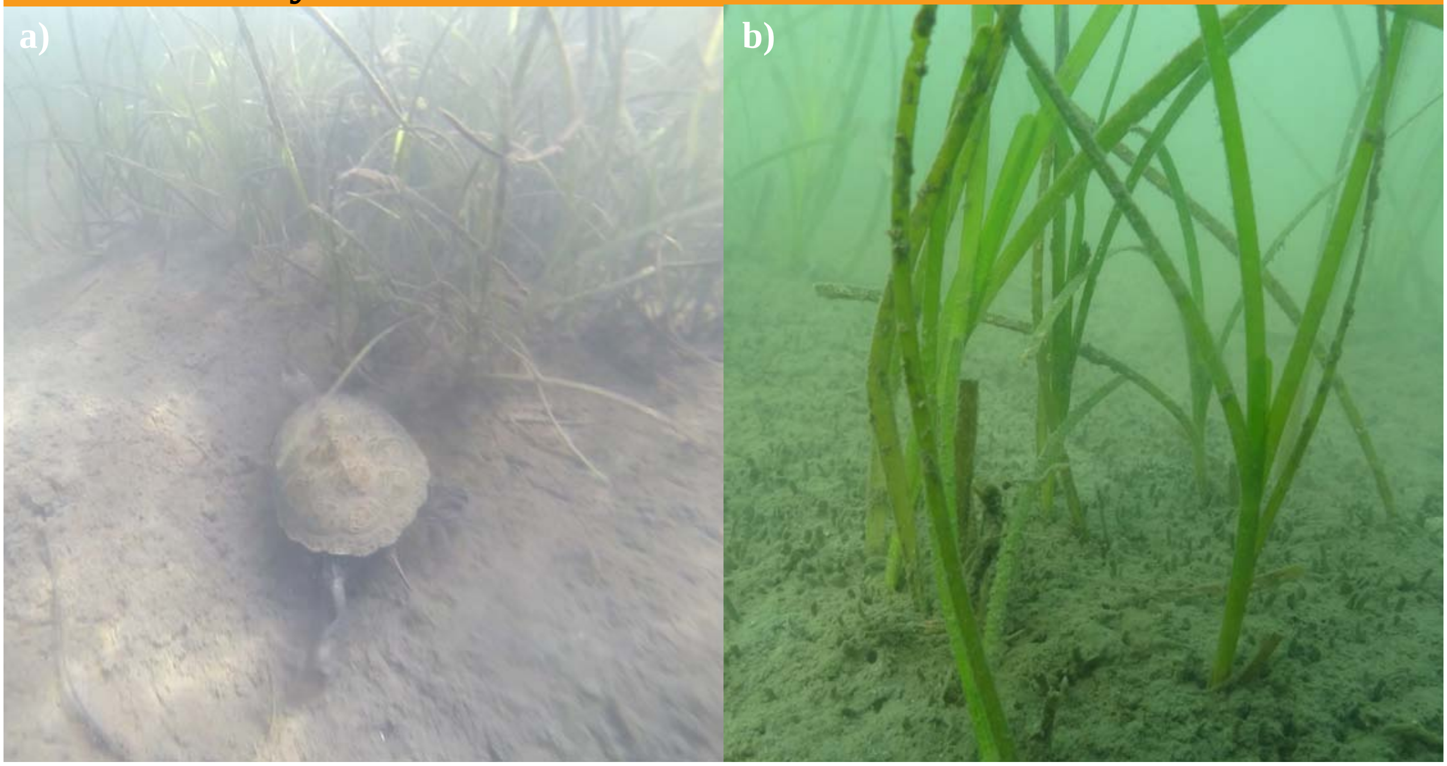


Figure BB-5. a) One of the Bullhead Bay's resident diamondback terrapins startled from its nap in the eelgrass meadow by a CCE diver. b) The unusual lack of macroalgae cover in the bay is illustrated by this photograph taken at station 5.

is needed to better understand how eelgrass has survived in Bullhead Bay has been presented in previous LTEMP reports. This site could represent a living laboratory for evaluating factors mitigating eelgrass growth in an environment slowly changing with global climate change. Consideration should be given to holding a meeting to discuss the potential for research in Bullhead Bay and development of a prioritized list of research questions to be pursued which could be used by organizations like SUNY Southampton, CCE, TNC, or others to secure future funding to address these questions.

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, taken in 1999, averaged 0.84% organic material in the sediments with a range of 0.31% to 1.73%. The new analysis of sediment characteristics completed in 2017 found that the sediment consisted of 22.5% gravel, 75.6% sand, and 1.9% silt+clay, with 0.41% organic content (lower than 1999). Sediments continue to be 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

Gardiners Bay 2017

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 2017. * Logger malfunctioned, no data.

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	12.4	0.1	7.9	-0.1	23.2
August	10.8	-2.0	6.6	-1.4	23.5
September*	ND	ND	ND	ND	21.3

periods of time.

Water quality has rarely been a factor in the health of this eelgrass meadow. The flushing that this site experiences is more than adequate to maintain nutrient concentrations at ambient levels for the eastern Estuary. Due to its significant fetch to prevailing winter winds, the turbidity can become high during storms, but suspended solids tend to settle quickly or be flushed shortly afterward. Water clarity also tends to decline with the outgoing tide. Depending on the time of year and/or the tide, drift macroalgae can be transported into the site by 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 logger deployments for the 2017 season were conducted for ten-day periods, monthly, from July-September 2017. During the September 2017 light logger deployment, there was a malfunction resulting in the collection of no data for that period. The collected light data is summarized in Table GB-2, above, and, unlike in previous years, the Gardiners Bay site ran a deficit for both Hcomp and Hsat in July. While there was no data for September, it is expected, based on previous years' data, that both Hcomp and Hsat would have also been a deficit.

Water temperature monitoring at the Gardiners Bay site found that 2017 was a significantly cooler summer than either 2015 or 2016. No daily average temperature exceeded 25°C for the season. The highest water temperature recorded (20 July, 2017 at 1600h) was 25.7°C, on an outgoing tide. In contrast, the 2016 season recorded 24 days above 25°C, with a reported high temperature a full degree higher at 26.7°C.

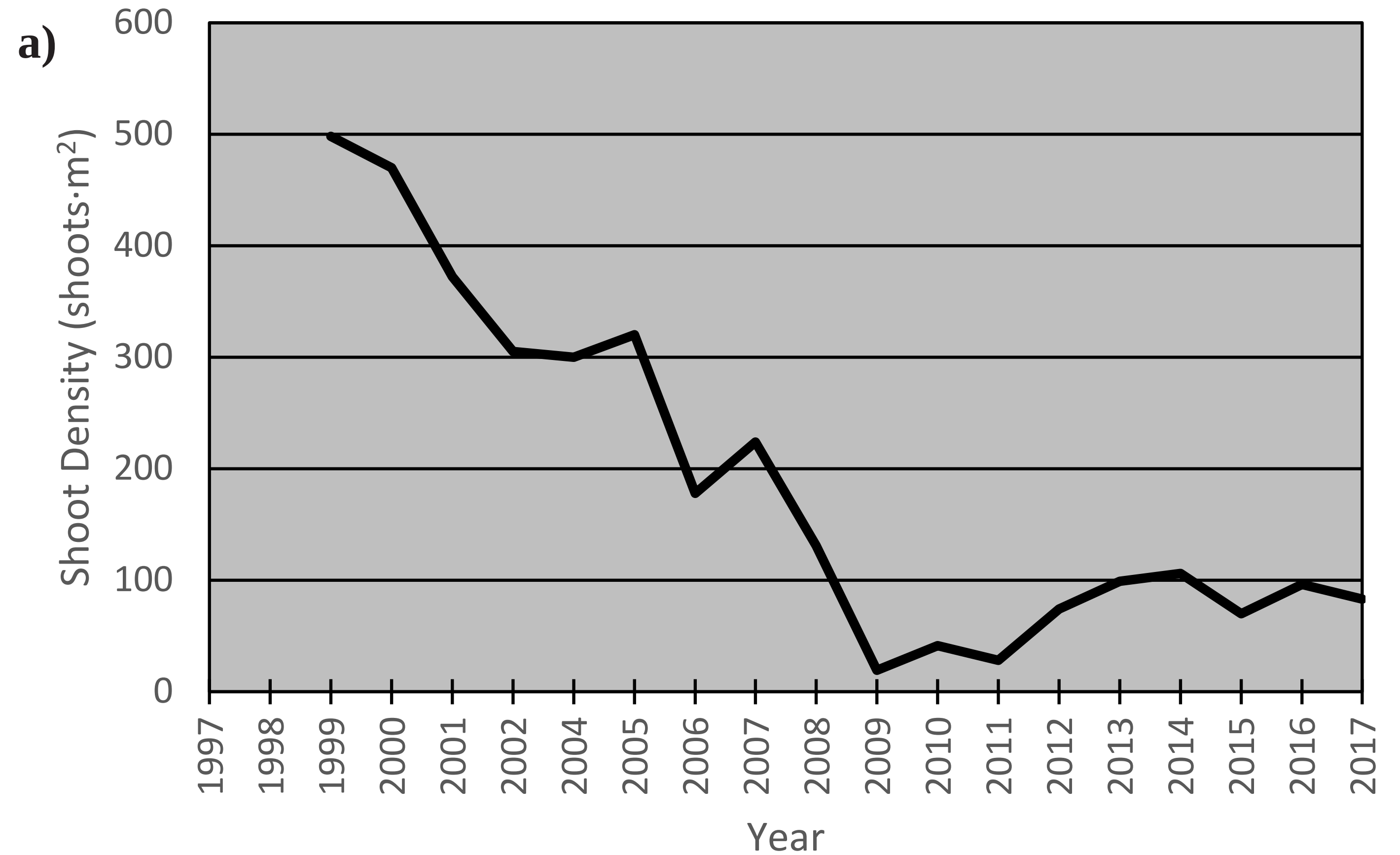
Eelgrass Shoot Density

The 2017 LTEMP was conducted on 7 September, 2017 at Gardiners Bay. In 2017, only three monitoring stations (6,7, and 8) supported eelgrass, however, eelgrass patches were spotted adjacent to Station 5 at this time. Analysis of eelgrass shoot density found no significant change at Gardiners Bay since 2014 (Table GB-2, Figure GB-2a). The average shoot density for the meadow in 2017 decreased to 83 shoots·m^2,

Table GB-2. The average annual eelgrass shoot density for Gardiners Bay from 1999 to 2017, 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
2016	96	+/-25
2017	83	+/-16

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



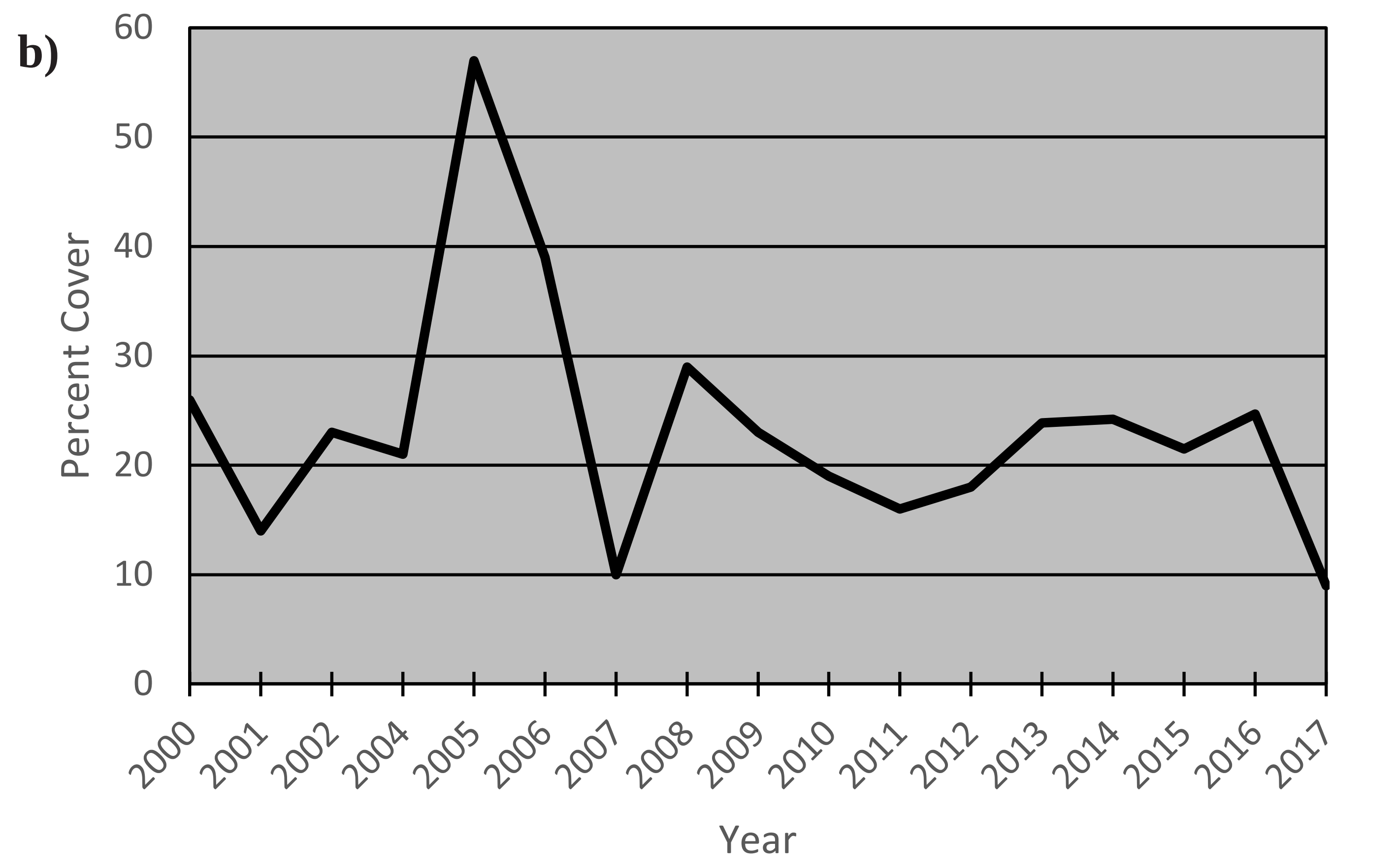


Figure GB-2. Graphs of average a) shoot density and b) macroalgae percent cover trends for all years of the PEP LTEMP conducted at the Gardiners Bay site.

Gardiners Bay 2017

Figure GB-3. The 2017 areal delineation of the Gardiners Bay eelgrass meadow on the northeast shore of Shelter Island, NY.

Table GB-3. The estimated areal coverage of the Gardiners Bay eelgrass meadow from 2000-2016.

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.)
2016	29.08 acres (11.77 hect.)
2017	20.80 acres (8.42 hect.)

compared to 96 shoots·m^2 in 2016. The average shoot density within the three monitoring station that still support eelgrass was 221 shoots·m^2.

Macroalgae Cover

The macroalgae percent cover at Gardiners Bay experienced a major decline from 2016 and recorded the lowest percent cover since the meadow has been monitored. The average macroalgae percent cover was 9%, representing a decline of almost 16% from 2016. Species diversity at the site was relatively unchanged at the site, with 9 species reported, however, overall biomass, particularly of the drift macroalgae that entangles in the eelgrass canopy was much reduced from previous seasons.

Bed Delineation and Areal Extent

The 2017 meadow delineations were completed using Google™ Earth imagery taken on 1 October, 2017. A total of 20.8 acres (Table GB-3; Figure GB-4f) was delineated from the 2017 aerial imagery. The loss in area from 2016 to 2017 can be attributed to the continued fragmentation of the center section of the meadow (Figure GB-4f).

Conclusions

Monitoring at the Gardiners Bay eelgrass meadow in 2017 found a minor decline in shoot density from 2016. Water temperatures collected over the course of the season recorded no days with temperatures exceeding 25°C, which was a reversal from the trends of the previous two seasons. Light availability at the site for 2017 was lower than average, based on the collected data. The lower Hcomp and Hsat number reported for the Gardiners Bay site are likely the result of an especially rainy summer, rather than a localized water quality issue. This is supported by similiar findings regarding light at the other monitoring sites within the Estuary. The meadow experienced a decrease in total area of eelgrass resulting from the increase fragmentation evident throughout the center of the meadow. This increased fragmentation could have resulted from a strong storm pattern over the winter. If the winter of 2017-2018 proves to be calmer than the previous winter, the meadow may have the respite to be able to stage some recovery over the 2018 growing season.

The main factors affecting the Gardiners Bay eelgrass meadow continue to be weather, waves and currents. With global climate progressing, weather patterns have become less predictable and storms more frequent and stronger, potentially resulting in greater disturbance to the meadow that can influence density and overall size. The difficult aspect of this situation is that there is nothing from a management perspective that

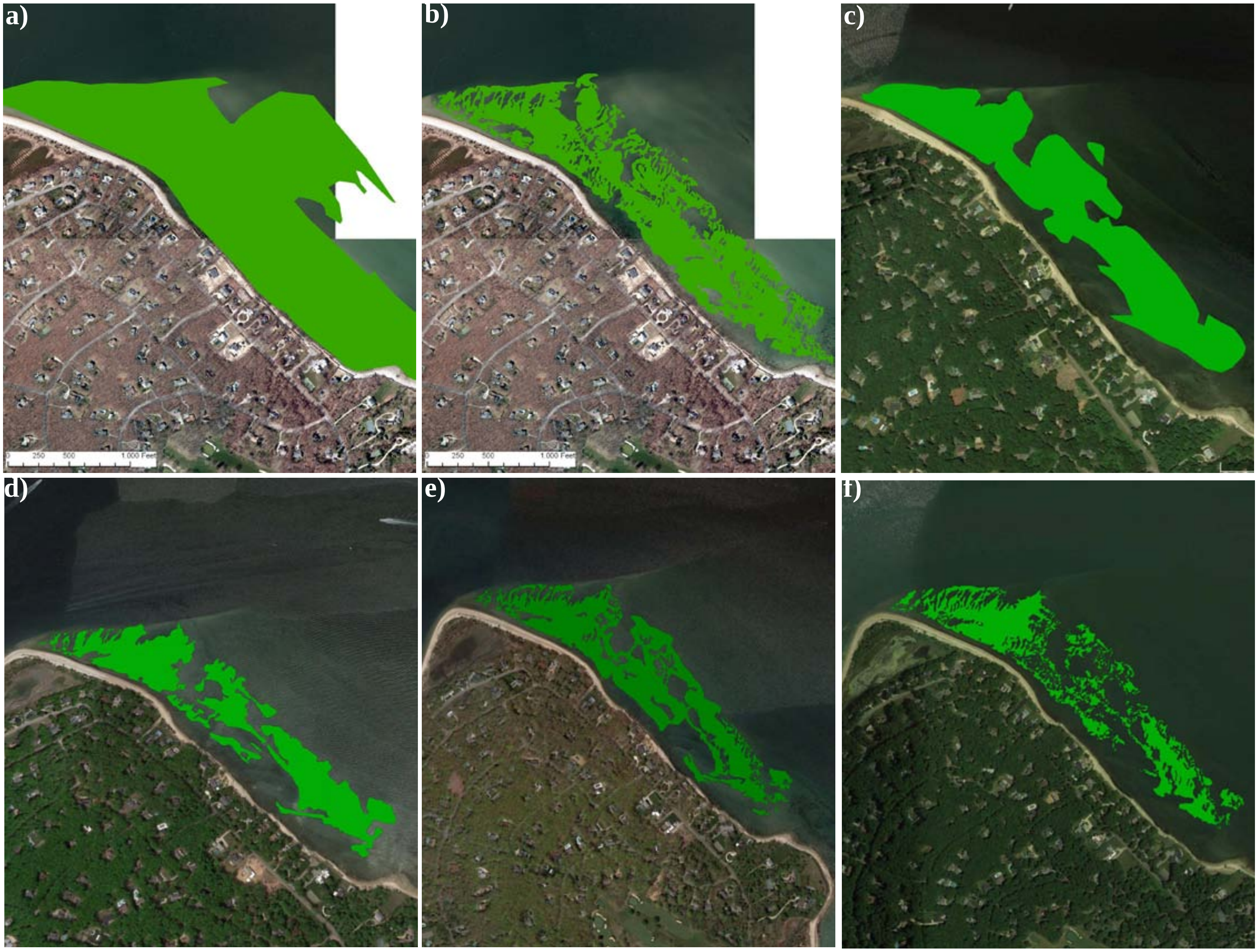


Figure GB-4. A series of aerial delineations of the Gardiners Bay eelgrass from select years from 2000 through 2016. The years represented are a) 2000, b) 2010, c) 2014, d) 2015, e) 2016, and f) 2017.

can be done to mitigate these natural impacts. Instead, effort could be made through education and changes in statute to reduce the anthropogenic impacts on the meadow, even though they are of a limited nature. Restricting moorings and shellfishing to unvegetated areas would assist in reducing fragmentation in the nearshore areas of the meadow. Reducing boat traffic through the meadow, an idea continually promoted by previous LTEMP reports, could provide significant relief from prop scarring/dredging in the mid to offshore sections of the meadow.

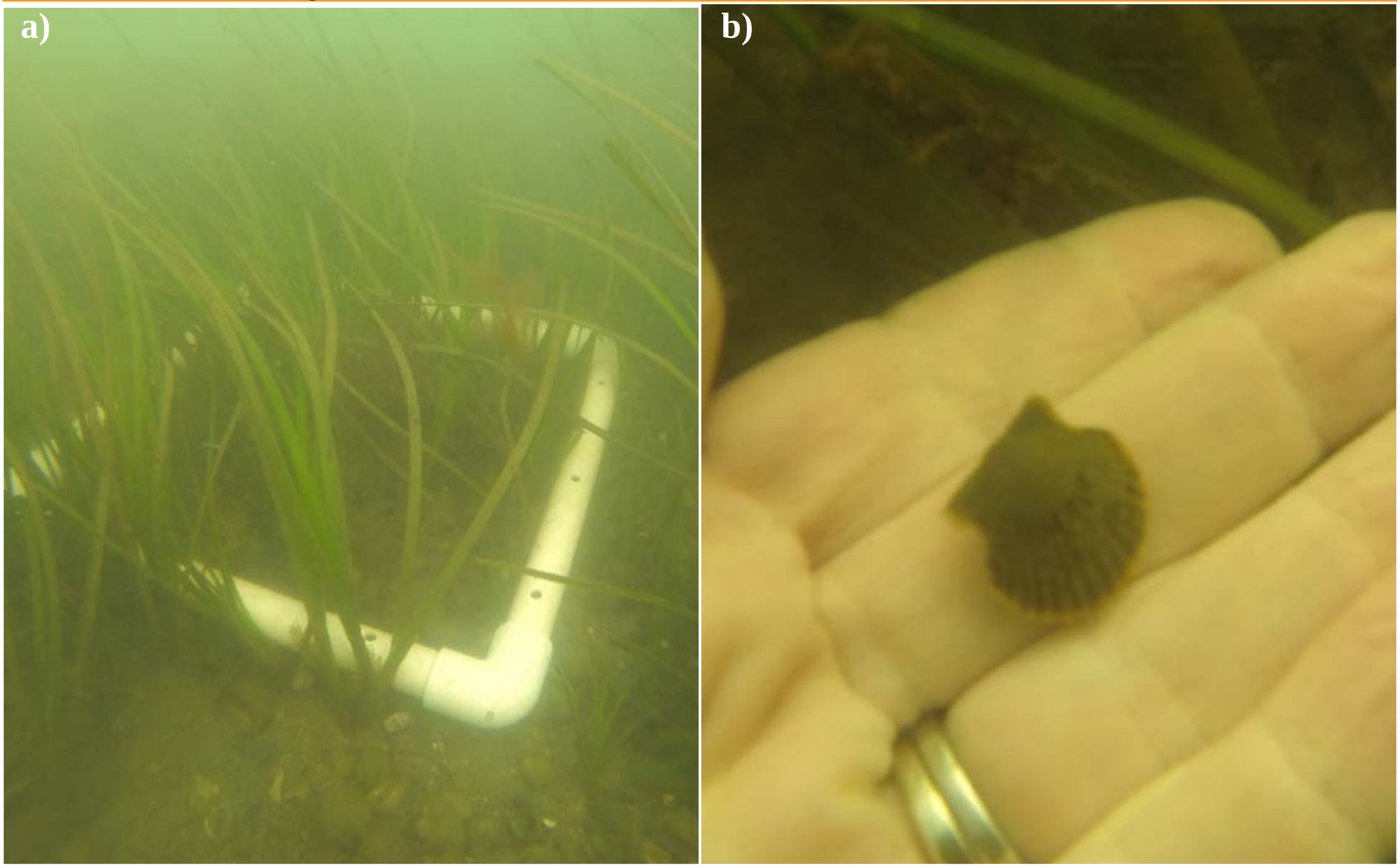


Figure GB-5. Underwater photographs taken by CCE divers while conducting the 2017 eelgrass monitoring at the Gardiners Bay LTEMP site. a) A quadrat placed within the meadow at station 8 for eelgrass shoot counts and macoralgae cover estimate. b) A ‘bug’ bay scallop found attached to an eelgrass blade within one of the sampling quadrats.

