Peconic Estuary Partnership 2022 Long-Term Eelgrass (*Zostera marina*) Monitoring Program

Progress Report 23

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

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Executive Summary

The nine PEP LTEMP sites were surveyed by CCE divers during the summer of 2022. The season started with the installation of light and temperature monitoring stations and deployment of water temperature loggers at all sites by late-May 2022. Monthly light logger deployments to the stations began in mid-July and finished in late-September 2022. Eelgrass monitoring surveys began on August 30, 2022 and were completed for all sites on September 14, 2022. In mid-October all temperature loggers were retrieved for the season. A summary of all of the data collected for the 2022 PEP LTEMP season follows below.

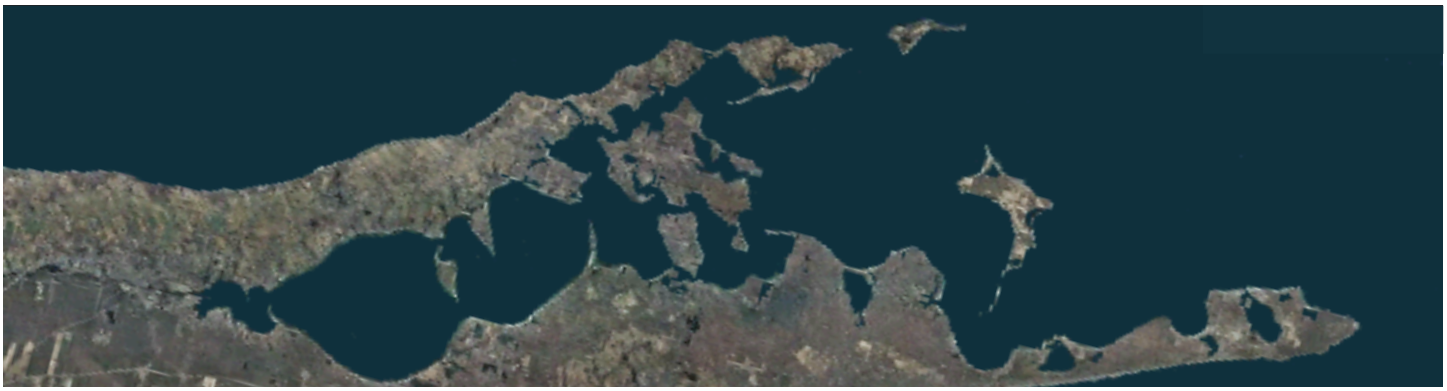
Light availability and water temperature data was collected from all nine LTEMP sites in 2022. Drought conditions persisted through the 2022 season, resulting in minimal cloud cover for the season and high ligh availability at all eelgrass monitoring sites. None of the nine sites experienced a deficit in light availability during the 2022 season, which is the first time since light data was adding to the monitoring protocol that this has occurred. The 2022 was warmer across all monitoring sites than the 2021 season. The 2022 season saw four sites (Bullhead Bay, Three Mile Harbor, Coecles Harbor, and Sag Harbor) that experienced more than 30 days with daily average water temperatures exceeding 25°C. The Gardiners Bay and Napeague Harbor sites recorded more than 20 days exceeding 25°C, while the Cedar Point, Orient Point, and Fort Pond Bay sites experienced one or fewer days above this threshold. The Bullhead Bay meadow faced 37 days with daily average water temperatures over 27°C and Three Mile Harbor recorded only one day over 27°C.

The 2022 eelgrass monitoring survey was initiated on August 30, 2022 and completed on September 14, 2022. For the 2022 season, four meadows (Bullhead Bay, Three Mile Harbor, Coecles Harbor and Sag Harbor) sites recorded a significant increase in eelgrass shoot density from 2021. The remaining eelgrass meadows showed small, non-significant increases in eelgrass density from the 2021 season. Macroalgae cover showed no significant change between the 2021 and 2022 seasons for all LTEMP sites.

At the time of this reporting, there are no 2022 aerial images available to complete delineations of the Bullhead Bay eelgrass meadow. If 2022 imagery becomes available at a later date, delineations will be completed and added to a revised monitoring report.