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 meadow's 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 on the bottom. 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 generally not an issue in Northwest Harbor, water clarity can be very low at times. Even under the moderate winds that the Harbor experiences, a good amount of

Northwest Harbor 2017

Table NWH-1. The average annual eelgrass shoot density for Northwest Harbor from 1997 to 2017, 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
2016	0	+/- 0
2017	0	+/- 0

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

Eelgrass Shoot Density

The monitoring visit to Northwest Harbor took place on 27 September, 2017. Divers observed no evidence of eelgrass (floating shoots or exposed rhizomes) at any of the monitoring stations within Northwest Harbor (Table NWH-1 and Figure NWH-3).

Macroalgae Cover

Macroalgae cover was minimal over all stations with the overall average percent cover up slightly from 2016's low of 0.5%, to 1% in 2017. (Figure NWH-4). The macroalgae population continues to be hampered by the lack of hard substrate (i.e., rock and shell) or eelgrasss that it would anchor in, likely resulting in continued low percent cover in the future.

Conclusions

Figure NWH-2. An underwater photograph from the Northwest Harbor LTEMP site showing a lone scallop on a featureless bottom.

Northwest Harbor has not supported eelgrass since 2007 and the decision to discontinue annual monitoring of the site was agreed upon by PEP. The site has not been totally abandoned, as it will be revisited every 3-5 years to determine if any recolonization of the site by eelgrass has occurred. CCE has determined that the restoration potential of the site is low, and has no plans to include the site for future eelgrass restoration.

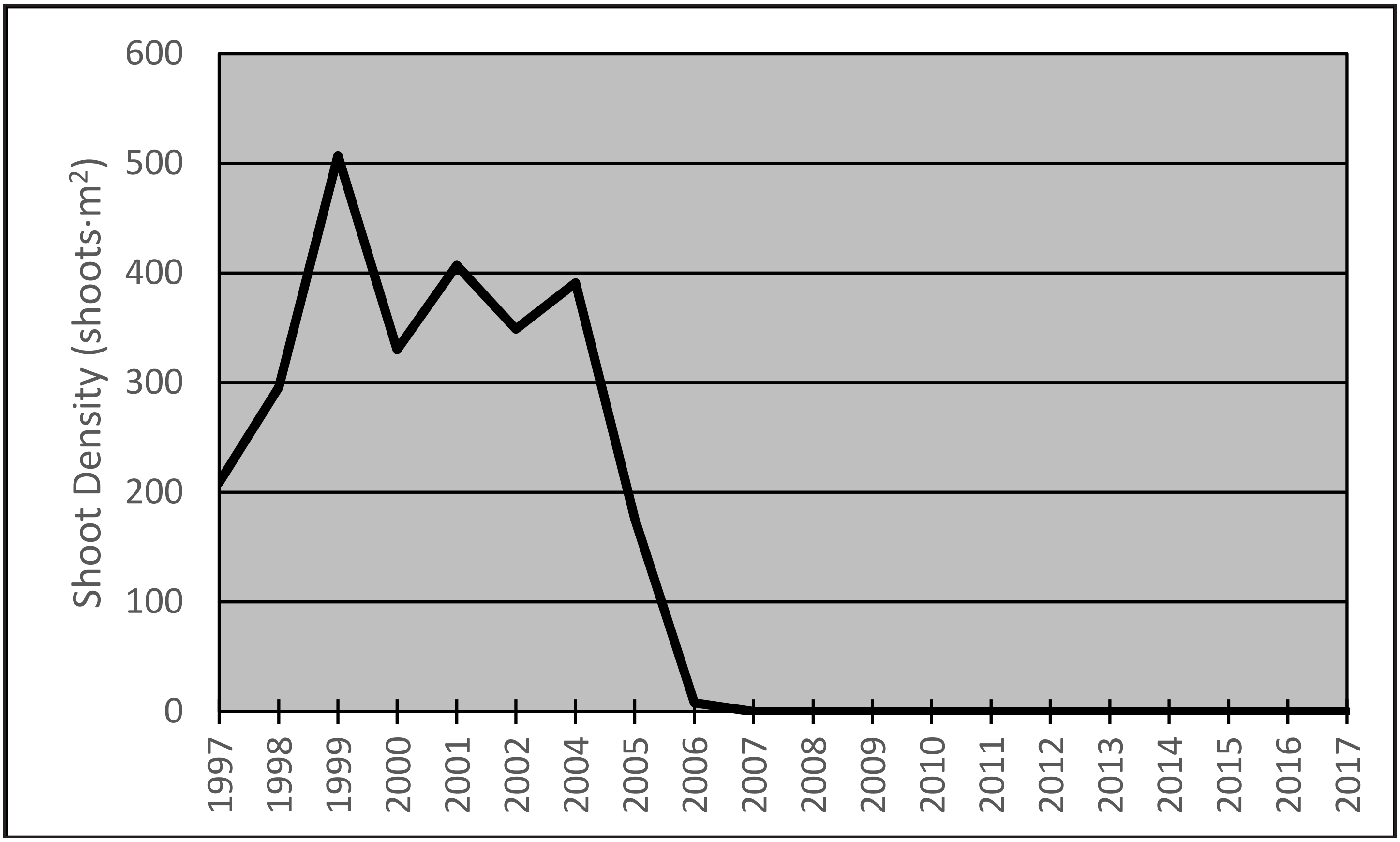


Figure NWH-3. Average annual eelgrass shoot density for Northwest Harbor, East Hampton.

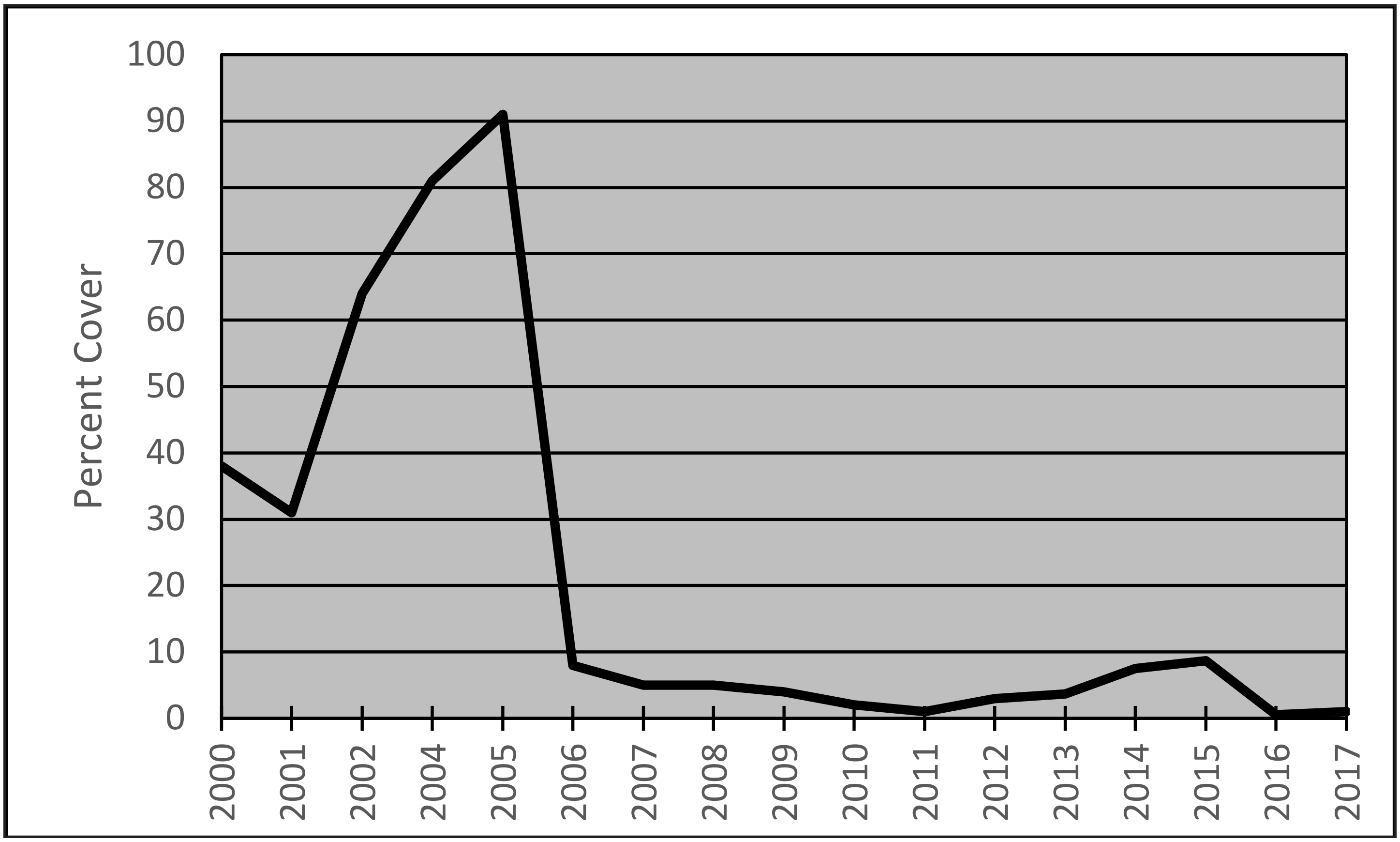


Figure NWH-4. Annual mean macroalgae cover for Northwest Harbor, East Hampton from 2000 to 2017.

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 LTEMP site, 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.

Orient Harbor 2017

A problem identified at the Seagrass Experts Meeting in 2007 was that groundwater inputs of nutrients (i.e. nitrogen) and herbicides could have a direct impact on eelgrass in some areas of the Peconic 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 study this issue throughout the Peconic Estuary, with Orient Harbor as a potential site for analysis.

In the past several years, phytoplankton blooms, *Cocchlodinium polykrikoides* (aka, rust tide), have been a common occurrence during late summer in Orient Harbor. The extent of the blooms have varied from scattered ribbon-like bands to concentrated, large patches. The impact of these blooms on a system are not fully understood, but they can influence shellfish health and could shade any plants, seagrasses or macroalgae, occurring under them.

Temperature

As in previous years, water temperature data for Orient Harbor, collected by the USGS water quality monitoring station (USGS 01304200 Orient Harbor at Orient, NY) located at the Orient Yacht Club pier, was summarized for 2017 and presented in Table OH-1 below. Data from the station was downloaded and average monthly temperatures were calculated and presented in Table OH-1. The August and September 2017 data sets were missing days, so the averages presented in Table OH-1 are not complete. Based on the available data, the number of days with water temperatures greater than 25°C were tallied (Table OH-1). Orient Harbor experienced only one day of water temperatures greater than 25°C in 2017, down from the 14 days in 2016. As 2017 was one of the hottest years on record, it is likely that the missing water temperature data for August and September would have yielded at least the same number of days above 25°C as 2016.

Table OH-1. The monthly average water temperatures take by the USGS water quality buoy stationed in Orient Harbor for June-September 2017. Also noted is the total days that daily average water temperatures met or exceeded 25°C.

Month	**Ave. Water Temperature (°C)**	**Days ≥ 25°C**
June	19.6	0
July	23.3	1
August*	24.1	0
September*	21.9	0

**Incomplete monthly dataset*

Table OH-2. The average annual eelgrass shoot density for Orient Harbor from 1997 to 2017, 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
2016	0	+/- 0
2017	0	+/- 0

Eelgrass Shoot Density

Eelgrass monitoring occurred at Orient Harbor on October 3, 2017. No eelgrass was observed at any of the monitoring stations within the Harbor at that time. Traversing the harbor between stations provided no-evidence, such as floating shoots, to suggest of extant eelgrass in the area.

Macroalgae Cover

The macroalgae cover in Orient Harbor continues to be highly variable (Figure OH-3). The average percent cover of macroalgae across the site was found to

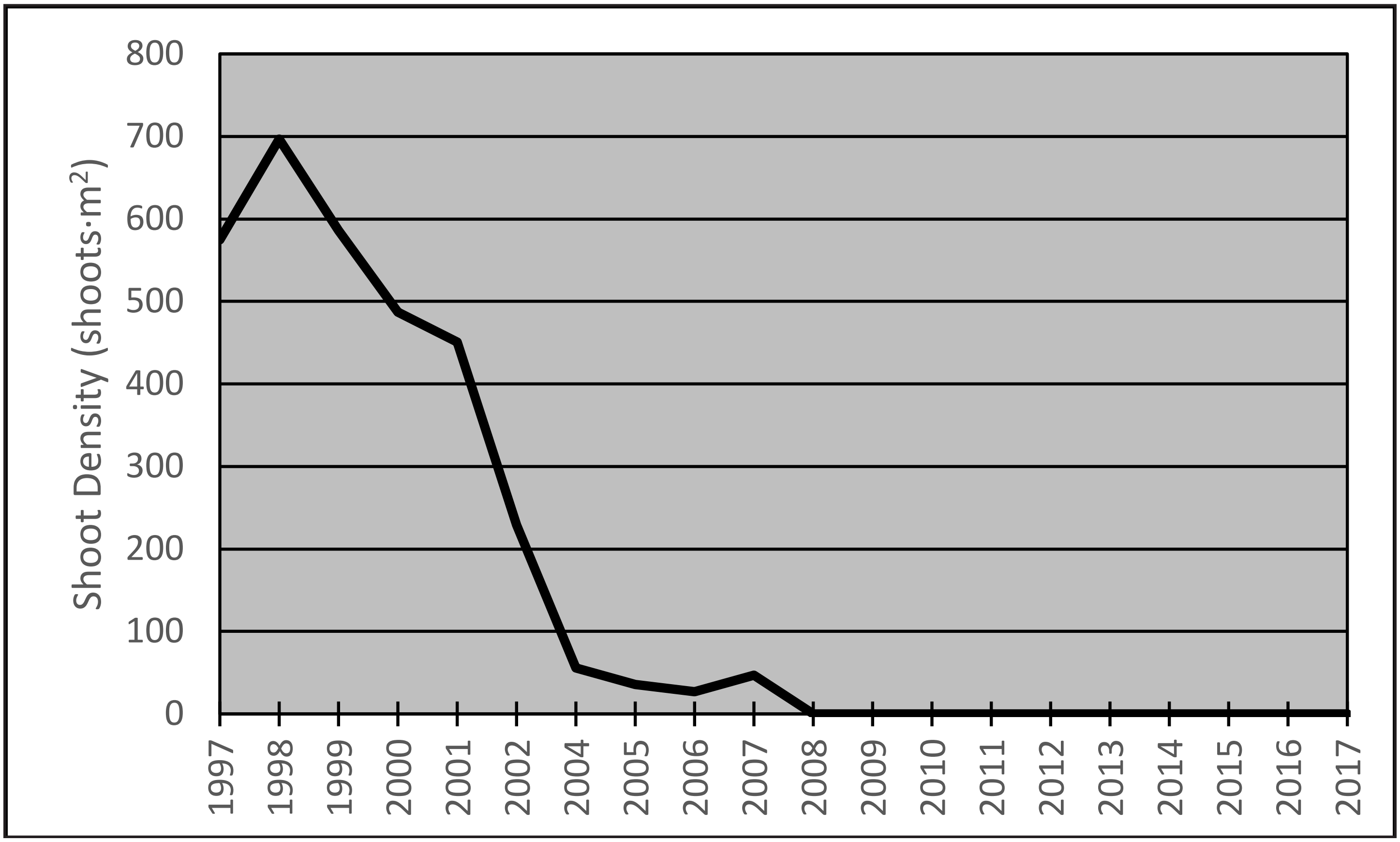


Figure OH-2. Average annual eelgrass shoot density for Orient Harbor, Southold (1997-2017).

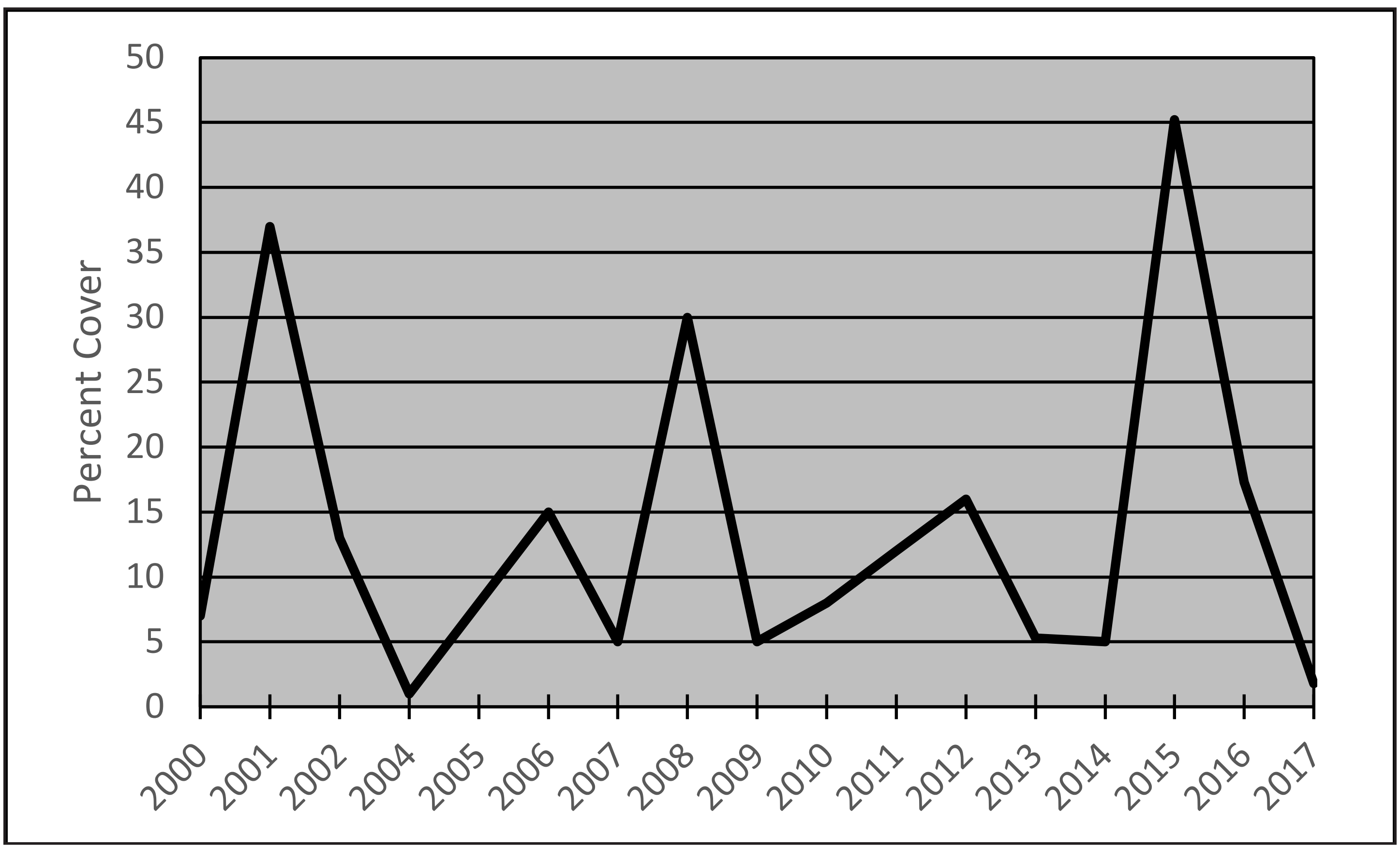


Figure OH-3. Annual mean macroalgae cover for Orient Harbor, Southold from 2000 to 2017.

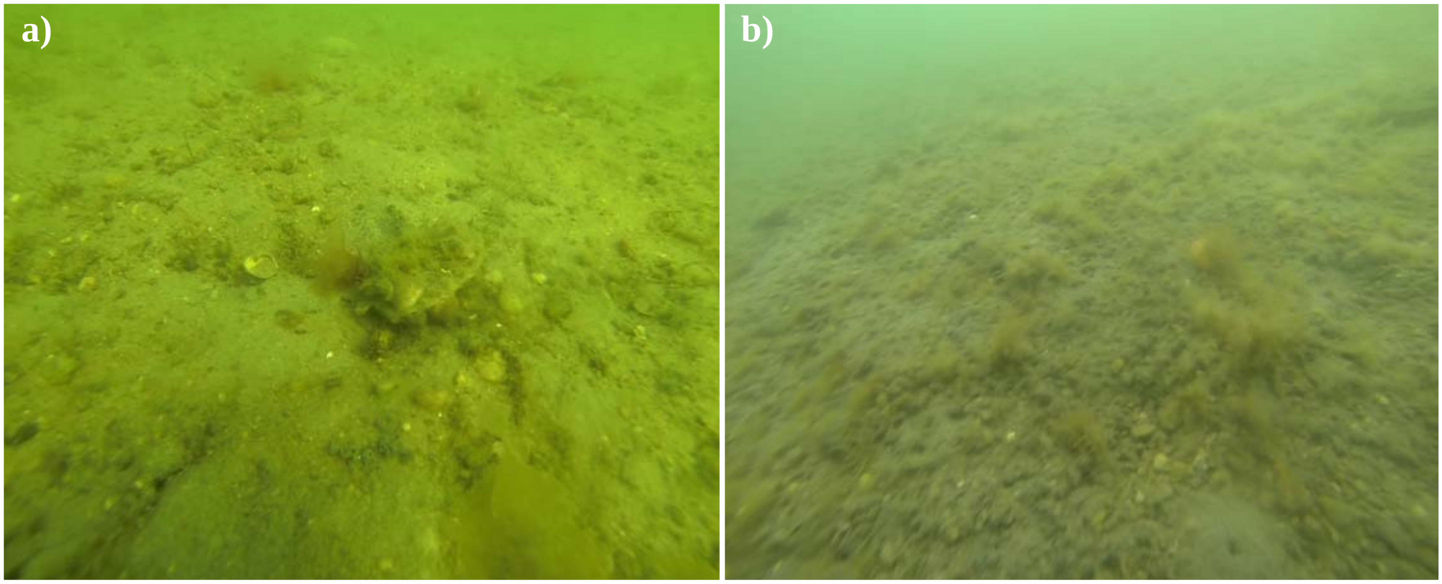


Figure OH-4. Photographs illustrating bottom conditions in Orient Harbor in 2017 at a) monitoring station 1 and b) monitoring station 5.

be 1.8% in 2017. Macroalgae diversity was relatively low, with only 5 species reportly observed from the six monitoring stations.

Conclusions

For Orient Harbor, the 2017 monitoring season was the tenth season in which no eelgrass had been observed in the monitoring area, including floating shoots or exposed rhizomes. Based on information from the public living around the harbor, there have been no reports of eelgrass growing in Orient Harbor or the adjacent Hallock Bay for a number of years. Due to the lack of existing eelgrass within Orient Harbor, the site will be removed from the annual monitoring schedule and instead, be revisited on a 3-5 year schedule. As with Northwest Harbor, the restoration potential for Orient Harbor is not high, especially given the fact that the cause of the initial decline of the meadow is still not known. Also, while the site receives propagules (vegetative and flower shoots) as drift from the eelgrass meadow at Hay Beach, Shelter Island, but has not shown any indication of natural recruitment, it is presumed that conditions are not conducive to the establishment and growth of eelgrass in Orient Harbor at this time.

Southold Bay 2017

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 site, 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.

This 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 former meadow from Hashamomack Pond may influence the temperature experienced by this site. Warm water temperatures within the Southold Bay are thought to have contributed to the chronic stress that the eelgrass population faced, before its extinction at this site. The shallow nature of the bed also allowed for rapid warming, especially on calm, summer days.

Southold Bay 2017

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 2017.

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	10.4	-1.9	1.6	-6.4	24.3
August	10.4	-1.9	3.5	-4.5	24.3
September	9.3	-3.0	2.1	-5.9	21.6

The waters that the Southold Bay site receive from the flushing of Hashamomack Pond not only influence temperature, as noted above, but also expose the site to nutrient-laden water. Nutrient-laden water causes increased phytoplankton and macroalgae biomass, which can decrease light availability and reduce eelgrass growth.

Light Availability and Temperature

Light loggers were placed at the Southold Bay site for one week each month, July through September, 2017, and the average Hcomp and Hsat for each month's deployment are presented in Table SB-1, above. The 2017 water clarity, based on Hcomp and Hsat, was significantly lower than conditions reported for 2016, with the site experiencing a deficit of light that eelgrass, which is extinct from the site, would need to grow.

Water temperature at the Southold Bay site was not as warm as the average temperatures reported for 2016. The site only experienced 11 days with daily average water temperature greater than 25°C in 2017, compared to more than forty day above 25°C in 2016.

Eelgrass Shoot Density

As has been the case since 2006 (Table SB-2, Figure SB-2), no eelgrass, or evidence of eelgrass, was observed at the site during the 2017 field visit.

Macroalgae Cover

Macroalgae cover at the Southold Bay site remained below 10% in 2017. The 8.3% cover represents the third season of relatively low macroalgae cover at the site (Figure SB-3). As in previous years, the red, filamentous seaweed *Spyridia filamentosa* remains the most prevalent species at the site.

Conclusions

As with other monitoring sites that have experienced a prolonged absence of eelgrass, the Southold Bay site will be removed from annual monitoring, starting in 2018, and moved to a more periodic schedule. The site has long been identified as a poor site for sustaining eelgrass due to high summer water temperatures and poor water clarity. The site's inclusion in the monitoring program was, in part, due to its perceived status, at the time, as an eelgrass meadow in decline. The site holds no potential for eelgrass restoration due to the perennial, poor water quality conditions.

Table SB-2. The average annual eelgrass shoot density for Southold Bay from 1997 to 2017, 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
2016	0	+/- 0
2017	0	+/- 0

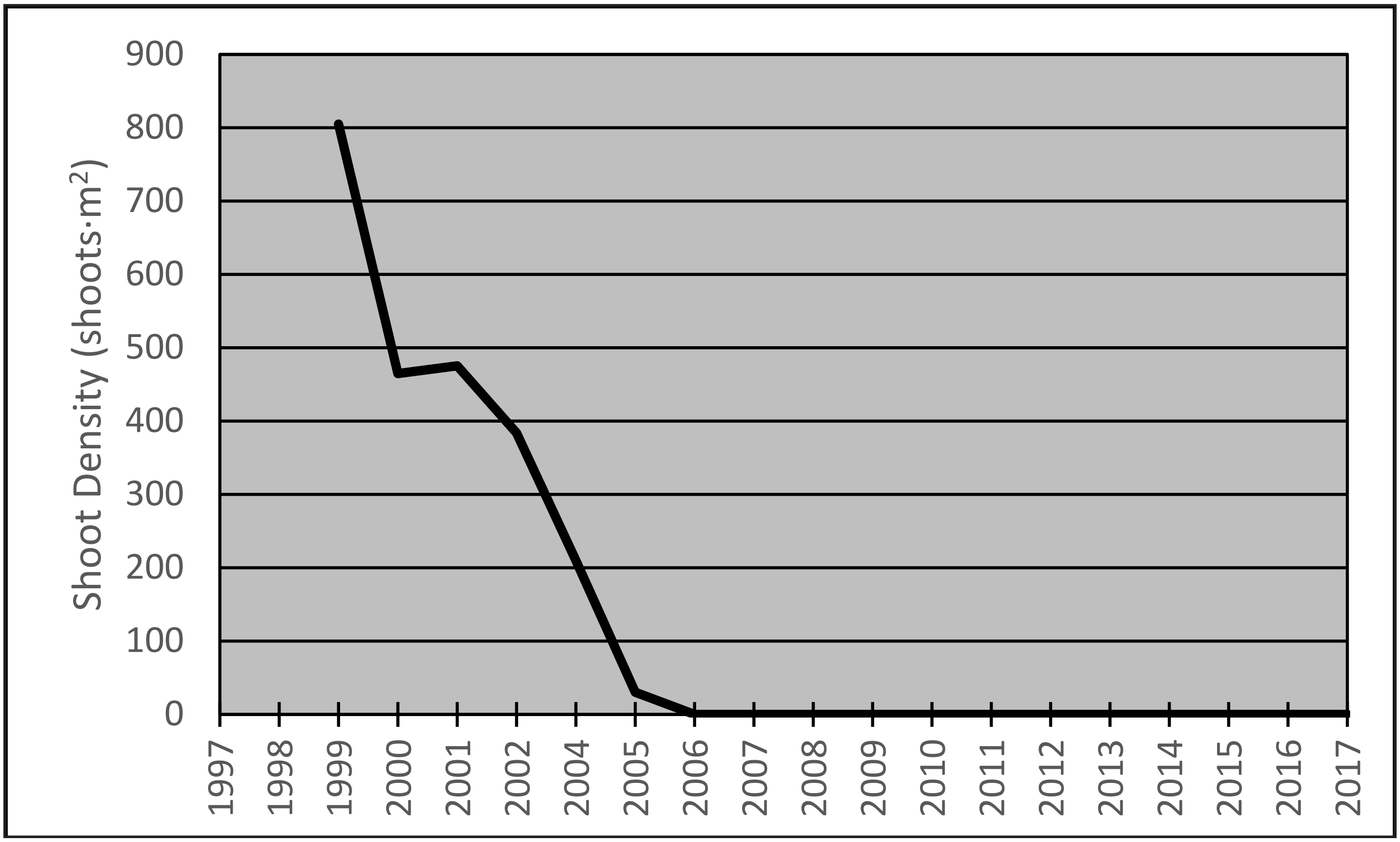


Figure SB-2. Average annual eelgrass shoot density for Southold Bay, Southold (1997-2017).

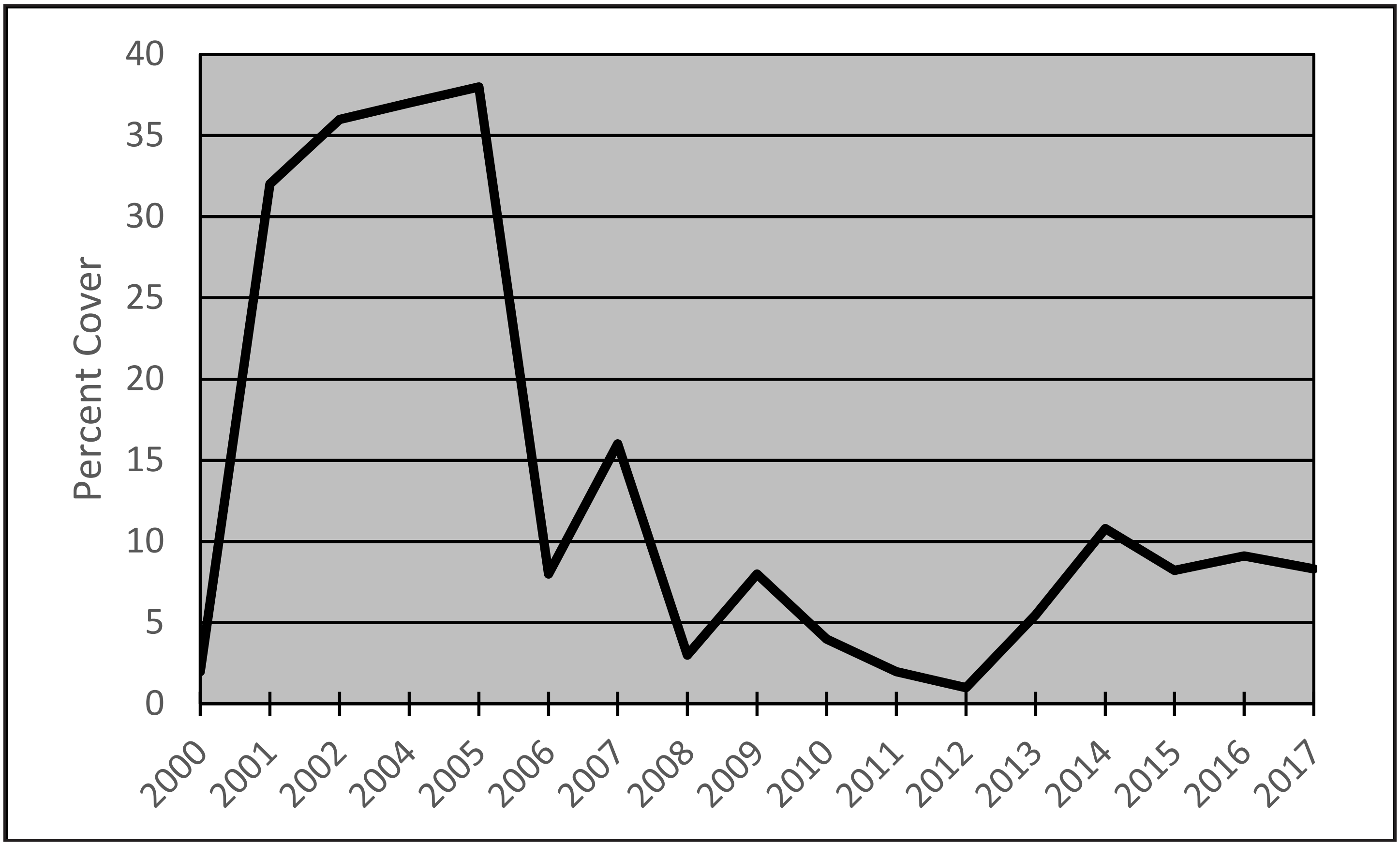


Figure SB-3. Annual mean macroalgae cover for Southold Bay from 2000 to 2017.

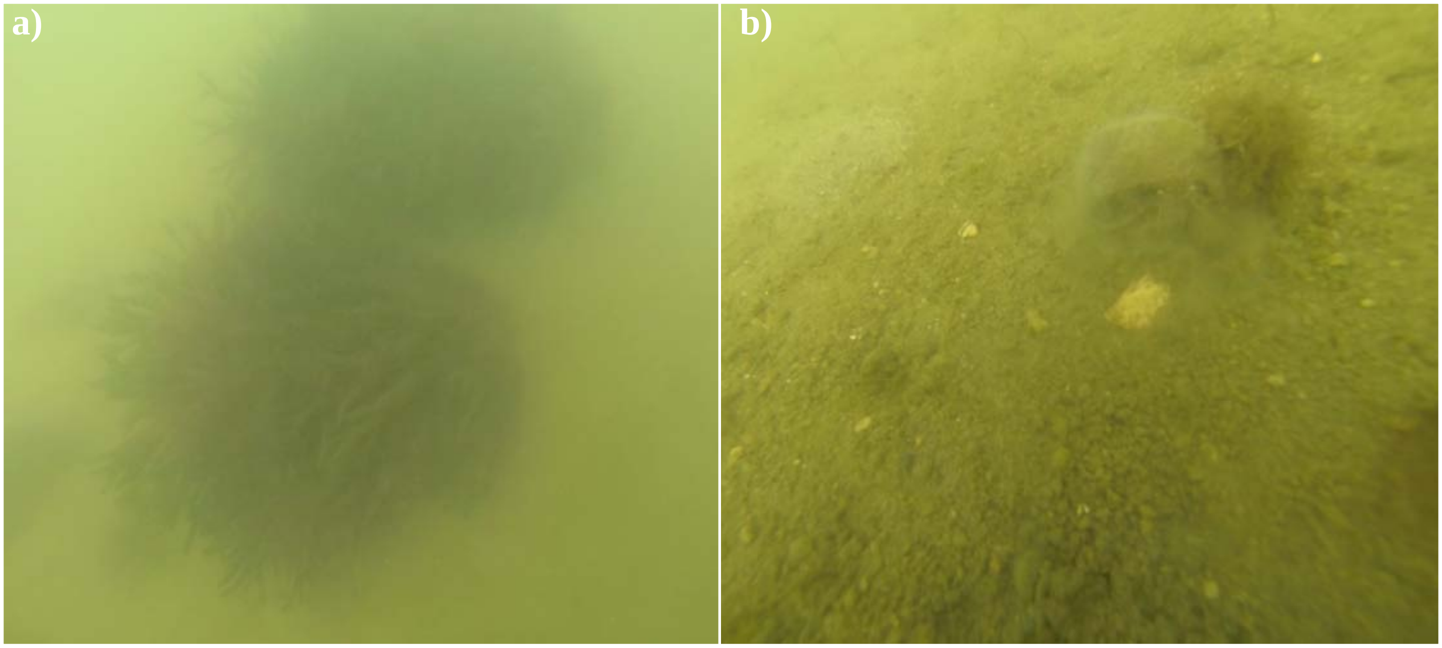


Figure SB-4. Photographs taken during the 2017 LTEMP monitoring of Southold Bay. a) Two of the several, scattered boulders covered in *Codium* are partially obscured by the poor water clarity on the eastern end of the site near station1. b) A flat-clawed hermit crab foraging for food at the Southold Bay LTEMP site.

Three Mile Harbor is situated inside a large, protected harbor, eelgrass once thrived throughout this system. The original 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, three extant eelgrass meadows near the headwaters of Three Mile Harbor 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.The deployment of temperature and light loggers to this meadow were continued in 2016, as was the quadrat survey.

Figure TMH-1. An aerial view of the original 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 2017

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 2017.

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					
July	13.1	0.8	7.9	-0.1	23.6
August	ND	ND	ND	ND	23.7
September	10.9	-1.4	5.6	-2.4	21.4
Three Mile Harbor New Meadow					
July	13.4	1.1	9.6	1.6	24.0
August	ND	ND	ND	ND	24.0
September	11.1	-1.2	5.7	-2.3	21.5

Site Characteristics

The original LTEMP 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 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.

Sediment samples for the 'new' meadow were collected in 2017. The sediment grain size analysis found that the site's sediment was composed of 0.1% gravel, 73.7% sand, and 26.2% silt+clay. The sediment organic content was found to be 6.1%, within published tolerance for eelgrass.

Light Availability and Temperature

Light and temperature loggers were deployed to both the original Three Mile Harbor LTEMP site and the "new" Three Mile Harbor site near the head of the harbor. The Odyssey PAR loggers were deployed for 10 days during July, August, and September, 2017 (Table TMH-1). The two sites showed similar results in Hcomp and Hsat for the season's deployments. Both sites experienced light levels that exceeded minimum requirements for Hcomp and Hsat for July and August. September light data reported a deficit at the LTEMP site, with no data collected at the "new" meadow due to a failure of the logger to collect data. With the light data from both sites trending so closely, it is likely that the "new" meadow did not meet the minimums for Hcomp or Hsat for the month of September.

Water temperature loggers were deployed to both the LTEMP and "new" sites in early June, 2017. Water temperatures did not differ significantly between the two sites, with monthly averages separated by only a few tenths of a degree (Table TMH-1). The "new" site recorded a higher maximum daily temperature of

Table TMH-2. The average annual eelgrass shoot density for Three Mile Harbor (original site) from 1997 to 2017, 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
2016	0	+/- 0
2017	0	+/- 0

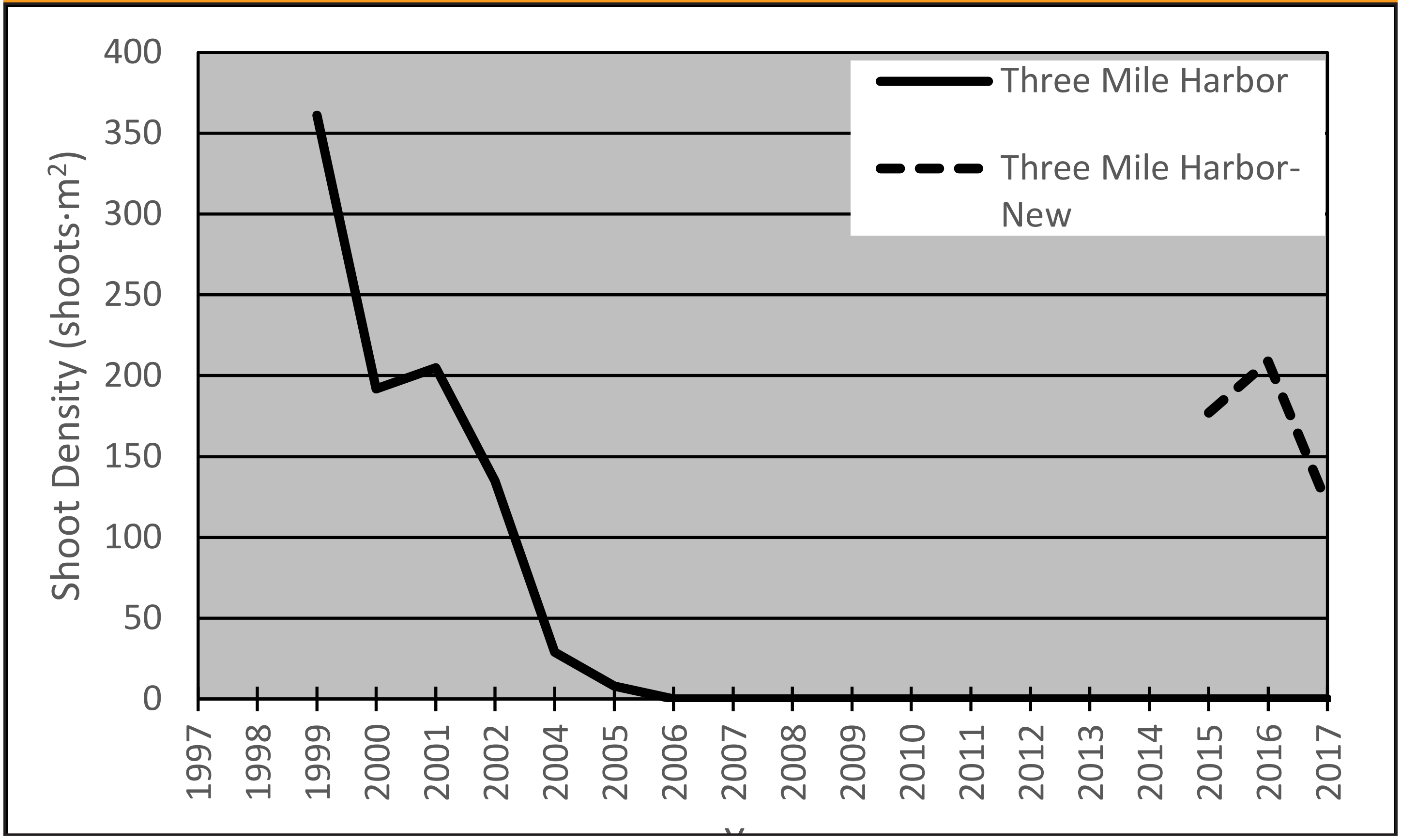


Figure TMH-3. Average annual eelgrass shoot density for Three Mile Harbor, East Hampton.

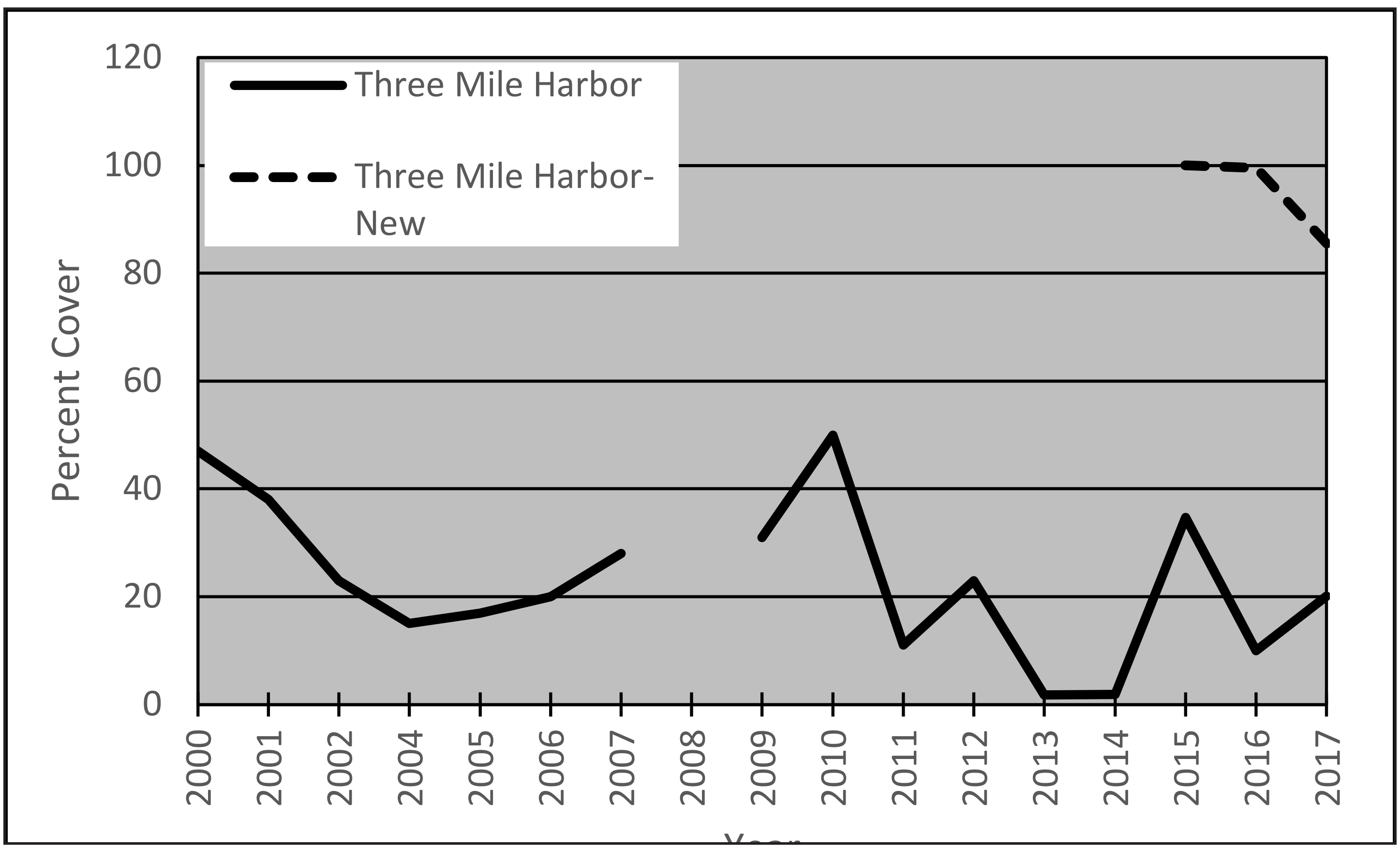


Figure TMH-4. Annual mean macroalgae cover for Three Mile Harbor from 2000 to 2017.