The results of the 2022 Peconic Estuary LTEMP found that the eelgrass meadows included in the survey program were healthy and maintained, or increased, shoot density from the 2021 season. The prevailing clear, sunny weather pattern that dominated the region for the summer season provided all meadows with ample amounts of light to support eelgrass growth at all sites. These same conditions lead to a very warm summer which found almost half of the LTEMP sites experiencing high water temperatures for extended (>30 days) time during the season, which could have lead to declines at these sites. However, no signs of decline were observed at any sites during the monitoring survey period at the end of the summer. Due to the unavailability of aerial images for 2022, it could not be determined if any of the meadows experienced significant changes to their areal extent. If an appropriate source of imagery for 2022 can be accessed, delineations of the meadows will be completed and the results added to a revised report. Notable observations for the 2023 season include the continued impact of boat moorings located in eelgrass meadows and readily observable in the Coecles and Napeague Harbor eelgrass meadows. While the overall impact of moorings on eelgrass is small in the Peconic Estuary, it could be a relatively easy situation to address through employing conservation moorings or changing local regulations to prohibit moorings/anchorage in eelgrass. A new concern for Peconic Estuary eelgrass meadows may be the presence of cownose rays our bays during the summer months. Cownose rays cause significant damage to seagrass meadows in the native range and could become a problem locally in the near future. To date, there have been no reported sitings of ray foraging pits, but these animals should be of concern for the future.

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 Partnership 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 Partnership'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 was revised in 2018 to remove the four monitoring sites that no longer support eelgrass (Northwest Harbor, Orient Harbor, Southold Bay, and Three Mile Harbor) from regular annual monitoring. These four sites will be revisited on a 3-year schedule to verify that eelgrass had not reestablished at the sites in the intervening years.Table Intro-1 has been revised to only include the current active eelgrass monitoring sites presented in this report.

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 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

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

Bullhead Bay (BB)	Southampton
Gardiners Bay (GB)	Shelter Island
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

Introduction and Methods

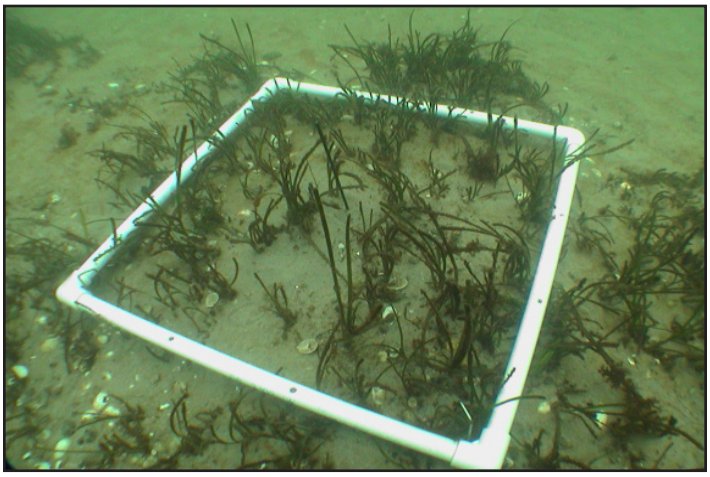


Figure Intro-1. A 0.10 meter^2 PVC quadrat used for eelgrass monitoring.

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 starting in the 2018 season, 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 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 respi-

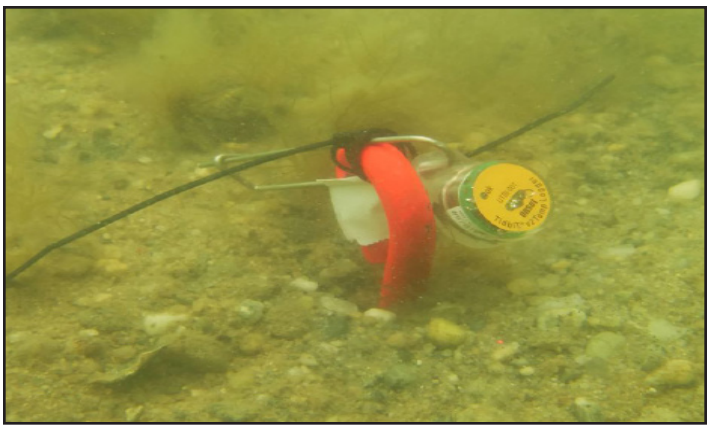


Figure Intro-2. A TidBit v2™ temperature logger attached to a screw anchor, deployed on-site.

ration 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.

Starting in 2018, water temperature loggers were deployed at all of the monitoring sites. 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 South-old 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 $\mu mols \cdot m^{-2} \cdot s^{-1}$ (Dennison and Alberte, 1985). The second parameter is H_{sat}, which is the number of hours eelgrass is exposed to PAR at an intensity at which the rate of photosynthesis is no longer limited by the amount of light the plant is receiving. This is known as the Saturation Point. H_{sat} is where plants generate the energy to support growth and development beyond the basic metabolic requirements. As with the Compensation Point, the light intensity for the Saturation Point was taken from Dennison and Alberte (1985) and considered to be 100 $\mu mols \cdot m^{-2} \cdot s^{-1}$ for the Peconic Estuary. Dennison (1987) calculated that his eelgrass population required a daily average of 12.3 hours (h) H_{comp} over the course of the year, to meet basic metabolic requirements, and this 12.3h period was adopted for the Peconic Estuary eelgrass meadows. In regard to H_{sat}, Dennison and Alberte (1985) calculated that their eelgrass population required a minimum of 6-8h per day. Taking the data collected in the Peconic Estuary in 2010 and comparing it to Dennison and Alberte's calculations, CCE made a conservative estimate that H_{sat} should be closer to 8 hours.