Figure TMH-5. Aerial views of the eelgrass meadow (new Three Mile Harbor) at the head of Three Mile Harbor presenting the a) 2016 and b) 2017 meadow delineations.

28.5°C, with the LTEMP site almost a degree lower at 27.8°C. The "new" site also experienced more days with temperatures ≥25°C, with a total of 39. The LTEMP spent 35 days above 25°C.

Eelgrass Shoot Density

Three Mile Harbor was visited on 4 September, 2017 for its annual monitoring visit, with both the original LTEMP site and "new" meadow surveyed. The LTEMP site had no observable eelgrass for the eleventh season (Table TMH-2; Figure TMH-3). The "new" site reported an average eelgrass shoot density of 120 shoots·m^2, a decline from both the 2015 and 2016 densities of 177 and 209 shoots·m^2, respectively (Figure TMH-3, Tabe TMH-3). The eelgrass meadow around each of the two monitoring stations were much patchier than the previous two seasons, which could be attributed to the very high cover of macroalgae that blankets this meadow.

Table TMH-3. The average annual eelgrass shoot density for Three Mile Harbor (new site) from 2015 to 2017, including standard error.

Year	Mean Density	S.E.
2015	177	+/- 17
2016	209	+/- 20
2017	120	+/- 17

Macroalgae Cover

Macroalgae cover at the original LTEMP site doubled in 2017 compared with 2016, but still remained relatively low (Figure TMH-4). Percent cover was reported to be 20% and composed of primarily the green, non-native *Codium fragile* and the red, filamentous S*pyridia filamentosa*, with no subordinate species identified.

The new Three Mile Harbor site recorded a decline from previous years, down from 100% cover (2015) and 99.5% cover (2016), but still supported a significantly high population of macroalgae at 85.5% cover, compared to other meadows. The macroalgae community was dominated by *Spyridia filamentosa* with only two secondary species, *Gracilaria* and *Polysiphonia*. Mats of *Spyridia* covered the eelgrass canopy over most of the monitoring area, and intact dead/decay-

Figure TMH-6.

ing eelgrass shoots were observed under matted areas, suggesting that, at least in these patches, the macroalgae likely 'smothered' the eelgrass.

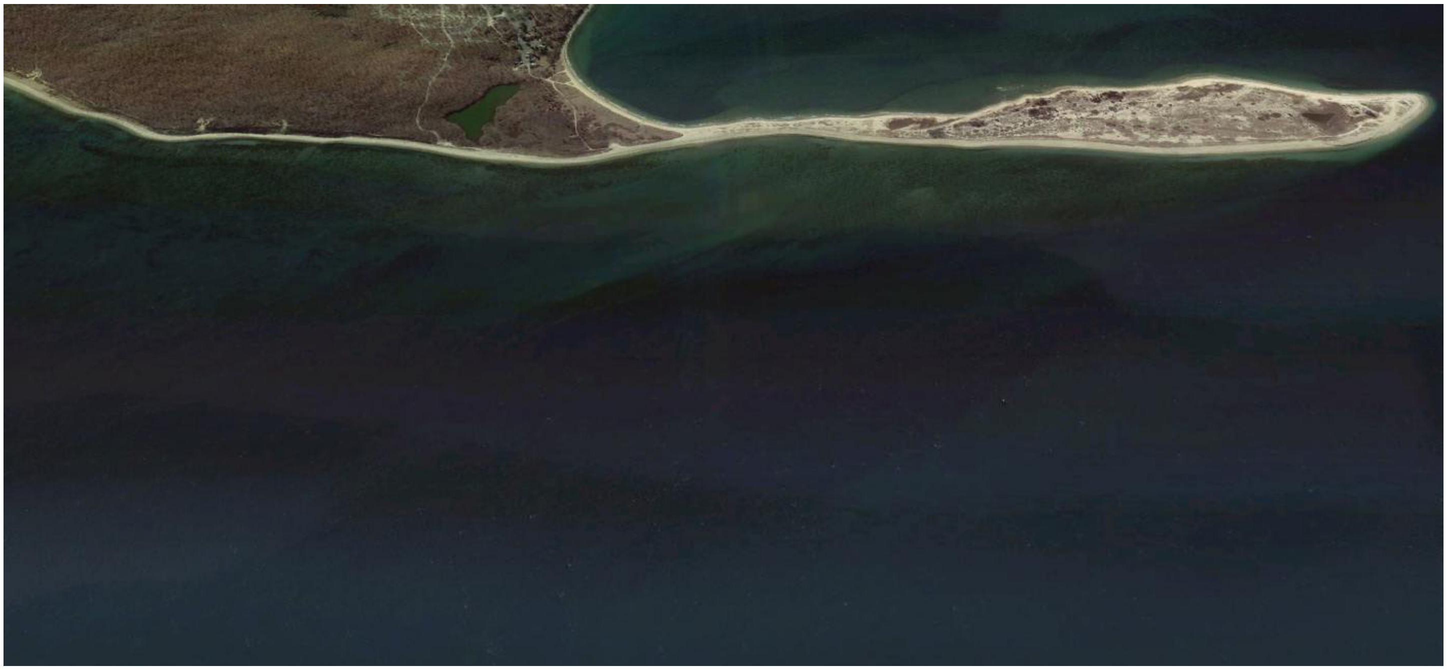
Bed Delineation and Areal Extent

The eelgrass meadow for the new Three Mile Harbor site was delineated using Google™ Earth imagery taken on 1 October 2017. The meadow delineation found a slight increase in meadow size from 2016, from 0.68 acres to 0.81 acres in 2017. The increase in size may be attributed to the higher quality 2017 images allowing for the more accurate identification of eelgrass growing on the deep edge of the meadow. Also, divers had observed sparse patches of eelgrass growing inshore of the main meadow. These patches normally would not present a strong enough signature, by themselves, to pick up in the aerial imagery, however, entangled macroalgae produced a dense signature that could be mapped, increasing the meadow area identified. The comparison between 2016 and 2017 meadow areas is presented in Figure TMH-5.

Conclusions

The 2017 monitoring season was the last that the original Three Mile Harbor site will be monitored on an annual basis for the LTEMP. Instead, it will be revisited on a 3-5 year schedule to identify any significant changes, specifically eelgrass recolonization, at the site. During the 2017 visit, no eelgrass was observed at the site, the eleventh year with no reported eelgrass. The macroalgae community doubled its percent cover over the 2016 season, but, as the macroalgae cover has been highly variable over the eighteen years the site was included in the monitoring program. The light and temperature data for 2017 are similar to previous years and suggest conditions that are less than optimal for eelgrass growth (low light and extended, high temperatures). Based on dataset for the site, and its relatively isolated location from other eelgrass meadows, it is unlikely that this site will support eelgrass in the future.

The 'new' Three Mile Harbor site represents the last extant eelgrass meadow in the harbor. Conditions are similar to the original LTEMP site in terms of recorded light availability and water temperature, yet this eelgrass population has persisted where the originally-monitored meadow has gone extinct. The new eelgrass meadow is not immune to loss though, with eelgrass no longer growing in two areas that were originally identified in the 2014 PEP Eelgrass Survey (Figure TMH-2). The 2017 season also reported a decline in eelgrass shoot density at the two stations monitored at the site. The decline could be attributed to the very high, almost complete, macroalgae cover at the site, possible delayed response to changes in environmental conditions, or it could simply be part of the natural cycle of this eelgrass meadow. With only three years of monitoring data, it is difficultt to determine the cause(s) and the potential direction that they will take this meadow. Continued monitoring will help to elucidate the trends at this site, identify factors impacting the health of this isolated meadow, and potentially address these factors, protecting the population. Additionally, other water quality projects, ongoing or planned, for the head of Three Mile Harbor may provide a better understanding of how the eel-grass meadow has survived and what future trends we may expect to see.



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 sites 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.

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 June-October, annually, and that data is presented below.

Sediment analysis of the site conducted in 2017, characterized the Cedar Point eelgrass meadow. Sediment samples were collected within the meadow at each of the monitoring stations, and the average grain size and organic content were found to be: 26.1% gravel, 71.0% sand, and 2.9% silt+clay. The organic content of the sediment at the site was very low, 0.44%. The coarse sediment grain size and low organic content are consistent with a site that experiences high wave energy and has a significant current.

Light Availability and Temperature

Light loggers were deployed for ten days, monthly, from July-September 2017. Water clarity/light avail-

Cedar Point 2017

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 2017. The temperature logger was lost between the July light logger deployment and the August light logger deployment

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	12.0	-0.3	7.8	-0.2	22.3
August	11.1	-1.2	6.4	-1.6	22.7
September	11.0	-1.3	7.6	-0.4	21.0

ability recorded deficits in both Hcomp and Hsat for each of the monthly deployments in 2017. This data contrasts with previous years where light conditions met or exceeded required levels for July and August, before seasonal declines start in September.

A water temperature logger was deployed to the site in early June 2017. Water temperatures were cooler than those recorded in 2016. The average monthly temperatures presented in Table CP-1 show that the site was remained well below 25°C for the period of July-September. The temperature data showed no days where the average daily temperature exceeded 25°C, compared with 2 days for 2015 and 1 day in 2016. The maximum recorded water temperature for 2017 at Cedar Point was 25.04°C, recorded in late July 2017. Overall, water temperatures stayed within the optimum range for the Cedar Point eelgrass meadow for 2017.

Eelgrass Shoot Density

The 2017 eelgrass monitoring had been delayed due to boat breakdown, resulting in the monitoring of Cedar Point taking place on 25 September, 2017. Average eelgrass shoot density for 2017 was reported as 341 shoots·m^2 (Table CP-2; Figure CP-2). Although this represents a decline from the 2016 densities (36 shoots·m^2), this was not found to represent a statistically significant change in densities at the site. Another change between 2016 and 2017 was the recruitment of eelgrass back into monitoring Station 6 in 2017. This station had no recorded eelgrass in 2016, but averaged 346 shoots·m^2 in 2017. The new eelgrass growth was represented by small, high-density patches, likely resulting from seed germination.

Macroalgae Cover

The 2017 monitoring season reported a significant decline in macroalgae percent cover over the site, as illustrated in Figure CP-3. The change in macroalgae cover within the Cedar Point eelgrass meadow was almost 30%, and was due to a decrease in epiphytes on the eelgrass blades and macroalgae growing within, or entangles with, the eelgrass patches throughout the meadow. Cover of *Sargassum filipendula* over open bottom showed no observable change between years,

Table CP-2. The annual average eelgrass shoot density for Cedar Point for 2008 and 2017, 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
2016	396	+/-41
2017	341	+/-41

Table CP-3. The estimated cover of the eelgrass meadow at Cedar Point for select years from 2000-2017.

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.)
2016	90.05 acres (36.44 hect.)
2017	77.1 acres (31.20 hect.)

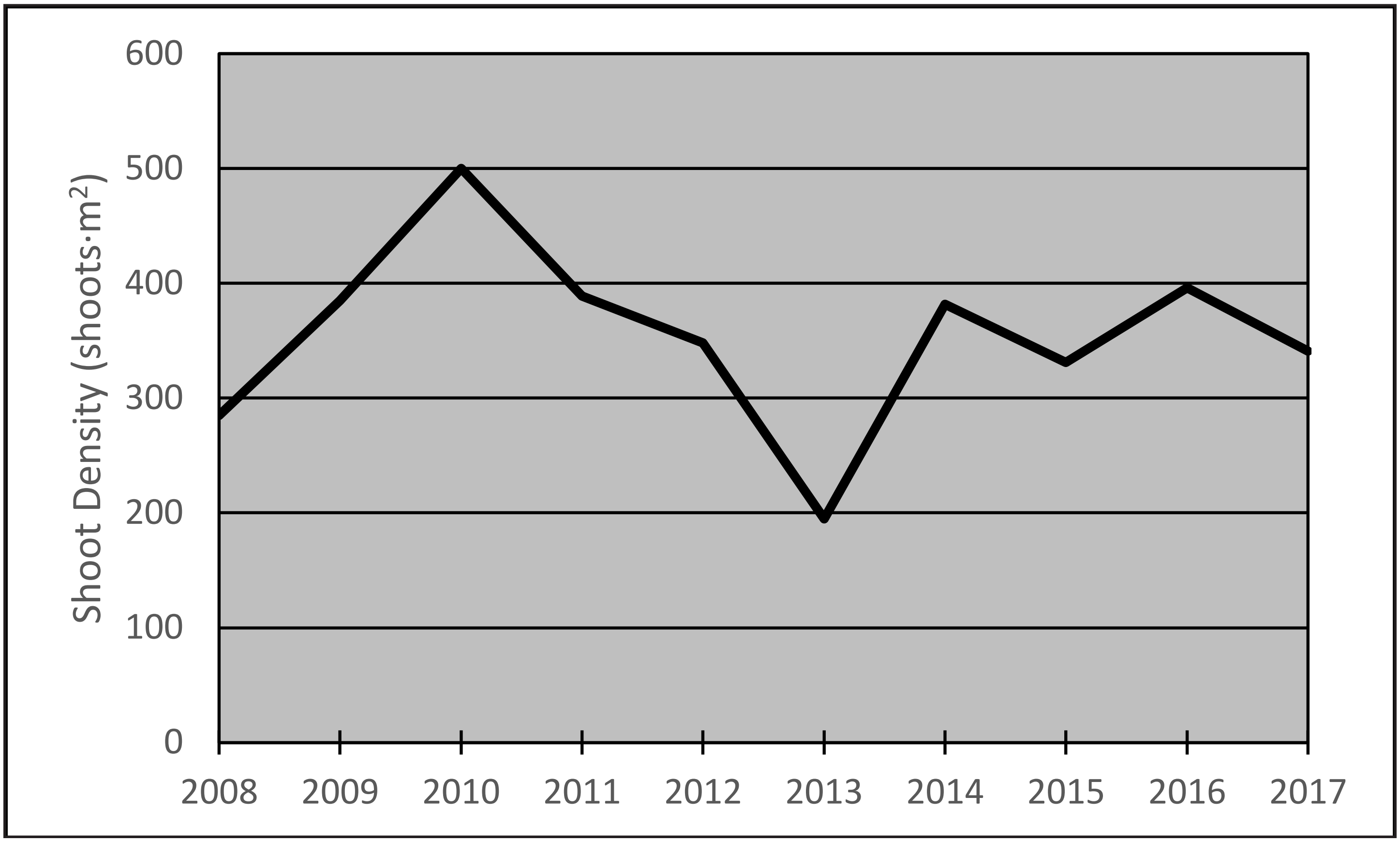


Figure CP-2. The average annual eelgrass shoot density for Cedar Point for 2008-2017.

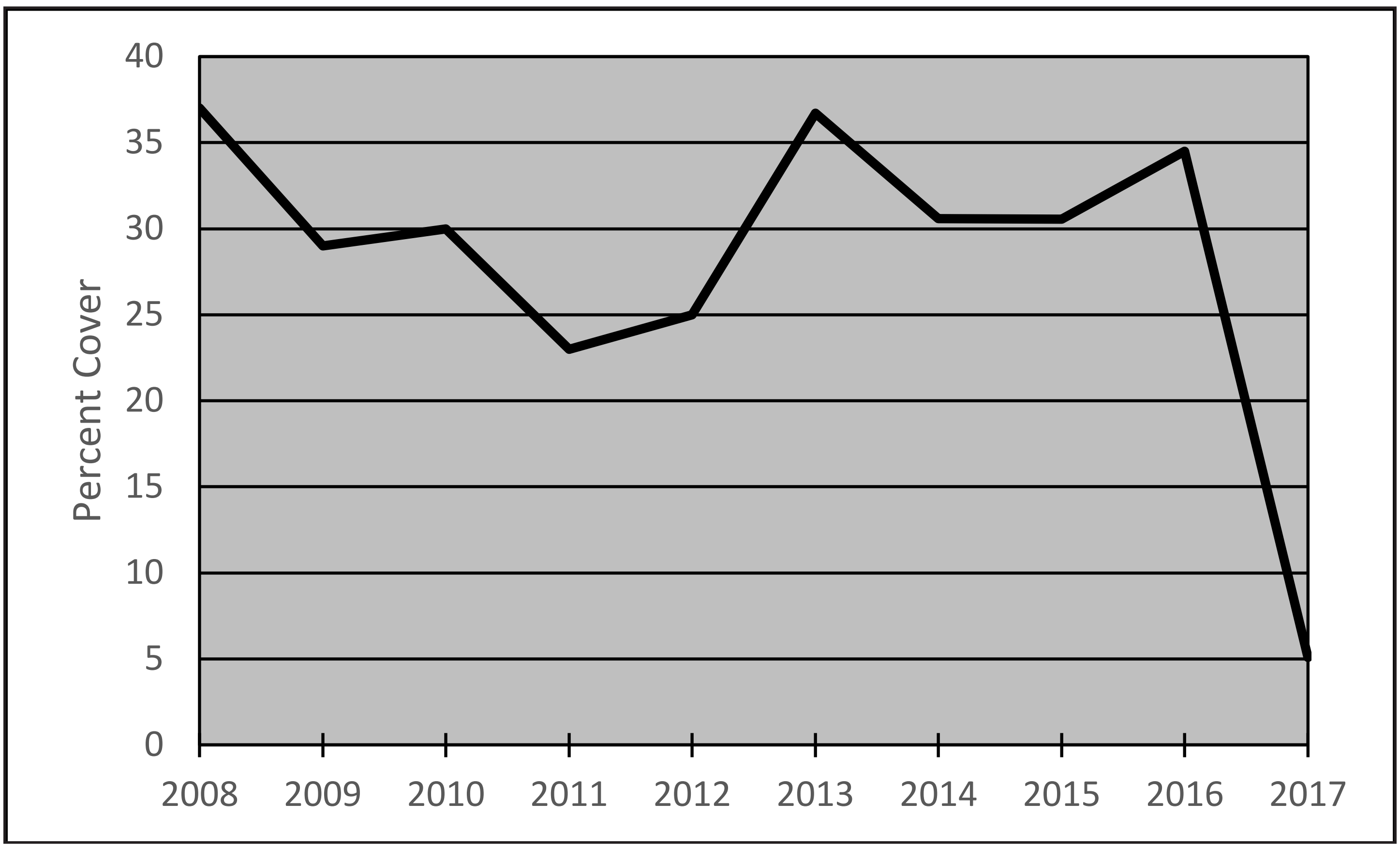


Figure CP-3 Annual mean macroalgae cover for Cedar Point, East Hampton from 2008 to 2017.

Figure CP-4. Quadrat sampling in the Cedar Point eelgrass meadow never fails to attract resident fish. a) A curious northern blowfish comes in for a closer look, while juvenile porgies circle in the background. b) One juvenile porgy proves to be braver than other members of its school.

but secondary species, like the filamentous red algae, were observably less abundant.

Bed Delineation and Areal Extent

The 2017 delineation of the Cedar Point eelgrass meadow was completed using Google Earth™ imagery taken on 1 October, 2017. The overall quality of the imagery was good and allowed for an accurate assessment of the meadow at this site. The overall acreage of the meadow experienced decline, with acreage decreasing from just over 90 acres in 2016, to 77 acres in 2017 (Table CP-3). The most notable change in the meadow from 2016 is the large, unvegetated area that has developed in the middle of the meadow (Figure CP-5) The loss of eelgrass in the center of the meadow began in 2014 and saw some recovery in 2016, but the winter of 2017 appears to have undone those gains. Since the 2012 delineations, the areal extent of the meadow has experienced minor fluctuations, but has remained relatively stable. The decline in overall area in 2017, while larger than recent changes, represents a relatively small change in the meadow, which may see recovery in 2018.

Conclusions

The 2017 LTEMP monitoring found that the Cedar Point eelgrass meadow showed minor declines in shoot density and areal extent. The macroalgae community also experienced a decline in overall percent cover at the site. While any decline in these measured parameters could indicate an issue negatively impacting the health of an eelgrass meadow, analysis of shoot density found that there was no significant change in that parameter since 2013. Similarly, areal extent has fluctuated up and down during this same period, suggesting an inter-annual trend instead of a long-term trend. The lack of significant overall changes in the meadow since Superstorm Sandy suggests that the meadow may be relatively stable, and barring another significant acute weather event, like a hurricane, may start to show a slow recovery from the damage incurred by Sandy.

The light and temperature parameters recorded for the Cedar Point eelgrass meadow for 2017 indicated that while water temperatures in 2017 remained in the optimal range for eelgrass, light availability, at least during logger deployments, was below optimal. The low light levels are likely due to the rainy summer weather Long Island experienced in 2017. According to the National Weather Service records for 2017, Long Island experienced more than 30 days with rainfall from June-September, 2017. As low recorded light levels was a common theme across all monitoring sites in 2017, weather would be the most likely factor. If eelgrass in this and other meadows were negatively impacted by light availability, the meadow's responses to the light deficit would not be evident until the following season.

Figure CP-5. Delineations of the Cedar Point eelgrass meadow from aerial photographs for a) 2004, b) 2010, c) 2014, d) 2015, e) 2016, and f) 2017(continued on next page).

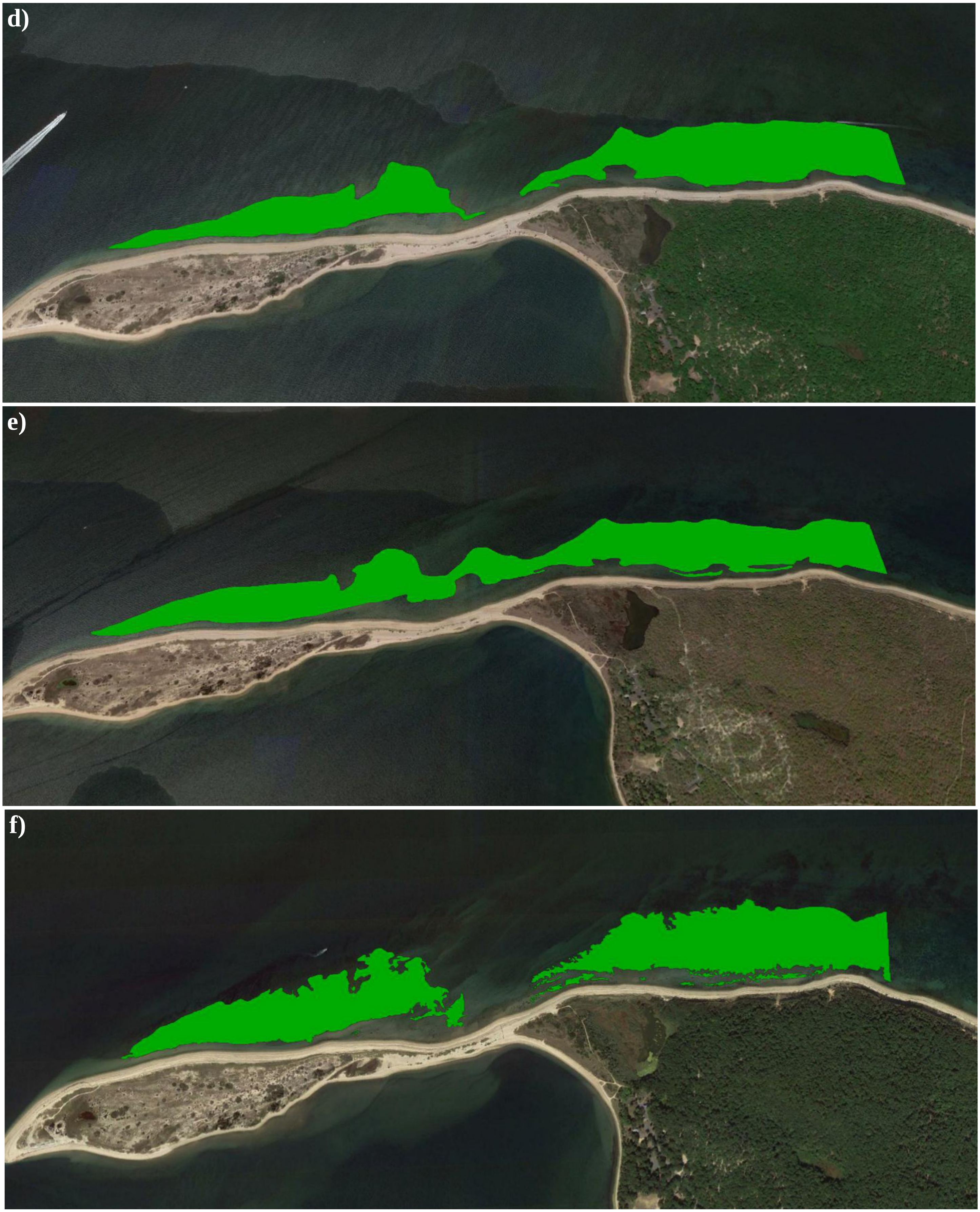


Figure CP-4. Continued.

Orient Point 2017

Orient Point is the eastern tip of the north fork of Long Island. To the south of the point is Gardiners Bay and an eelgrass meadow that was added to the Peconic Estuary Program Long-term Eelgrass Monitoring Program in 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. CCE had established a sentinel site at Orient Point to monitor the recovery of the meadow along three permanent transects, but it was 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 shows the locations of the established monitoring stations within the Orient Point eelgrass meadow.

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 sediment 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 sediment at this site was analyzed initially in 1997, when the site was considered for the monitoring program. The 1997 analysis found that the sediment

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 2017.

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	12.0	-0.3	7.8	-0.2	20.8
August	10.8	-1.5	7.0	-1.0	21.8
September	11.2	-1.1	8.1	0.1	20.5

was predominantly sand (68.5%) with a significant amount of gravel (26.7%). Organic content of the sediment was found to be relatively low at an average of 0.86%. The follow-up sediment analysis conducted in 2017 found that the site had changed minimally in the intervening years. The sediment was composed of 23.5& gravel, 73.7% sand, and 2.8% silt+clay, with an organic content of 0.63%.

Light Availability and Temperature

Light logger deployments were similar to previous years, with a logger deployed for 10-day periods, once monthly from July-September 2017. The daily average Hcomp and Hsat were calculated from this data and daily averages for each month are presented in Table OP-1. Light availability within the Orient Point site displayed a similar trend to ther monitoring sites for 2017, with Hcomp and Hsat both running deficits for the months of July and August. These two months have historically provided the Orient Point meadow a surplus of light, however, due to the excessive number of days report with rainfall by the National Weather Service, 2017 will be the first year that the Orient Point meadow experiences an overall deficit for the season.

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
2016	247	+/-27
2017	94	+/-16

As in previous years water temperature loggers were deployed in early June 2017 to the Orient Point eelgrass meadow. The summer of 2017 was very warm, but as with 2016, daily average water temperatures at Orient Point never exceeded 25°C. No water temperatures were recorded reaching 25°C during monitoring season in 2017, resulting in no thermal stress on the eelgrass population.

Eelgrass Shoot Density

The 2017 Orient Point eelgrass monitoring was conducted on 25 September, 2017. Eelgrass shoot density declined significantly from 2016, from 247 shoots·m^2 (2016) to 94 shoots·m^2 in 2017 (Table OP-2; Figure OP-2). Two of the monitoring stations (4 and 6) supported no eelgrass, while Station 1 showed obvious signs of disturbance/damage, with exposed rhizomes and low shoot densities (Figure OP-4a), versus 2016. Notably missing from the eelgrass meadow in 2017 were the high numbers of small lateral shoots that were observed and counted in 2016. Quadrat counts in 2016 frequently included densities above 500 shoots·m^2, with a high of 820 shoots·m^2; in 2017, quadrat counts only ranged on the high end into the 400's. while recorded quadrat counts exceeded 400 shoots·m^2 in 2017. There were no obvious signs of the cause(s) for the severe decline of the Orient Point meadow in 2017. Winter storm damage could be to blame, and exposed, tattered rhizomes could support that hypothesis. If the meadow took substantial damage from storms, overall shoot density would be impacted and recovery of above-ground biomass could be slowed due to the loss of energetic reserves in the meadow.

Macroalgae Cover

Macoralgae cover reported a small, insignificant decline of 4% from 2016. (Figure OP-3). Disturbance at the site from winter storms could result in an overall decline in macroalgae cover as large perennial spe-

Orient Point 2017

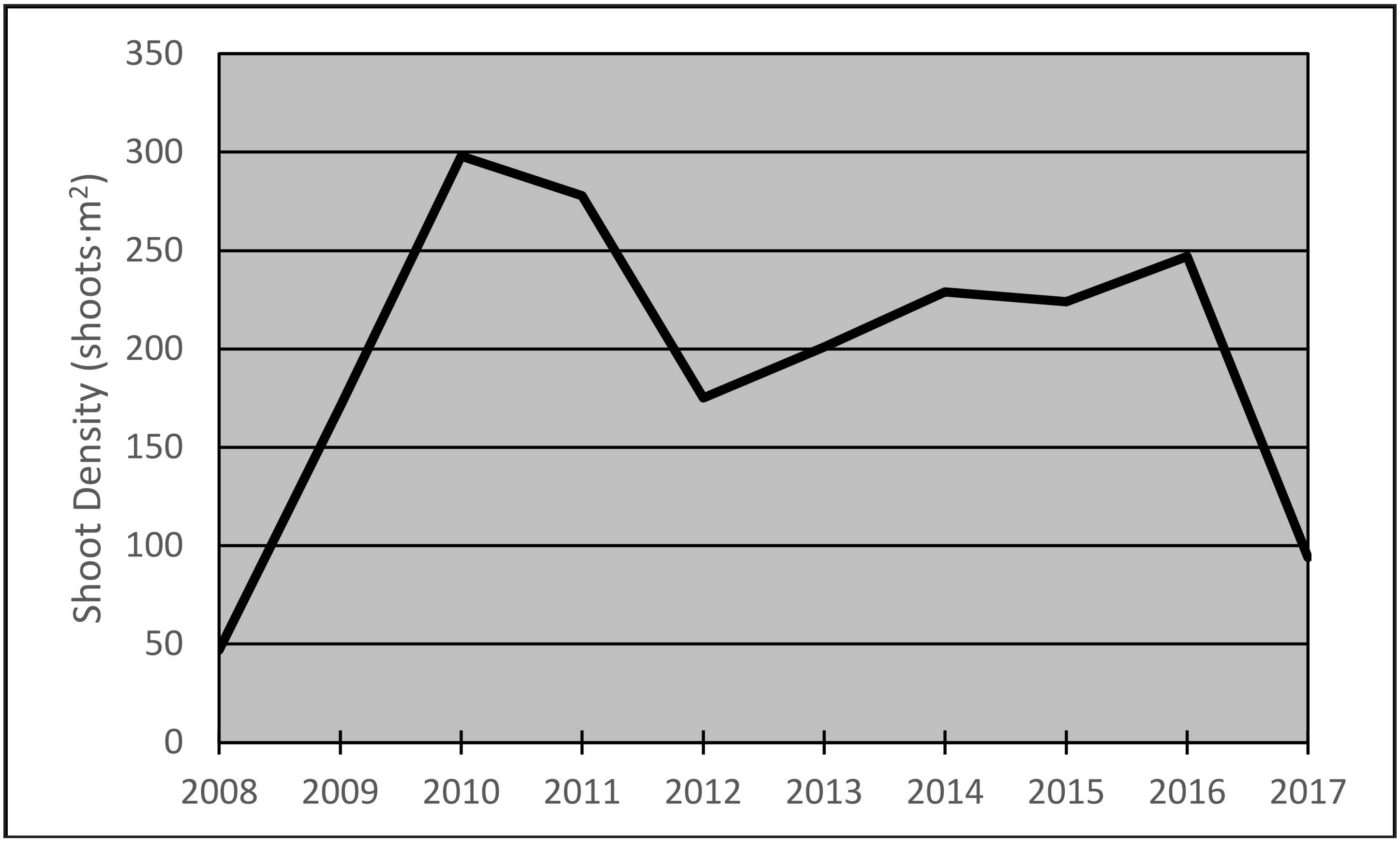


Figure OP-2. Graph of the annual mean eelgrass shoot density for Orient Point from 2008-2017.

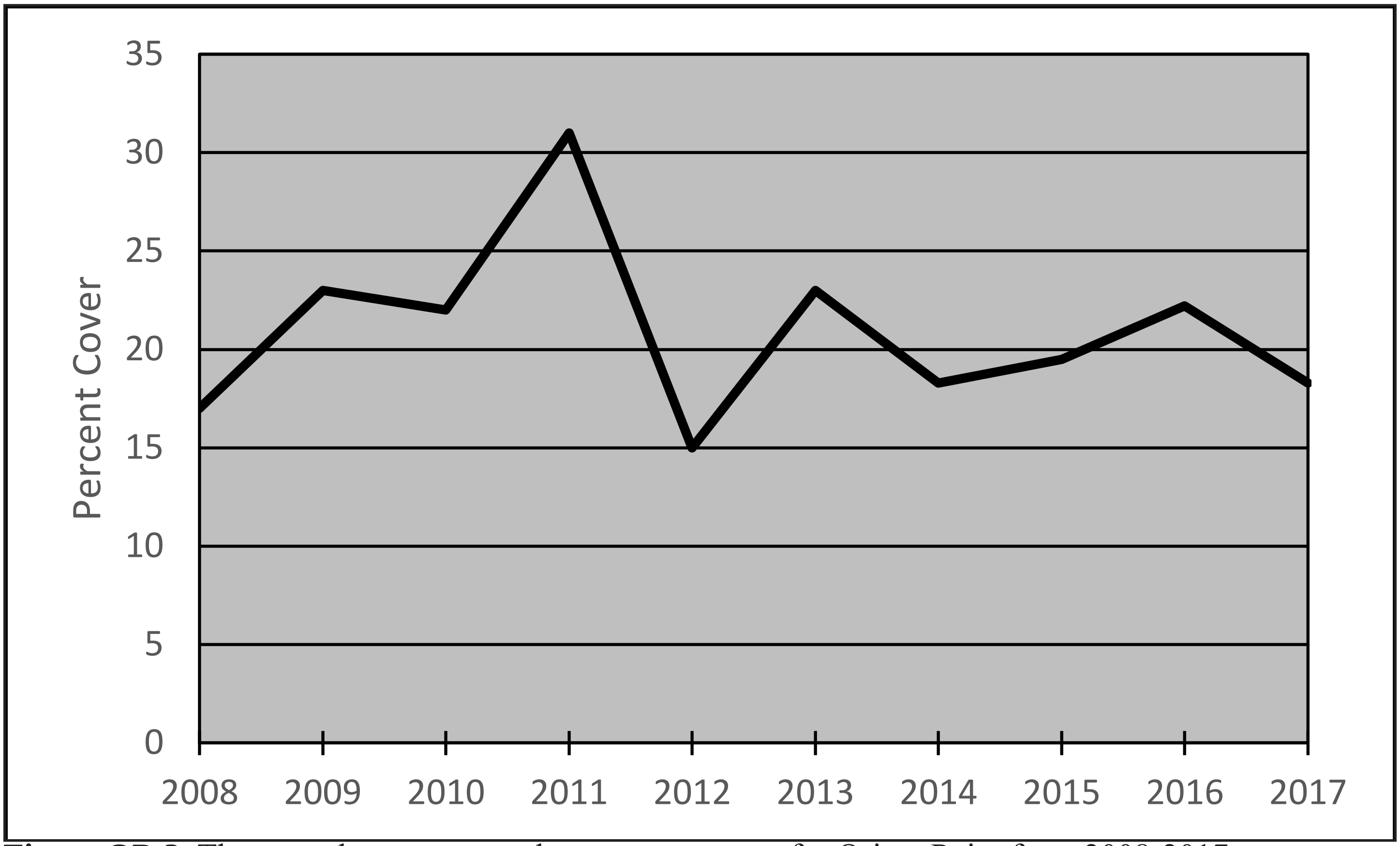


Figure OP-3. The annual mean macroalgae percent cover for Orient Point from 2008-2017.

Table OP-3. Trend analysis of the estimated area of the Orient Point meadow as determined from aerial photographs from 2000 to 2016.

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.)
2016	17.40 acres (7.04 hect.)
2017	14.70 acres (5.95 hect.)

*Area of meadow was significantly underestimated in aerial survey.

cies are removed from rocks by hydrodynamic forces or buried under shifting sediments. Percent cover of seaweeds is also influenced by declines of eelgrass density, as macroalgae recorded in the survey include drift as well as attached specimens. Less dense eelgrass meadows tend to retain less drift macroalgae. Macroalgae species diversity was down slightly in 2017, with only 13 species identifiied during the monitoring visit.The brown seaweed *Sargassum filipendula* continues to be the primary species at the site, covering the larger, hard substrate available. As in past years, secondary species included two invasive, non-native species—*Codium fragile* (green) and *Grateloupia turuturu* (red)—as well as *Chondrus crispus* (red), *Agardhiella tikvahiae* (red), and several of the filamentous reds.

Bed Delineation and Areal Extent

Based on aerial images taken in October 2017 (Google Earth™, 1 October, 2017), the Orient Point meadow lost area along its offshore edge (Figure OP-5f). The area delineated from the 2017 aerial image found the meadow to cover just under 15 acres, representing a loss of more than two acres from 2016. The loss in meadow area primarily occurred near Station 4 (Figure OP-1), where the meadow was found in the 2016 aerial image (Figure OP-5e) to 'bulge out' from the offshore edge presented along the rest of the meadow. As mentioned in previous monitoring reports, the meadow has shown of trend of moving inshore, with most of the lost area since 2008 having been along the offshore edge.

a)

b)

Figure OP-4. Underwater photographs of a) exposed rhizomes near station 1 and b) an eelgrass patch at station 5 presenting an eroded, inshore edge.

Conclusions

The 2017 monitoring season was the first time since 2009 at the Orient Point site that the overall eelgrass density dropped below 100 shoots·m^2.The monitoring data and the aerial delineations both identify losses along the offshore edge as contributing to the decline in the meadow reported in 2017, however, the factor(s) driving this loss is not clear. Water quality at the site continues to be within optimal ranges for eelgrass, barring the minor decline in light availability due to the rainy summer. Physical disturbance in the meadow seems to be increasing and is likely tied to climate change and the increased frequency of strong coastal storms. The damage observed at monitoring Station 1

Orient Point 2017

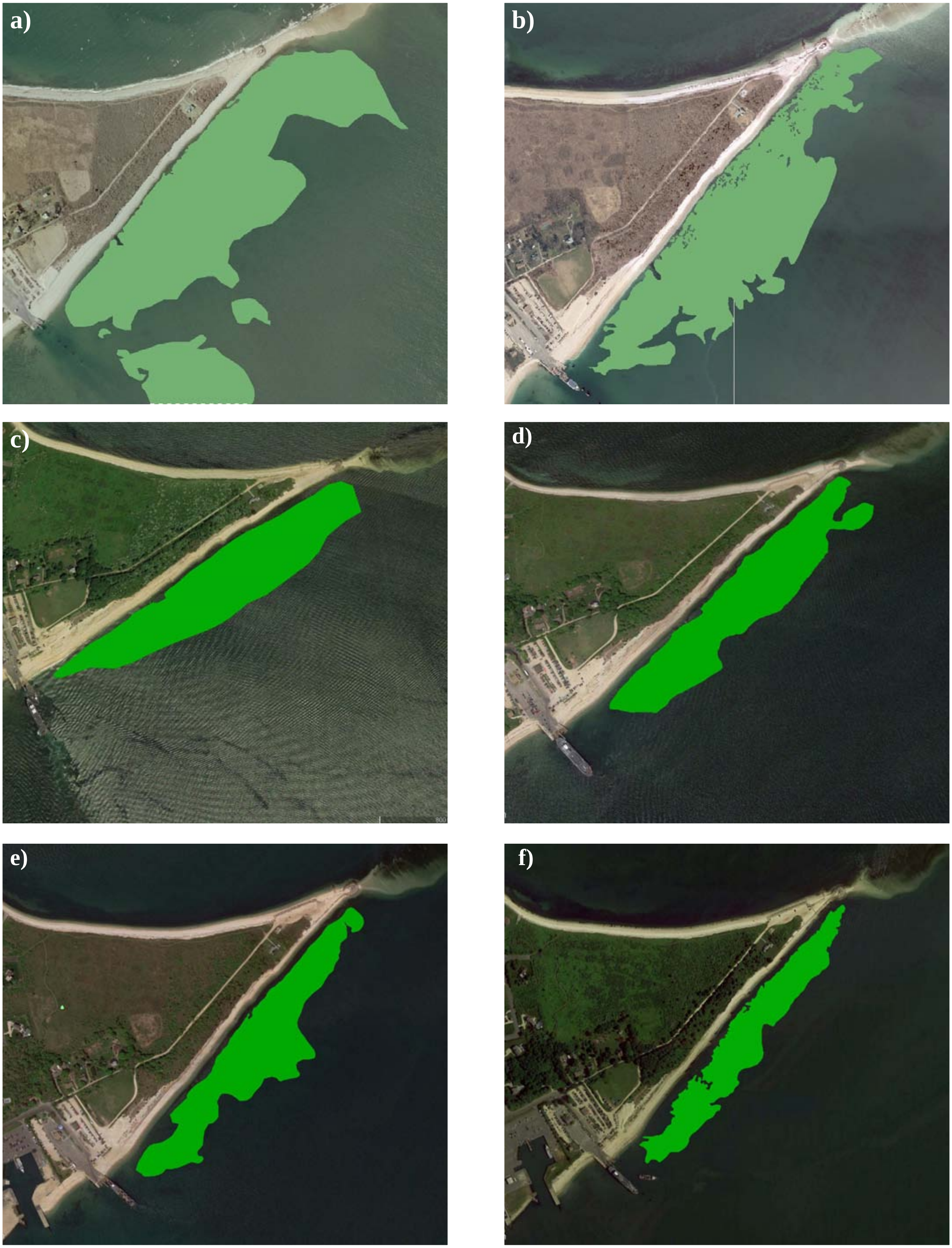


Figure OP-5. Delineations of the Orient Point, Southold, NY eelgrass meadow from aerial imagery for a) 2004, b) 2010, c) 2014, d) 2015, e) 2016, and f) 2017.

covered too large of any area to be likely be attributed to bioturbation from crabs or other animals, leaving wave damage from severe weather as the likely cause. Increased frequency and intensity of storms at the site is also supported by the observed degradation of the shoreline along the meadow. A rock seawall was installed in 2015 near the point to protect access to the Plum Island power cable crossing due to the constant loss of beach. Concrete seawalls that were placed along the upland edge of the shoreline in the 1930s-1940s, well back from mean high water, are currently within 10 feet (less in may areas) of mean high water. If these conditions represent the new normal for sites like Orient Point, then it can be expected that the eelgrass community will have to adapt to the changes in their environment.

Another consideration regarding the impacts of storm damage on the eelgrass meadow is the energetic costs of a plant to recover from damage induced by storms. The low shoot density appeared to be due to the low number of lateral shoots observed in the meadow in 2017, compared to previous years. New shoot production could be impeded by storm damage due to loss of carbohydrate reserves with rhizomes removed by the storms. The consequence of this lost energy source could have been the reduced shoot density reported for 2017. Additionally, the density of eelgrass flower shoots was observably lower in 2017 than had been noted at any other time at Orient Point. Flower shoots are initiated during the fall and develop through the winter making them susceptible to damage from winter storms. Lost or damage flower shoots are not regenerated within that same season, so seed potential is lost.

The decline in the meadow, both in shoot density and area, may be due to an exceptionally bad year, similar to the situation in 2006 that significantly impacted the meadow and lead to its inclusion in the LTEMP. The meadow has slowly recovered over the following years. The situation identified for the 2017 season may follow a similar pattern and we may expect to see recovery in the coming years.

Coecles Harbor 2017

Coecles Harbor is an enclosed embayment located on the eastern side of Shelter Island, connected to Gardiners Bay by a narrow, dredged inlet. The eelgrass meadow covers 111.5 acres (2014 PEP eelgrass survey) in the northern part of the harbor and includes two separate mooring fields within its boundaries.

Site Characteristics

The sediment characteristics determined from sampling during the 2017 season found that the Coecles Harbor meadow grows in a predominately silty-sand (28%:70%) with a relatively low organic content of 4.24%. The site is protected from wind and storms on all sides, minimizing wave impacts on the meadow. Water quality appears to be within the optimal range for eelgrass, based on the extensive meadow at the site, but observation made throughout the season suggest that water clarity can be moderate to poor during the growing season. Also, the site has had a history of *Cochlodinium polykrikoides* (rust tide) blooms in resent years. As this is a new site for the LTEMP, and CCE has minimal past experience working in this meadow, factors influencing the health and extent of this meadow will be identified in subsequent monitoring seasons.

Figure CH-1. An aerial view of the Coecles Harbor monitoring site with monitoring stations indicated by the superimposed numbers.

Light Availability and Temperature

Due to the Coecles Harbor site being a new addition to the LTEMP monitoring for 2017, and some miscommunications, the site did not have light or temperature loggers deployed for the months of July and August in 2017. The oversight was corrected in time for the September 2017 deployment of both light and temperature loggers. However, this mistake leaves the 2017 monitoring season with a significant void in its first year of data that, unfortunately, cannot be recovered. The light data for September found light availability to be critically lacking at the site with Hcomp and Hsat running a 4.3h and 5.4h deficit, respectively (Table CH-1). Poor water clarity has been observed within

Table CH-1. H_{comp}, H_{sat} and temperature data calculated from the deployment of Odyssey PAR loggers and TidBit temperature loggers in Coecles Harbor over 10-days for September 2017.