For the 2021 season, Odyssey PAR loggers were deployed at all active monitoring sites.

Eelgrass Monitoring

The 2022 monitoring began on 30 August and completed on 14 September, 2022. 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 shoot 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 the Real Statistics add-on for Excel. 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

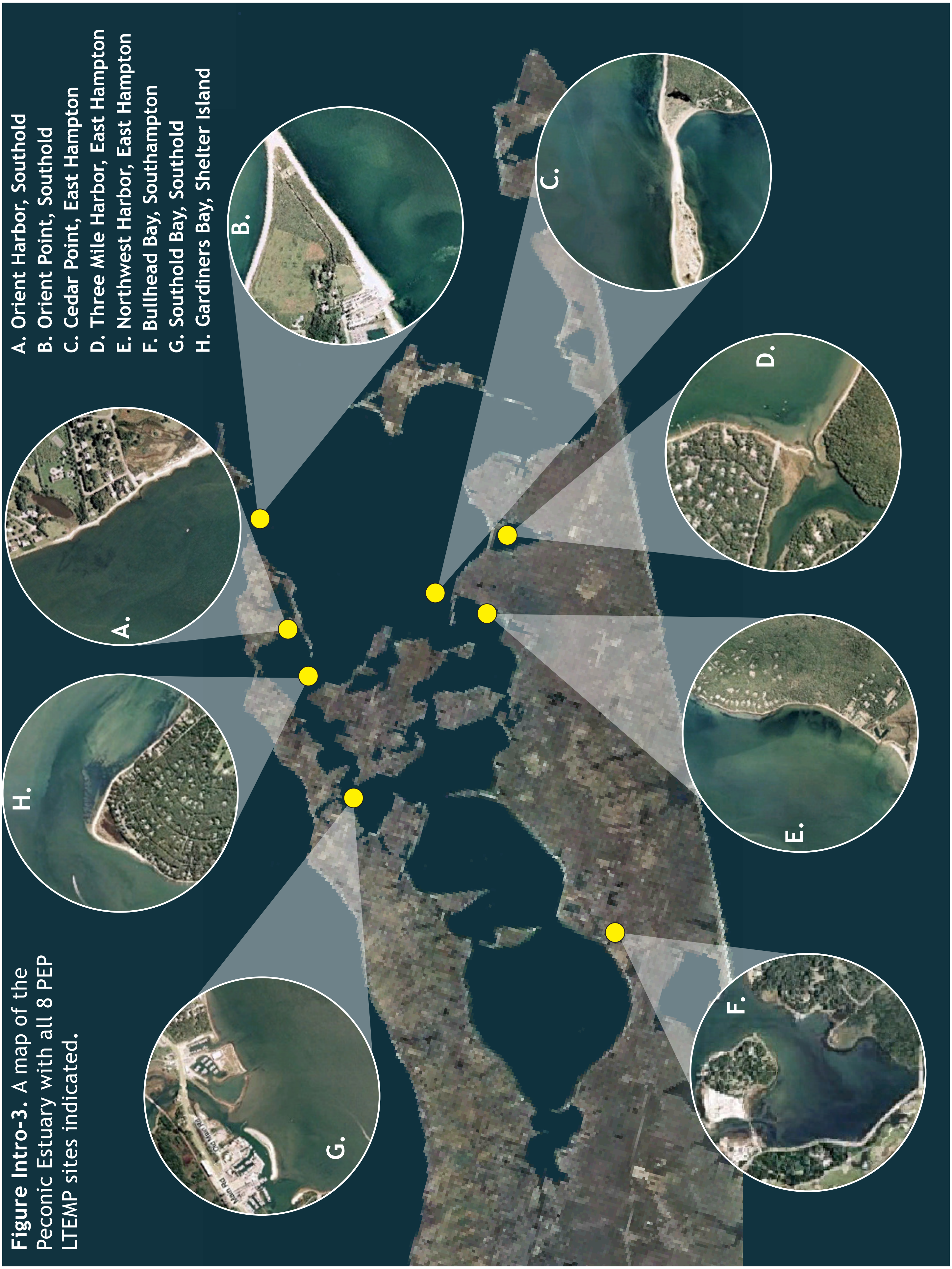


Figure Intro-3. A map of the Peconic Estuary with all 8 PEP LTEMP sites indicated.