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	ND	ND	ND	ND	ND
August	ND	ND	ND	ND	ND
September	8.0	-4.3	2.3	-5.7	21.4

Coecles Harbor in past visits by CCE, however, it has been noted in previous sections of this report that 2017, overall, experienced a high number of overcast days, resulting in uncharacteristicly poor Hcomp and Hsat levels across the entire estuary.

Water temperature was limited to a 30-day deployment in September of 2017. As the data is missing for the hottest period of the summer, the temperatures collected do not allow us to make an accurate prediction as the what the temperature regime is for Coecles Harbor throughout the growing season. The average monthly water temperature for September was 21.4°C, which is only slightly higher than the two closest sites (Gardiners Bay and Cedar Point), suggesting that Coecles Harbor may experience moderate temperatures during the summer months.

Eelgrass Shoot Density

The Coecles Harbor eelgrass meadow was visited on 26 September, 2017. While the meadow is the largest, continuous meadow in the estuary (2014 PEP eelgrass survey), it is one of the lowest density meadow as well. Eelgrass shoot densities across the six monitoring sites in Coecles Harbor average only 78 shoots·m^2 for 2017. Shoot densities ranged from less than 10 shoots·m^2 to a maximum of 240 shoots·m^2, with most of the majority of quadrat counts resulting in densities under 100 shoots·m^2.

Macroalgae Cover

Macroalgae cover in Coecles Harbor was found to be very extensive. The site recorded the second highest average macroalgae percent cover of any of the LTEMP sites for 2017 at 72%. The macroalgal biomass was almost entirely composed of one species, *Spyridia filamentosa*, with only three other species identified during the survey. Due to the soft bottom and lack of hard substrate for anchorage, the macroalgae tends to be drift, growing entangled in the eelgrass canopy.

Bed Delineation and Areal Extent

Google Earth™ imagery taken on 1 October, 2017, was used to delineate the Coecles Harbor eelgrass meadow. The clarity of the water column in the imagery was poor, providing a very weak eelgrass signature for delineation and resulting in 102 acres of eelgrass delineated for 2017. This should be considered a conservative estimate based upon the available imagery and in-water experience collected during the 2017 monitoring visit. Compared to the 2014 delineation of the meadow that was collected as part of the PEP Eelgrass Survey, the 2017 results are considered a minor decline in overall acreage.

Conclusions

The 2017 monitoring visit was the first survey conducted in Coecles Harbor. Its inclusion into the LTEMP program provides a new eelgrass community to the program with unique factors that influence the eelgrass community in this system. The Coecles Harbor meadow is the largest in the LTEMP at over 100 acres, but it is also has the lowest eelgrass shoot density of the extant meadows surveyed in 2017. Due to an oversight early in the season, light and temperature loggers were not deployed in Coecles Harbor for most of the season. However, while the oversight regarding the July and August deployments of light and temperature loggers will not allow for an accurate characterization of light and temperature regimes for the entire season, based on the data from September, and comparing to other sites, an inference can be drawn regarding these parameters.The light data for Coecles Harbor matches that of Bullhead Bay, and both waterbodies share characteristics that could influence water clarity (e.g. soft bottom and enclosed, slow-flushing system). These similarities suggest that, in the worse case, Coecles Harbor would have light availability similar to Bullhead Bay. The same exercise could be used with water temperature. Coecle Harbor's average monthly water temperature for September was

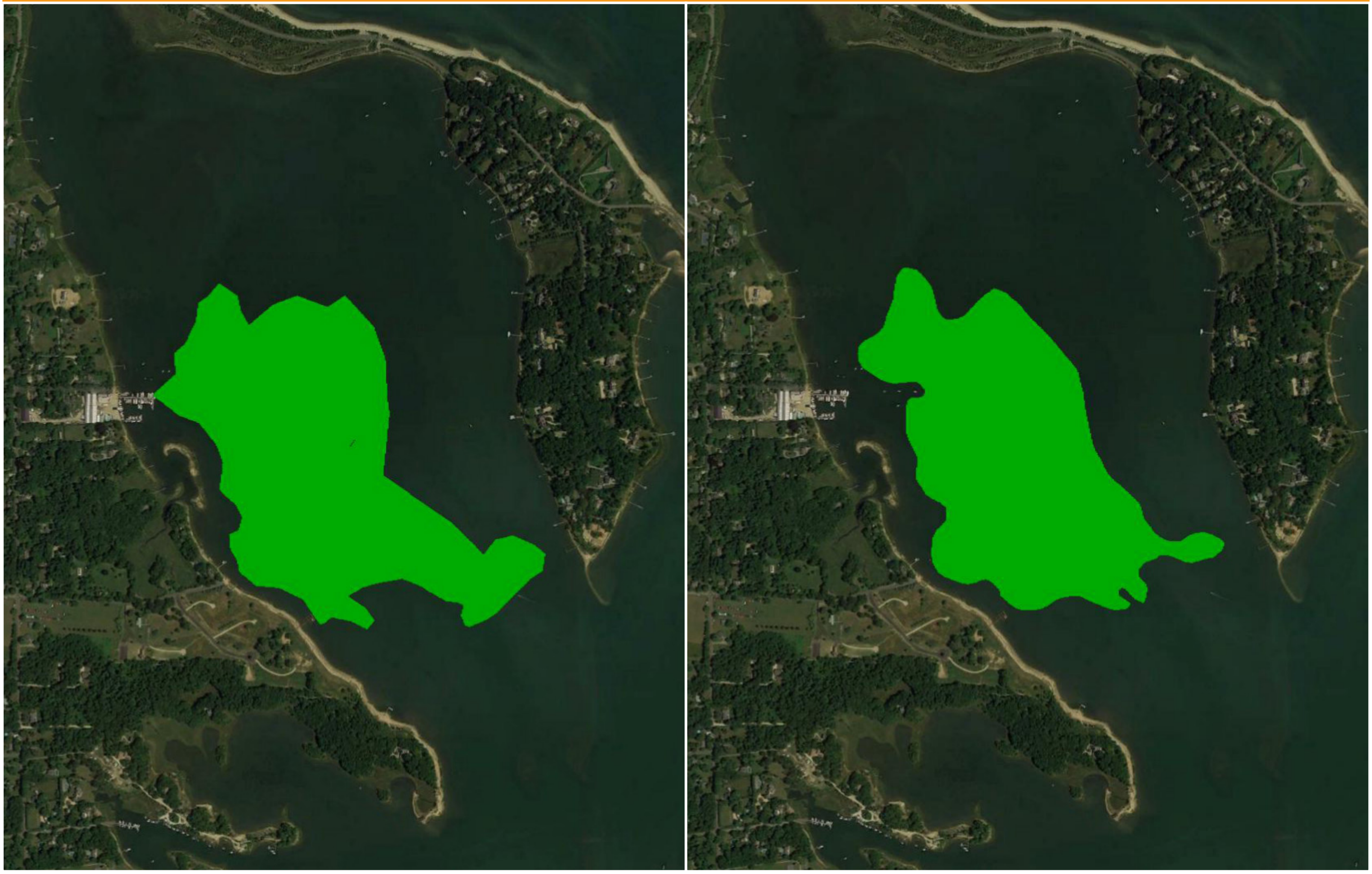


Figure CH-2. The Coecles Harbor eelgrass meadow delineations completed in a) 2014 and b) 2017, for the LTEMP monitoring site.

21.4°C, which is only slightly higher than the two closest sites (Gardiners Bay and Cedar Point), suggesting that Coecles Harbor may experience moderate temperatures during the summer months. The extent of the eelgrass meadow in 2017 was compared to the delineation completed during the PEP Eelgrass Survey in 2014 and found that the areal extent of the meadow had not significantly change. While the 2017 delineations indicated a decline in total area, the aerial imagery from 2017 was not optimal for producing an accurate map of the meadow, and may have resulted in an underestimation of the actual size of the meadow.

There have been recommendations in the past regarding studies that could be conducted in Coecles Harbor to better understand impacts to the eelgrass meadow. One topic of interest is the placement of moorings in eelgrass, and the impacts mooring gear has on the meadow. While this has been studied globally, Coecles Harbor presents an opportunity to look at this problem in the Peconic Estuary. A proposed plan to install conservation moorings in one of the two mooring fields within the meadow was seeking funding, but the status of the project is currently not known. Another point of interest is the influence of groundwater on the eelgrass meadow in Coecles Harbor. To follow this avenue of interest, a survey would be required to identify if there is groundwater actually interacting with sections of the eelgrass meadow. As monitoring continues in Coecles Harbor, it is likely that new questions will arise and provide opportunities for new projects.

As this was the first year of monitoring in Coecles Harbor, conclusions regarding the health and community dynamic in this system are not appropriate at this time. With added information from the 2018 monitoring season, a clearer picture may be presented, but several years of monitoring data will be required to identify the changes this meadow is currently undergoing and create a baseline for future management.

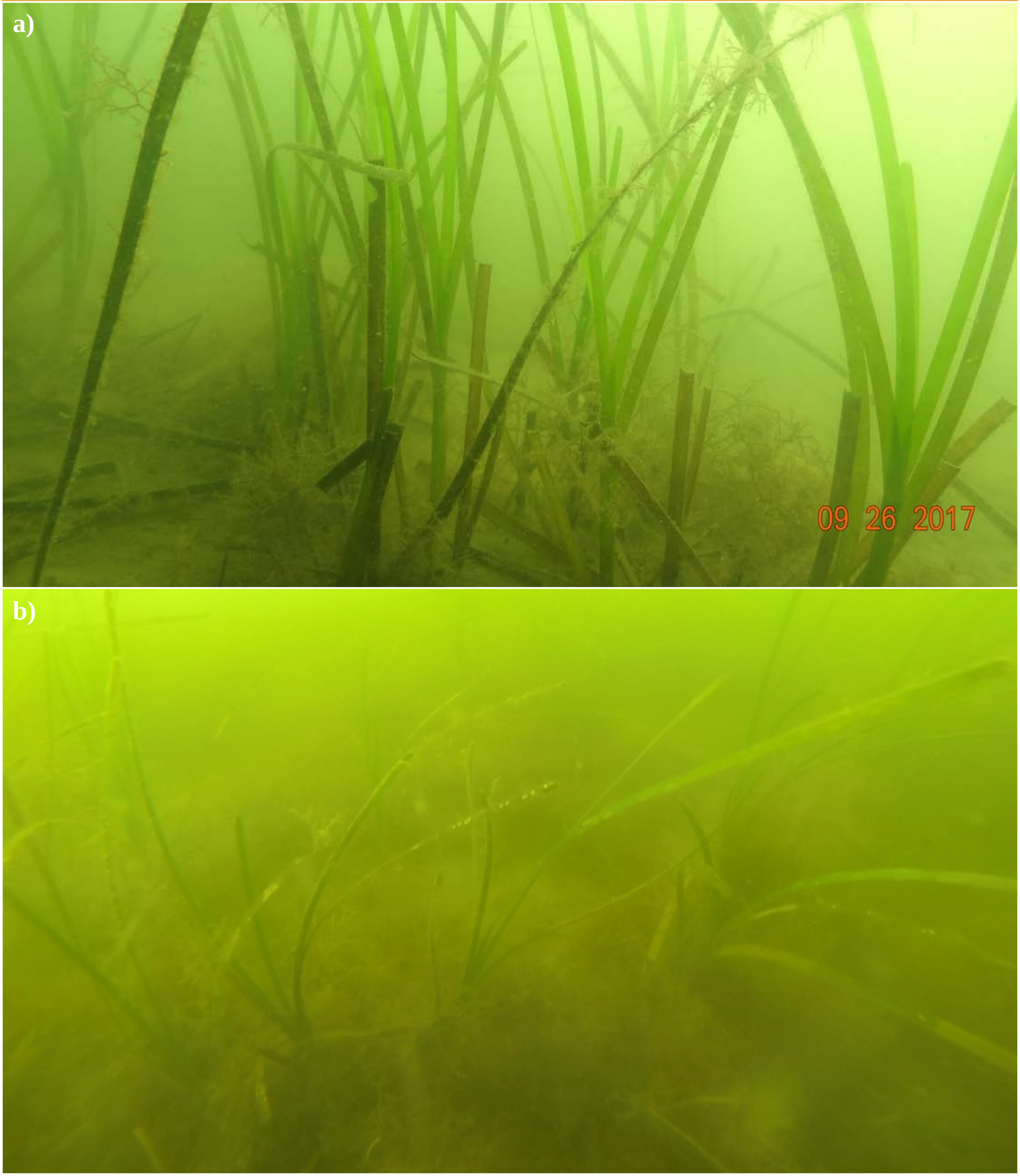
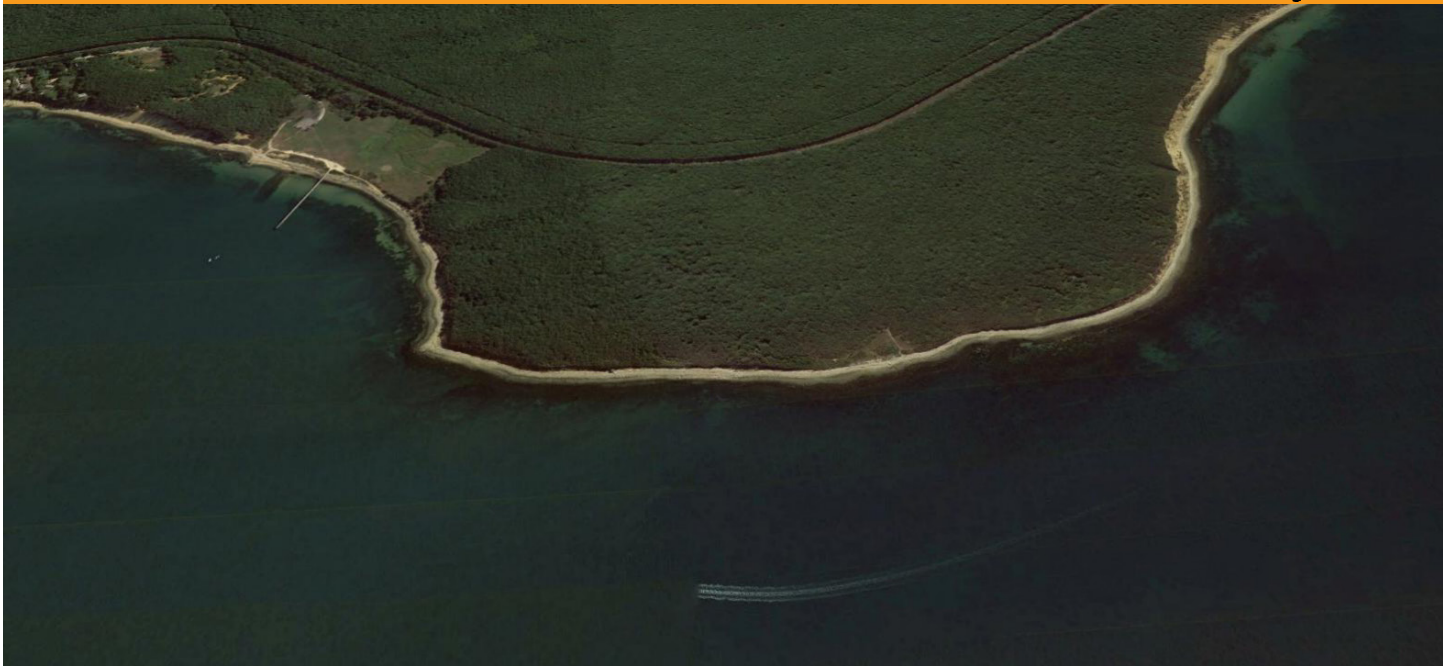


Figure CH3. Photographs showing the observed conditions at a) station 1 and b) station 3 during the Coecles Harbor eelgrass monitoring visit in 2017.



Fort Pond Bay is the easternmost eelgrass meadow in the LTEMP. The meadow starts in Fort Pond Bay near the pier at the Edward Vincent Ecker, Sr. County Park, extends north, then west toward Hither Hills State Park (Figure FPB-1).

Site Characteristics

The Fort Pond Bay eelgrass meadow extends along more than 1.5 miles of shoreline. The site is divided into a section of open coast, subject to waves generated by winter storms, and a more sheltered section of meadow, protected in the lee of Rocky Point. The open coast eelgrass grows in relative deep water, occupying open spaces in the boulder field. This habit likely provides protection from hydrodynamic forces generated by storms that could erode the meadow. In the sheltered section of the meadow, the eelgrass grows on shallow flats, on sandy bottom. The eelgrass creates large, dense patches with dense rhizome mats that should be able to withstand occasional waves generated from the northeast. As the meadow extends out of the sheltered bay and onto the more exposed northern shore of the South Fork, the meadow occupies deeper water (8-15 feet) and is found in smaller patches growing in open areas of what is essentially a boulder field. This section of the meadow resembles the eelgrass meadow at Cedar Point. Sediment characteristics vary greatly between areas of the meadow. Some sections have a high gravel content (up to 44%), while others are nearly pure sand (more than 90%). However, all sections of the meadow were found to be low in organic content, averaging less than 1% over the six monitoring stations.

Figure FP-1. An aerial view of the Fort Pond Bay monitoring site with monitoring stations indicated by the superimposed numbers.

Light Availability and Temperature

An Odyssey PAR light logger was deployed monthly to Fort Pond Bay for 10-day intervals to record the amount of light available to the eelgrass plants at the site. The logger site was located 100 feet southeast of the old, concrete boat ramp at the site in approximate-

Fort Pond Bay 2017

Table FP-1. H_{comp}, H_{sat} and temperature data calculated from the deployment of Odyssey PAR loggers and TidBit temperature loggers in Fort Pond Bay over 10-days for 2017.

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	9.1	1.1	20.1
August	12.8	0.5	9.9	1.9	21.1
September	10.0	-2.3	5.3	-3.7	20.0

ly 4 feet of water at mean low tide. Light data was collected monthly from July-September 2017. Table FP-1 includes the average daily Hcomp and Hsat record for the site, by month. Fort Pond Bay was one of the few LTEMP sites not to run a deficit for Hcomp and Hsat for July and August 2017, even with the more than 30 days with precipitation recorded by the National Weather Service for the summer of 2017.

Due to this location of this meadow near the eastern end of the South Fork and in close proximity to the cool waters of the Atlantic Ocean, it would not be expected that high water temperatures would pose a threat for the eelgrass meadow. The water temperature data presented in FPB-1 provides the average monthly water temperatures calculated for Fort Pond Bay from logger data. The meadow did not experience any days with water temperatures reaching, or exceeding 25°C in 2017. Water temperatures in August averaged just over 21°C, which is will below the threshold at which eelgrass would start to be stressed.

Eelgrass Shoot Density

Monitoring in the Fort Pond Bay eelgrass meadow was conducted on 12 September, 2017. This was the first eelgrass survey conducted in this meadow as part of the LTEMP and, therefore represents a baseline. The average eelgrass shoot density for the Fort Pond Bay meadow was 584 shoots·m^2. This was the second highest shoot density behind the Napeague Harbor meadow. The high shoot density was the result of few quadrats returning counts of zero and several quadrats returning shoot densities over 1000 shoots·m^2. High quadrat counts were due to large numbers of small lateral shoots among the larger primary shoots.

Macroalgae Cover

Macroalgae cover within the Fort Pond Bay eelgrass meadow averaged just under 20%. The macroalgae community at the site primarily consists of specimens attached to the abundant hard substrate found throughout the meadow. There was minimal drift macroalgae observed in the meadow. Fort Pond Bay provided the most diverse macroalgae community, with 14 species identified during the survey. The primary species along this rocky shore was the brown rockweed *Sargassum filipendula*, with common subordinate species expected of a cool, rocky shore, including the red alga *Chondrus crispus,* the brown alga *Halosiphon tomentosus*, and the rockweed *Ascophyllum nodosum*.

Bed Delineation and Areal Extent

Meadow extent for Fort Pond Bay was delineated using Google Earth™ imagery from 1 October, 2017. For most of the meadow, the image quality was adequate to create a relatively accurate determination of the meadows size. The areal extent of the meadow was delineated as 35.8 acres for 2017. The PEP Eelgrass Survey, conducted in 2014, identified the meadow as covering 41.8 acres. The change between the two sets of delineations could be due to quality differences between the two years' imagery, or could reflect the extensive groundtruthing that occurred in 2014, which was able to more accurately map the deeper sections of the meadow. The two sets of delineations are presented in Figure FP-2.

Conclusions

The 2017 monitoring season was the first to include the Fort Pond Bay eelgrass meadow. The initial data collected for this meadow will provide a baseline for comparison of future monitoring efforts. In general, the meadow presents as a healthy eelgrass community with no obvious stressors. Light availability and water temperature were within optimal ranges, supporting this high density meadow. The area of the meadow has changed minimally since the 2014 survey, compared to other meadows in the LTEMP that have experienced more significant declines. Based on this first year's observations of the site, most of the human activity in and around the meadow is passive with little impact on

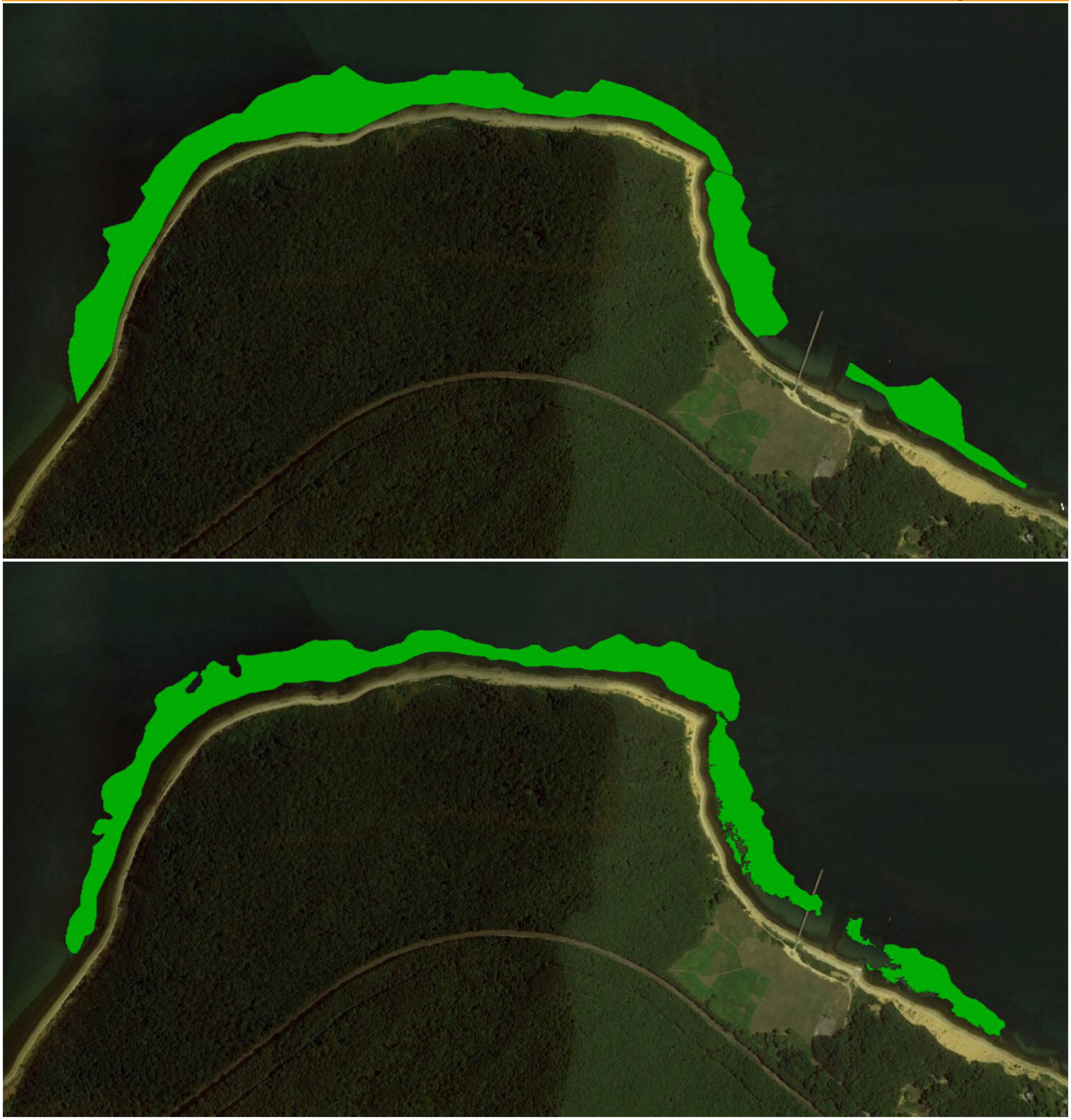


Figure FP-2. A comparison of Fort Pond Bay eelgrass meadow delineations completed in a) 2014 and b) 2017.

the meadow. The only potential man-made disturbance at the site could be the annual movement of a pound net along the shoreline. The impact from the pound net activity should be minimal as the posts are driven/ pounded into the bottom and only impact an area slightly larger than the post, however, the placement of the net and any potential impacts to the meadow should be watched carefully.

Going forward with future monitoring visits, it will be interesting to see how the data resolves to provide an accurate picture of the dynamics of this eelgrass meadow. The data collected during the 2017 monitoring season provides a good introduction and baseline data for the Fort Pond Bay eelgrass meadow, but additional data will provide insight into how this meadow is evolving to deal with changing conditions facing the

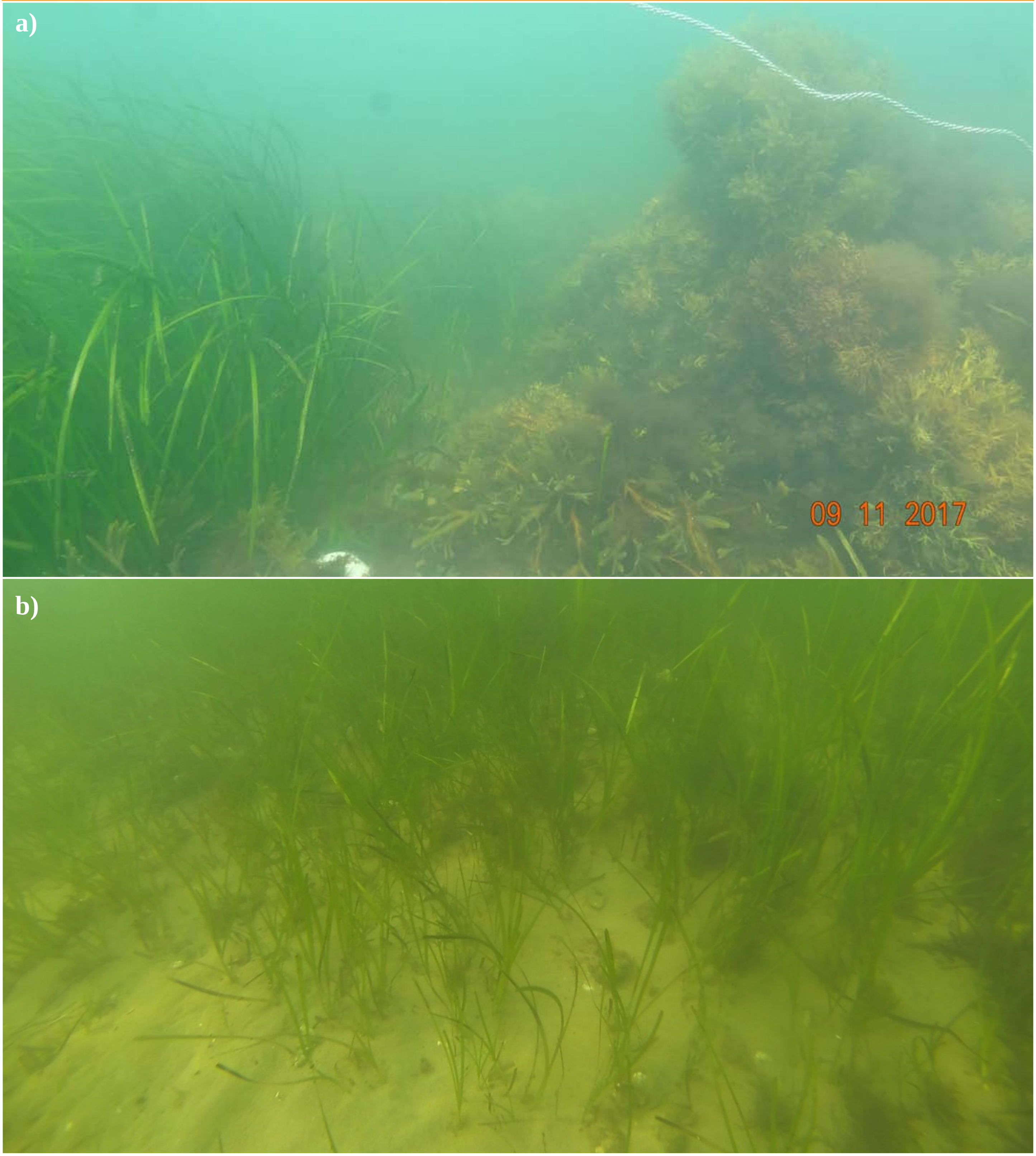
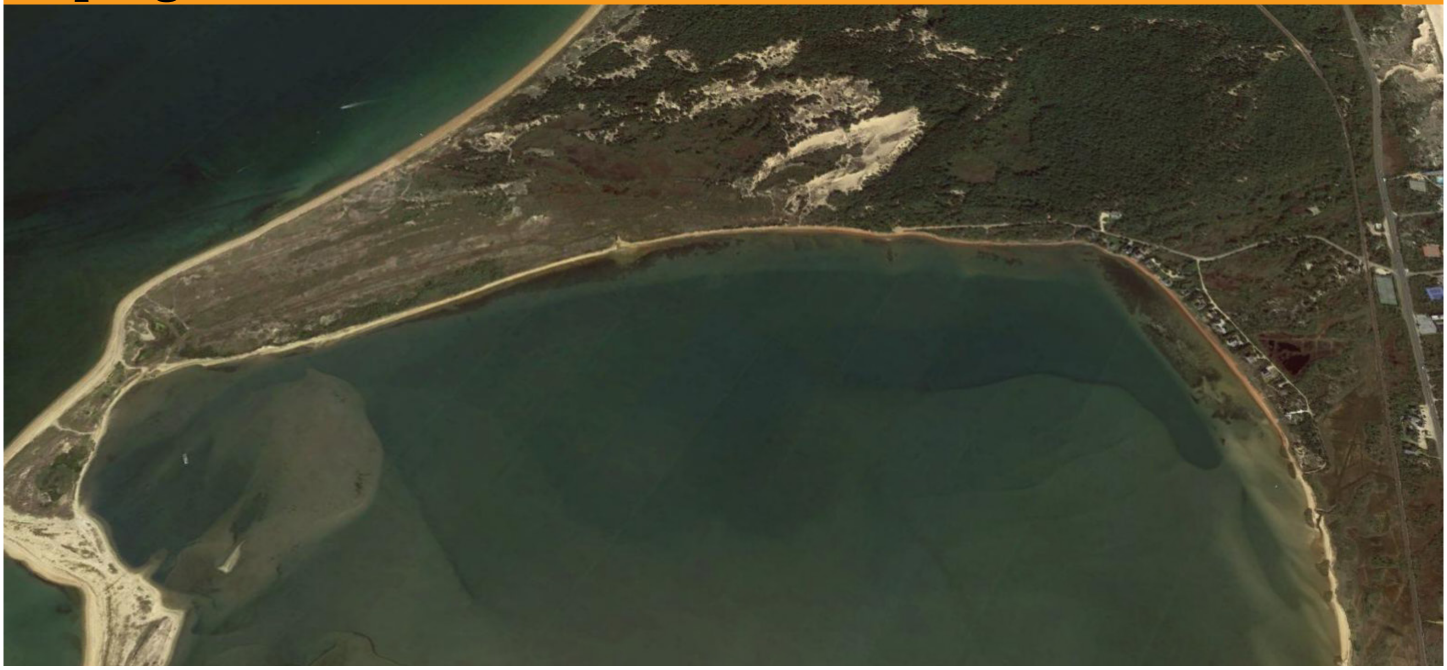


Figure FP-3. Underwater photographs taken during the course of completing the 2017 monitoring at the Fort Pond Bay eelgrass meadow. a) An example of eelgrass growing in the boulder fields along the open northern shoreline (station 3) of the site. b) Eelgrass growing in the lee of Rocky Point on fine sand at station 6.

Peconic Estuary going into the future.

Napeague Harbor 2017



Napeague Harbor is an enclosed embayment located in East Hampton and opens into Napeague Bay. The eelgrass meadow is situated in a shallow band along the east side of the harbor (Figure NAP-1).

Site Characteristics

The Napeague Harbor eelgrass meadow is limited to the eastern shore of the harbor, growing at water depths of less than one foot to four feet at mean low water. The entire bay is sheltered with little fetch allowing the generation of large waves. Due to the shallow nature of the meadow, ice formation in cold winters could impact the meadow by scouring the shallower sections. The sediment over the meadow area is almost uniformly sand, averaging 92% across the meadow. Organic content is low, averaging 0.44%, as would be expected of a sandy site. Napeague Harbor may be unique of all the LTEMP sites in that it has significant, shallow-water groundwater seepage along almost the entire shoreline, and these areas can be identified by the reddish color of the sand bottom.

Figure NAP-1. An aerial view of the Napeague Harbor monitoring site with monitoring stations indicated by the superimposed numbers.

Light Availability and Temperature

Light loggers were deployed monthly, July-September, for 10-day intervals for 2017. The light data was converted to average daily Hcomp and Hsat values presented in Table NAP-1. For July and August 2017, the meadow met its Hcomp requirement of 12.3 hours, and was even provided with a small surplus those months. September recorded the meadow with a 1.5 hour deficit for Hcomp. The Hsat ran a small deficit, 0.6 hours, in July, but made up for it in August with a 1.3 hour surplus. September's Hsat ran a significant deficit (3.8 hours), which may be attributed to the expected seasonal change in daylength.

An Onset HOBO TidBit v2 water temperature logger was deployed to the meadow in mid-June 2017 to an area adjacent to monitoring station 4 (Figure NAP-1). The data from the logger was analyzed and average daily and monthly water temperatures were calculated

Table NAP-1. H_{comp}, H_{sat} and temperature data calculated from the deployment of Odyssey PAR loggers and TidBit temperature loggers in Napeague Harbor over 10-days for 2017.

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	12.5	0.2	7.4	-0.6	24.1
August	12.7	0.4	9.2	1.2	23.0
September	10.8	-1.5	5.2	-3.8	20.5

for the site. The monthly average water temperatures (Table NAP-1) remained below the 25°C temperature threshold, however, the meadow did experience 17 days at temperature $\geq$ 25°C during the summer of 2017. The meadow did not reach 27°C in 2017.

Eelgrass Shoot Density

The Napeague Harbor eelgrass meadow was monitored on 13 September, 2017. Quadrat counts of eelgrass shoots recorded an average shoot density of 806 shoots·m^2, the highest average density ever recorded for any monitoring site in the history of the program. The high density resulted from 23 of the 60 total quadrats sampled returning density counts greated than 1000 shoots·m^2. These high shoot density areas were spread across most of the meadow and not localized in one or two monitoring stations.

Macroalgae Cover

The macroalgae community in Napeague Harbor was was found to have a modest biomass and diversity. The average percent cover across the meadow was 20% and only six species were reported for 2017. The primary species occupying the meadow was the red, fialmentous seaweed, *Spyridia filamentosa*. Other red filamentous seaweeds were noted along with infrequent sitings of *Codium fragile* and *Sargassum filipendula*.

Bed Delineation and Areal Extent

The 2017 areal extent of the Napeague Harbor eelgrass meadow was completed using aerial imagery from Google Earth™ taken on 1 October, 2017. Due to the shallow nature of the meadow and the light colored sanding bottom it inhabits, an accurate delineation of the meadow was created (Figure NAP-2). The 2017 delineation identified 17.6 acres of eelgrass along the eastern shore of Napeague Harbor. In contrast, the 2014 PEP Eelgrass Survey identified 21.9 acres of eelgrass within the same area. Much of the lost meadow area has occurred in the northern end of the meadow where the old inlet to Napeague Harbor was once located. The southern section of the meadow was found to have declined in area slightly but has visibly increased in density since 2014.

Conclusions

The Napeague Harbor eelgrass meadow was found to be a relatively healthy meadow exhibiting some unique characteristics. The meadow occupies the shoreline furthest from the current inlet to the harbor, which should result in lower tidal exchange and water turnover rates, and in a shallow-water system, result in chronic high water temperatures during the summer months, similar to the conditions in Bullhead Bay. However, like Bullhead Bay, the Napeague Harbor eelgrass meadow appears to benefit from near shore groundwater discharge to mitigate high water column temperatures, resulting in a densely vegetated, shallow eelgrass community that is healthy and, in some areas, has shown evidence of small-scale expansions in area in recent years. The prevalence of near shore groundwater discharge is readily identifiable along the eastern shore of the harbor by the red color that the sandy sediment takes on (Figure NAP-3a) and the eelgrass meadow seems to be associated with these discharge areas.

A preliminary study completed by Ron Paulson (CCE) in August of 2017, at the request of East Hampton Town, conducted transects from mean low water and extending 100 feet offshore at a dozen locations around Napeague Harbor to identify and determine the presence and relative discharge rates of groundwater. The transects included both eelgrass-vegetated areas and non-vegetated areas of shoreline. The preliminary results found that eelgrass was associated with areas of groundwater discharge and may be due to the mitigation of high water temperature. Transects along the western shore of Napeague, with no groundwater,

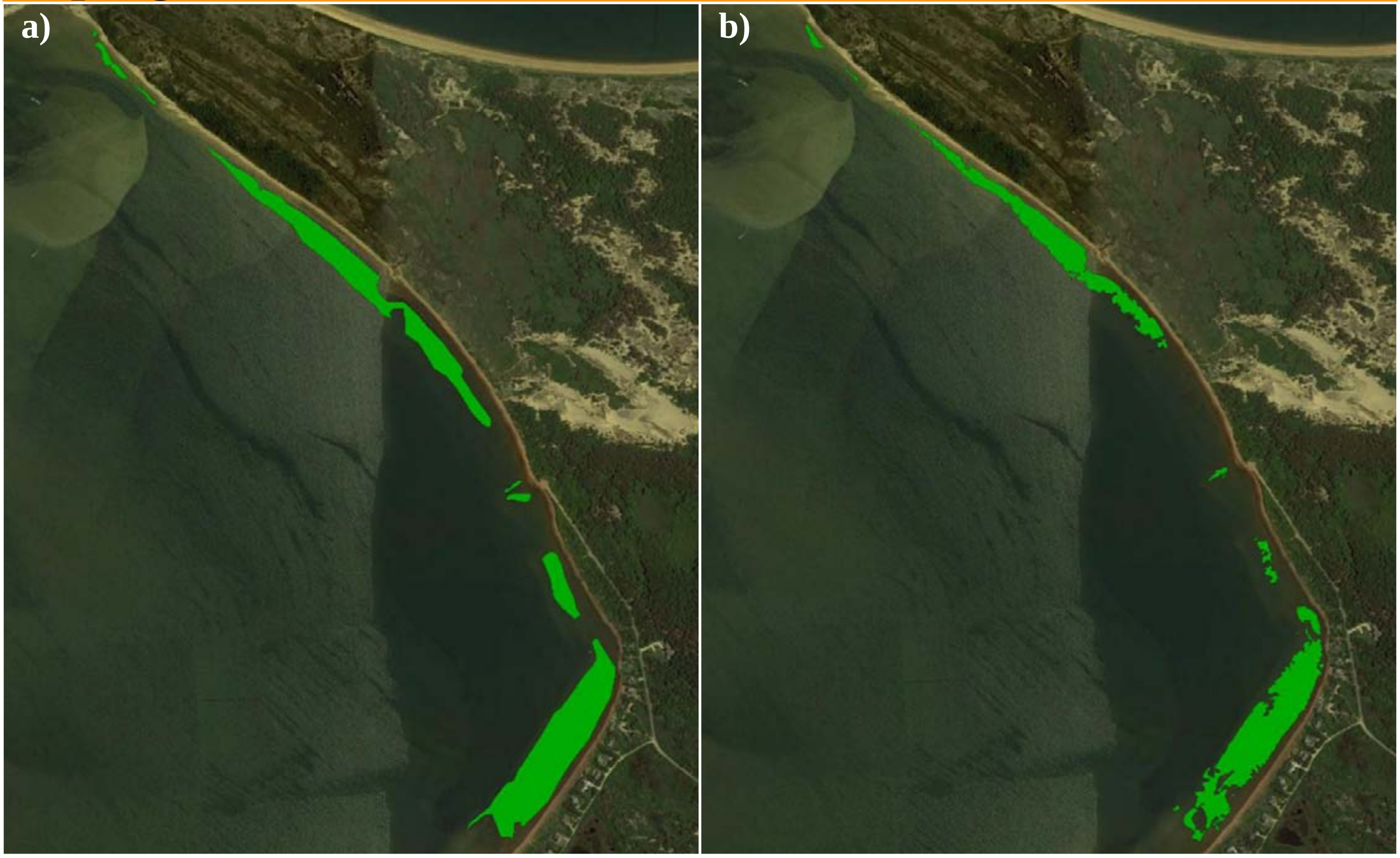


Figure NAP-2. A comparison of Napeague Harbor eelgrass meadow delineations completed in a) 2014 and b) 2017.

found that high water temperatures transferred more almost 12 inches below the sediment surface. In locations with groundwater discharge, subsurface sediment temperatures were at least 1-2°C below water column temperatures. In most cases, the temperature mitigation from groundwater translated in the water column above the sediment surface. The groundwater-eelgrass connection suggested by this preliminary study requires further investigation and hopefully funding can be obtained to expand this work.

The 2017 monitoring season is not the first time that CCE has conducted eelgrass monitoring activities in Napeague Harbor. From 2009-2013, the East Hampton Town Shellfish Hatchery contracted CCE to conduct surveys in an established scallop sanctuary in Napeague Harbor to collect data on the health of the eelgrass population and scallop retention/survival. The sanctuary area corresponded with the current monitoring station NP2 and the eelgrass shoot density data collected from 2009-2013 in this area of the meadow is comparable to the densities recorded for NP2 in 2017. This suggests that the eelgrass meadow, at least in this area, has maintained a steady dynamic for the last 8 years. Hopefully, this is a trend that will continue to prevail in the Napeague Harbor eelgrass meadow.

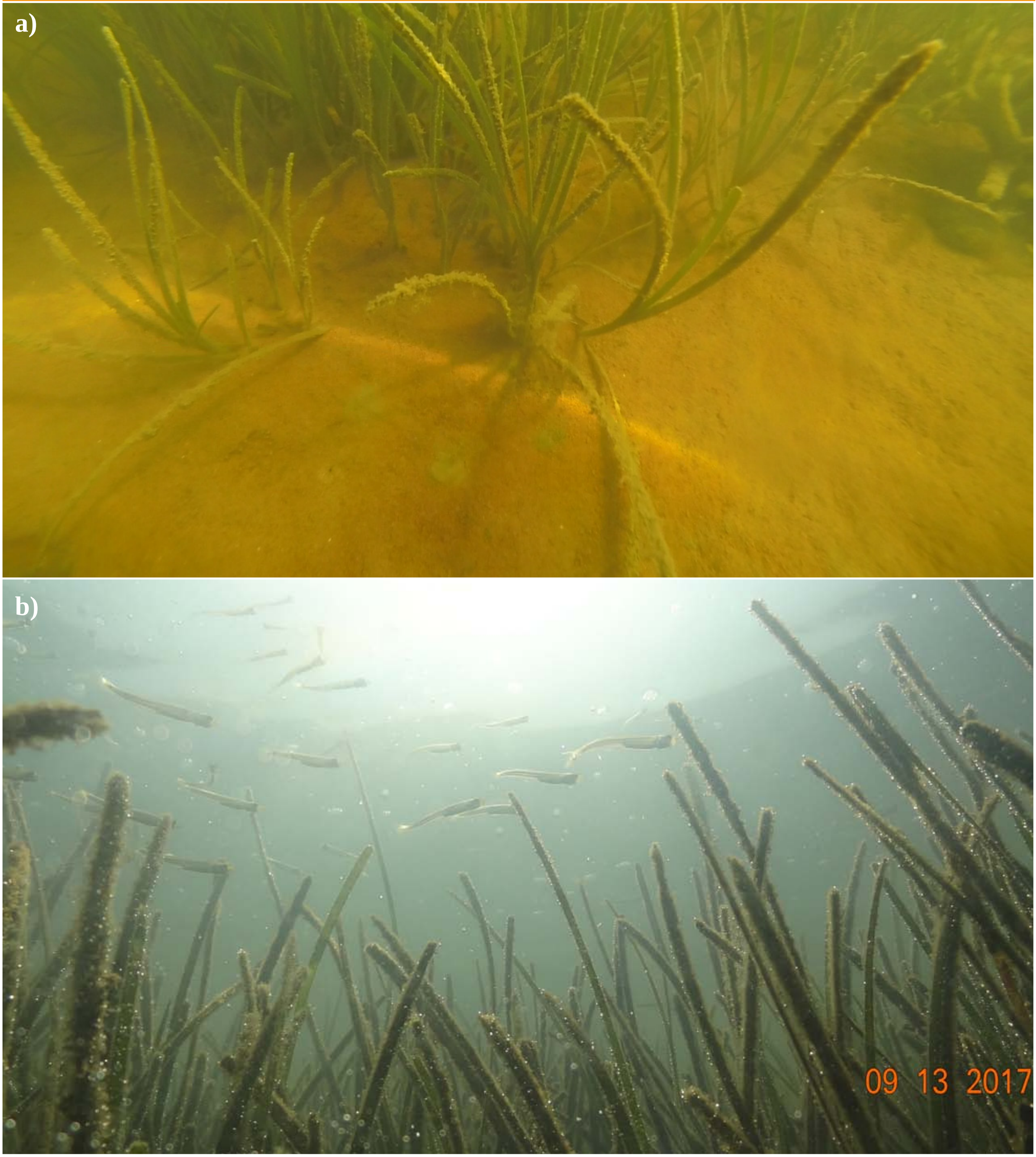
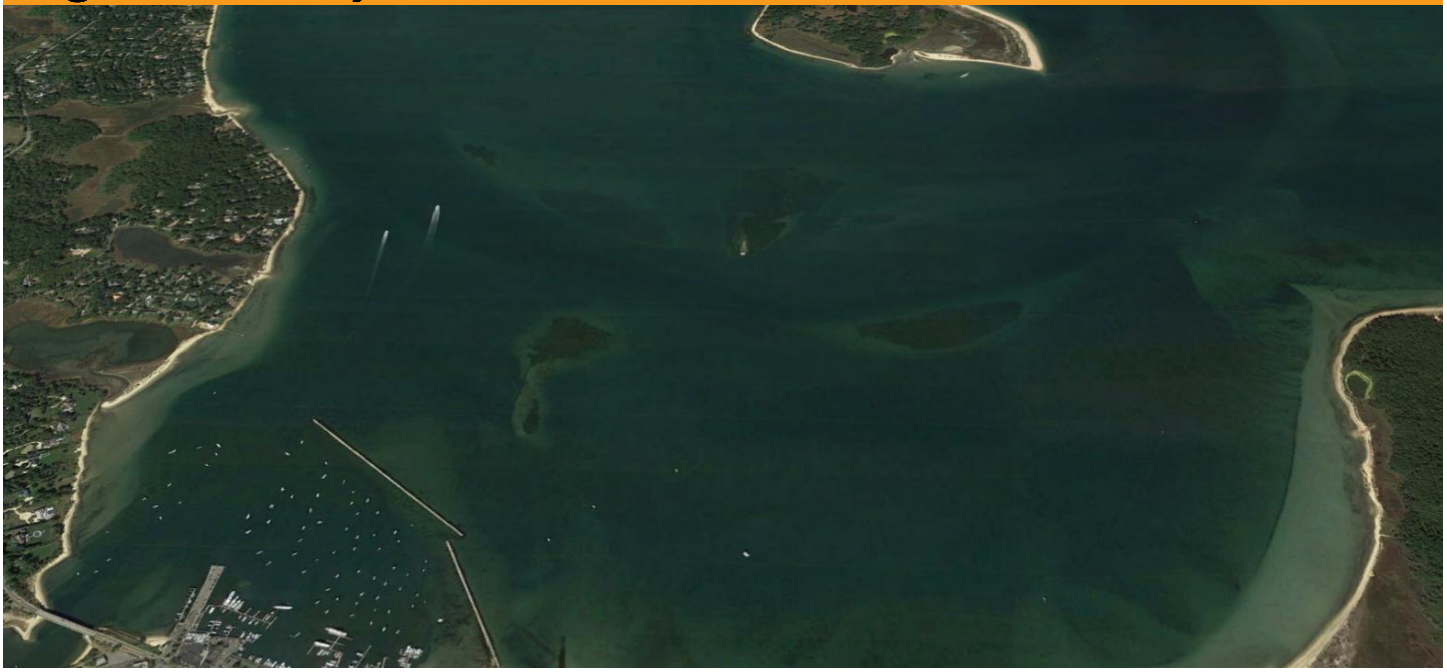


Figure NAP-3. a) An example of the red color due to the iron in groundwater seeping out of the sediment at station 3 in Napeague Bay. b) Atlantic silversides schooling above the eelgrass. The bubbles covering the blades (oxygen generated by photosynthesis) attest to the productivity of this eelgrass meadow on a sunny, September day.

Sag Harbor Bay 2017



Sag Harbor Bay is an open bay surrounded by North Haven (Southampton Town) to the west, Mashamock (Shelter Island) to the north and Barcelona Point (East Hampton) to the east. The eelgrass meadow monitored at this site is actually a group disctinct eelgrass beds within the bay. The LTEMP monitors three of these beds with 6 monitoring stations divided among the beds (Figure SH-1).

Site Characteristics

Figure SH-1. An aerial view of the Sag Harbor Bay monitoring site with monitoring stations indicated by the superimposed numbers.

The Sag Harbor eelgrass meadow complex consists of at least five individual meadows over 0.5 acres in size. The meadows are all subjected to moderate current velocities during changing tides and can be subjected to significant wave actions during the winter months with prevailing winds out of the north-northwest. The sediment in all the meadows primarily consists of sand, averaging 83% across the meadow, although station SH1 had a higher constituent of gravel-sized sediment at 22% and a sand component of 57%. The overall organic content for the site was less than 1% (0.66%) which may be due to tidal current washing organic materials out of the meadows.

Light Availability and Temperature

An Odyssey PAR light logger was deployed adjacent to the SH2 monitoring station monthly, from July-September 2017. The loggers collected 10 days of light data per deployment and the results are summarized in Table SH-1 in terms of Hcomp and Hsat. Light condition throughout 2017 at Sag Harbor were not optimal for eelgrass. The meadow, at least at the logger site, experienced deficits for both Hcomp and Hsat for all three months sampled. July experienced especially poor light conditions with large deficits for both parameters.

Water temperatures in Sag Harbor Bay were found to be moderate, with average monthly temperatures running well below 25°C (Table SH-1). Daily average temperatures for Sag Harbor Bay did not reach 25°C at any time during the season. The highest individual

Table SH-1. H_{comp}, H_{sat} and temperature data calculated from the deployment of Odyssey PAR loggers and TidBit temperature loggers in Sag Harbor Bay over 10-days for 2017.

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	8.7	-3.6	0.5	-7.5	23.4
August	10.8	-1.5	6.6	-1.4	23.5
September	10.9	-1.4	7.6	-0.4	21.3

temperature recorded was 26°C on 22 July, which was taken on an outgoing, spring tide.

Eelgrass Shoot Density

Monitoring of the eelgrass meadow in Sag Harbor Bay was completed on 26 September, 2017. As a whole, the meadow averaged an eelgrass shoot density of 249 shoot·m². As the site consists of three distinct eelgrass beds, the quadrat counts were analyzed for each bed. The individual beds are identified as Bed1 (stations SH1 and SH2), Bed2 (stations SH3 and SH4) and Bed3 (stations SH5 and SH6). Bed3 had a significantly high shoot density than either of the other two beds at 349 shoot·m². Bed2 was the next densest at 226 shoot·m², followed by Bed1 with a density of 174 shoot·m². The densities in Bed1 and Bed2 were not found to be significantly different.

Macroalgae Cover

Macroalgae cover within the Sag Harbor eelgrass meadow was low, with only a 4% cover reported for the meadow. Analysis of the individual beds within the complex found no significant difference between beds in terms of macroalgae cover. The percent macroalgae cover was reported as 3%, 2%, and 7% for Beds 1-3, respectively. Species composition was different between the three beds, as well. Bed1 was dominated by *Sargassum filipendula* and *Codium fragile* attached to the abundant gravel and rock. Bed2 supported the filamentous red algae, including *Spyridia filamentosa* and *Neosiphonia harveyi*, as drift and epiphytes on the eelgrass blades. Bed3 was predominantly colonized by *Codium fragile* attached shells covering the bottom.

Bed Delineation and Areal Extent

The aerial delineations of the meadow's extent was completed using Google Earth™ imagery flown on 1 October, 2017. The meadow covered a total of 50.3 acres in 2017, compared to 52.4 acres reported from the 2014 PEP Eelgrass Survey. The difference in the toal areas between the two delineations is minimal, however areas of meadow were identified in the 2017 delineations that were not presented in the 2014 set (Figure SH-2).

Conclusions

The first year's monitoring data for the Sag Harbor Bay eelgrass meadow complex found the three constituent eelgrass beds to be relatively healthy, stable communities. The overall average shoot density was above the average normal for meadows in the Peconic Estuary, however when the three beds are taken individually, they become distinct eelgrass communities. The differences in the individual beds may result from differing levels of exposure to waves and currents. Of the three beds, Bed 1 is the most exposed to waves and current. The resulting exposure to these forces has resulted in this meadow having a coarser sediment that supports larger, wave-tolerant macroalgae species (e.g. *Sargassum*) which can compete with eelgrass for space and light. This competition could result in lower shoot densities across this bed. Bed 2 is protected from most of the wave energy produced in the bay, however, it is exposed to the moderate tidal currents of the area. The sandy sediment does not promote the growth of large seaweeds that would compete for light and space, but the currents are strong enough to lay the eelgrass blades down during flood and ebb tides. If this bed supported a high density of eelgrass shoots, self-shading could become an issue, with the eelgrass essentially competing with its neighbor for light. At lower densities, each shoot is less likely to shade or be shaded by neighboring plants, potential self-regulating the density of this bed. Bed 3 is the most sheltered from both wave and current forces. It is also the most densely populated of the beds, possibly due to alleviation of the stress these factors place on the bed. With hard substrate limited to shell that cannot support large macroalgae, and lower currents resulting in less self shading, this bed can support a more dense population

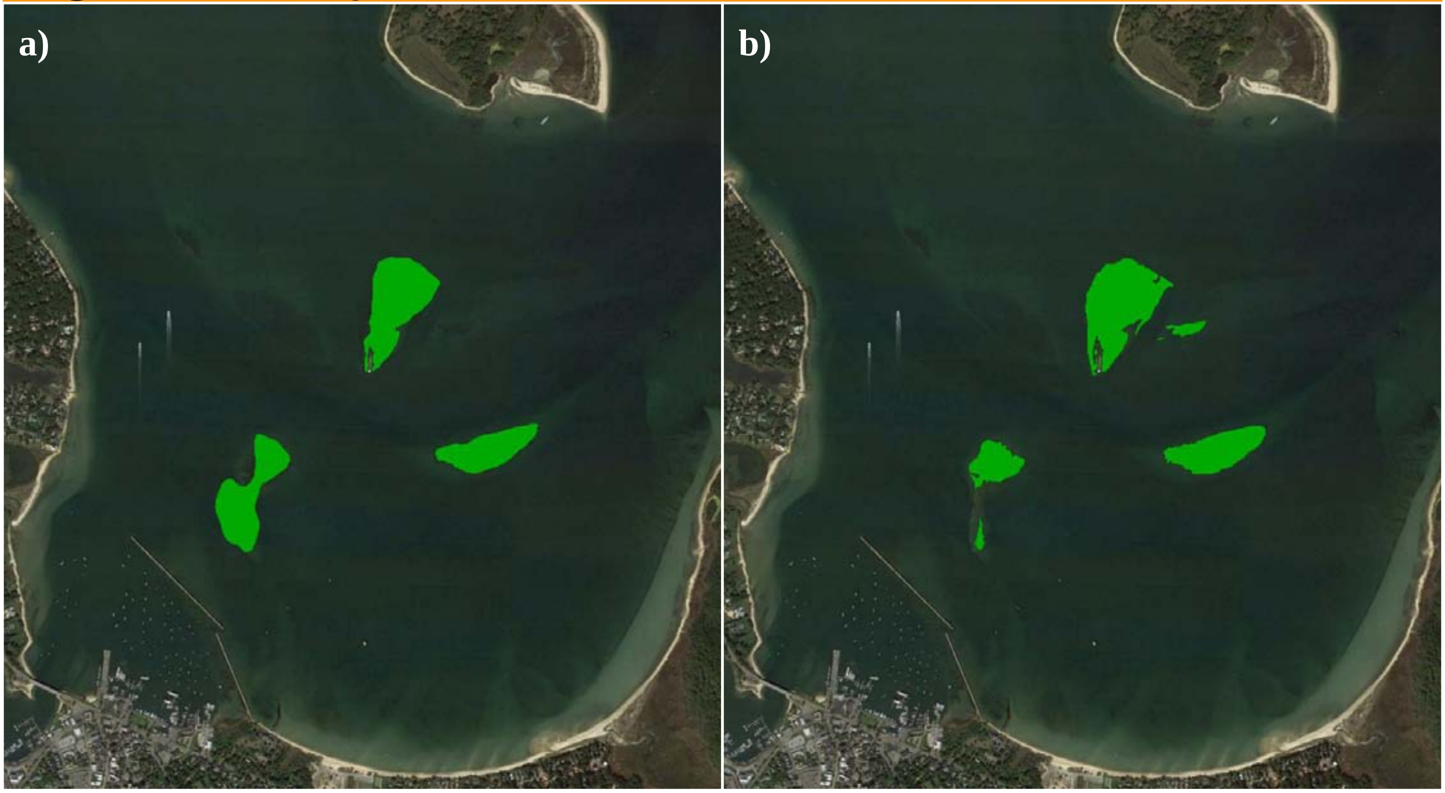


Figure SH-2. Comparison of delineations between a) 2014 and b) 2017 for the Sag Harbor Bay eelgrass meadow complex.

of eelgrass than the other two beds. Going forward with future monitoring of the Sag Harbor Bay eelgass meadow complex, the three beds will be considered individually and as a whole when evaluating the annual monitoring data.

With only one year of data available, it is hard to make a definitive conclusion regarding the potential long-term health and survival of an eelgrass meadow. In the case of Sag Harbor Bay, CCE has had some practical experience indicating that conditions in the bay are optimal for eelgrass growth. CCE, sponsored by the Great Peconic Paddleboard Race, has conducted two sets of eelgrass plantings along the south edge of Bed2. More than 2000 eelgrass shoots were planted in this area from 2016-2017, with the 2016 plantings showing promising growth in only their first year at the site. This restoration planting has proven to be one of the most successful undertaken by CCE in the Peconic Estuary to date, in terms of survival and first year growth. Future plantings to this location, to further enhance the natural meadow, are being considered, as is an effort to accurately map the expansion of the planting over time.

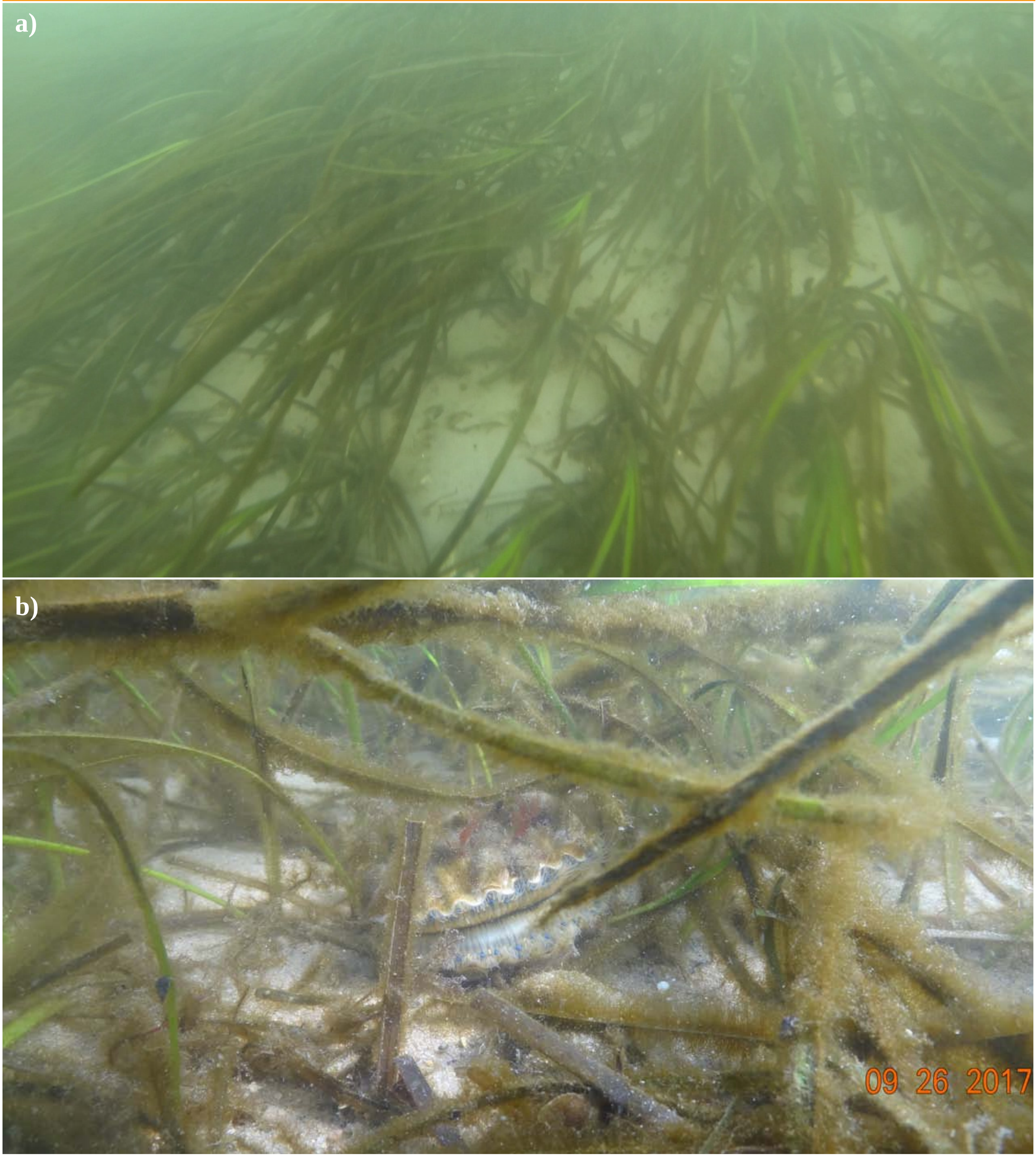
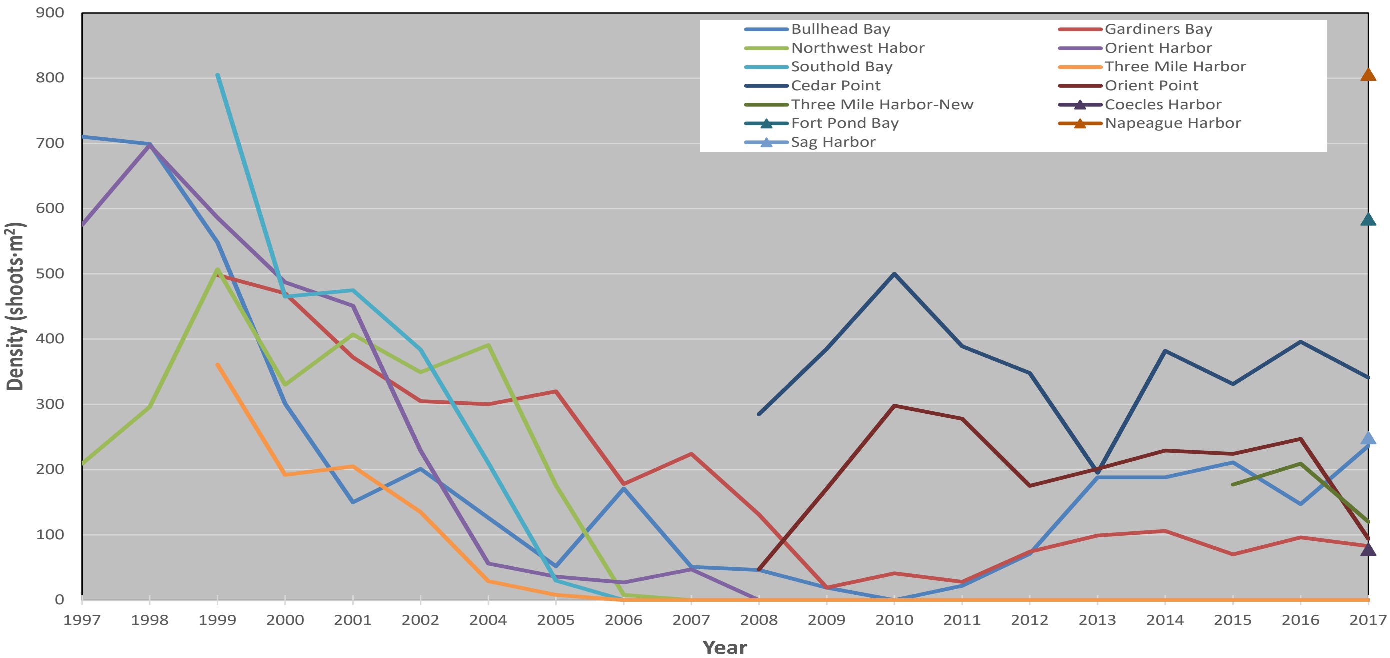


Figure SH-3. a). Eelgrass at station 3 (Bed 2) laying over in the current. Self-shading may explain why the shoots are not growing denser in this area of the meadow. b) A bay scallop shelters in the meadow near station 6.

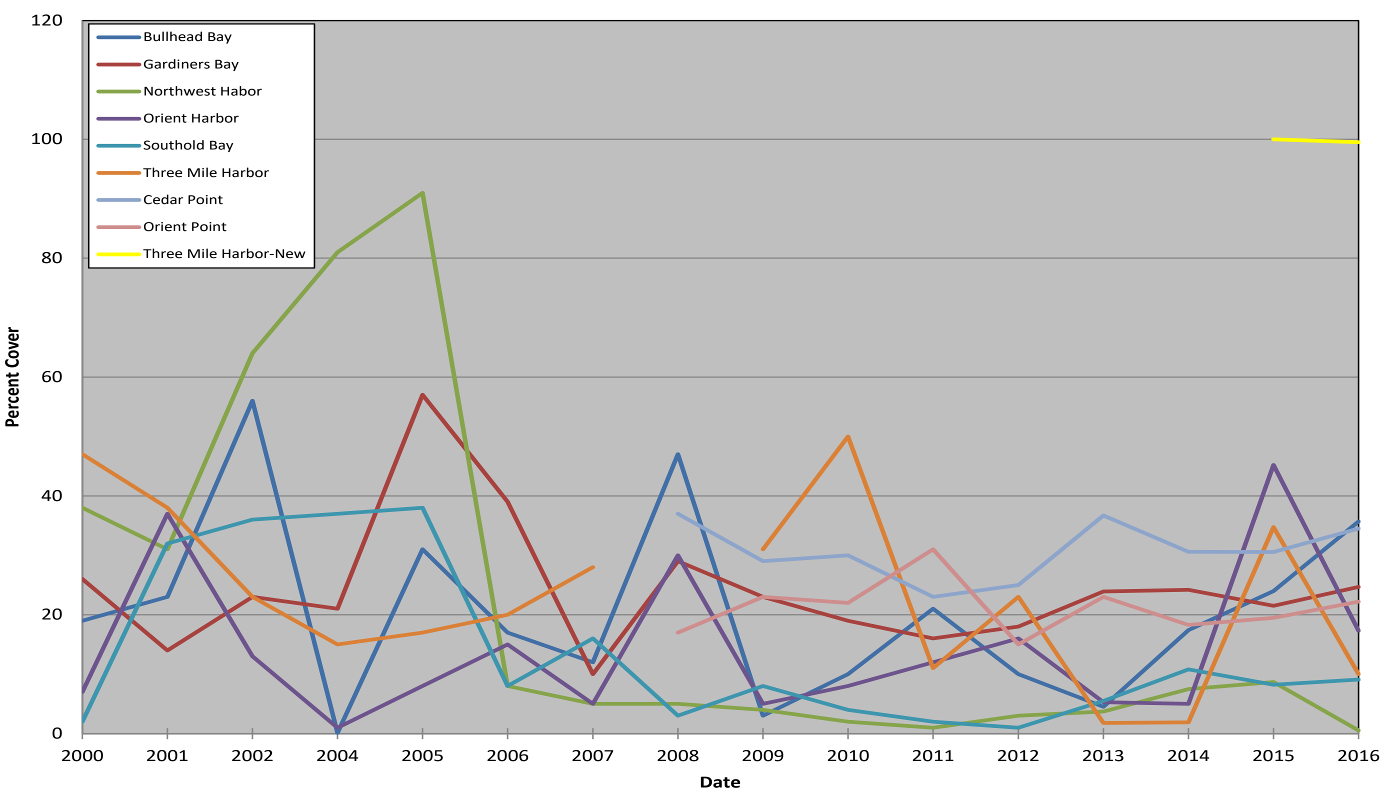
Appendix

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

Figure 1. Average annual eelgrass shoot densities for all PEP LTEMP sites from 1997-2017. The new monitoring sites added in 2017 are represented by the triangular points.



PEP LTEMP Macroalgae Percent Cover Trends (2000-2016)



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