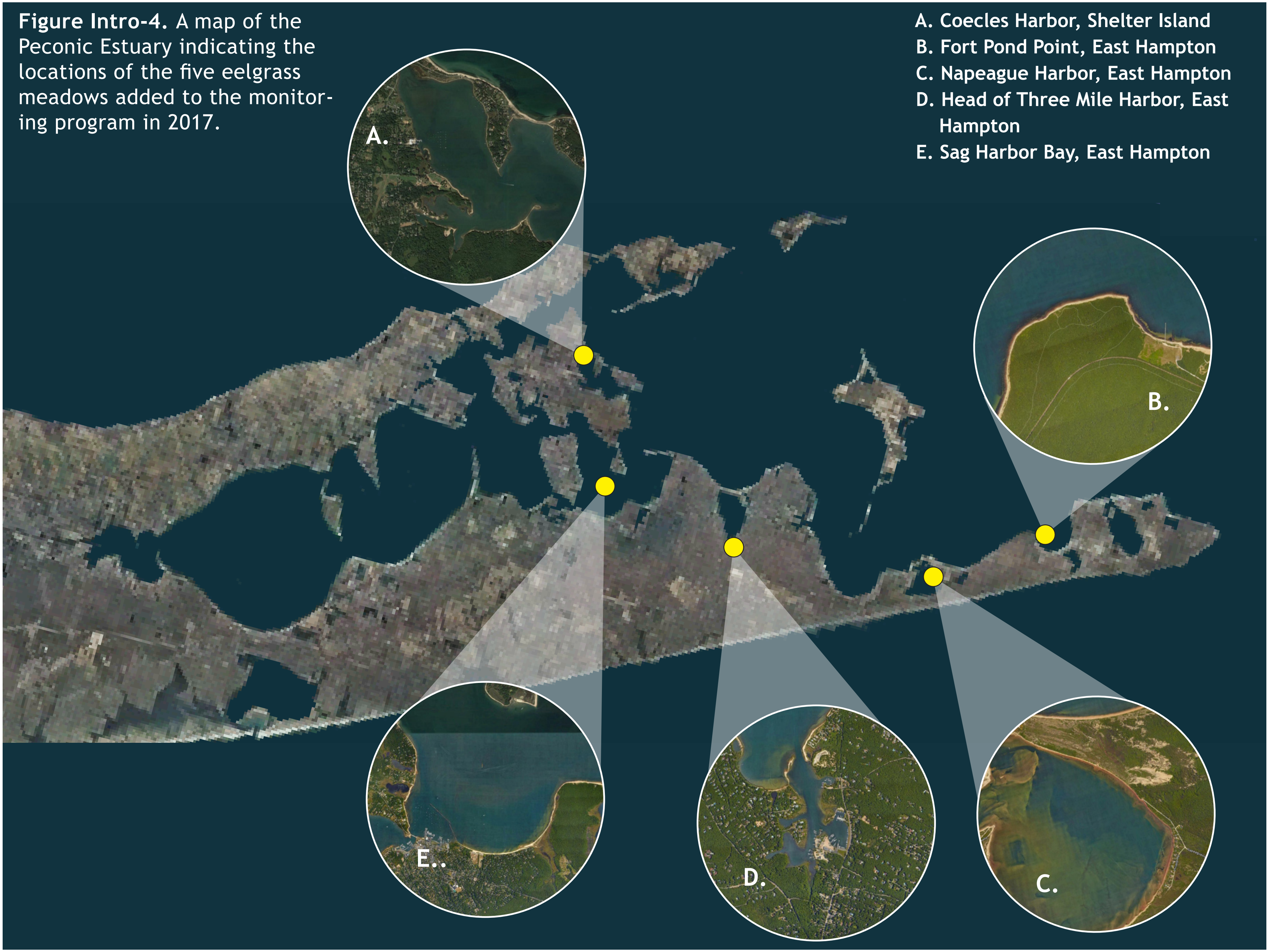


Figure Intro-4. A map of the Peconic Estuary indicating the locations of the five eelgrass meadows added to the monitoring program in 2017.

Introduction and Methods

At the time of this reporting, there are no 2022 aerial images available to complete delineations of the Bullhead Bay eelgrass meadow. If 2022 imagery becomes available at a later date, delineations will be completed and added to a revised monitoring report.

Underwater Video

As with previous monitoring efforts eelgrass monitoring, each diver was equipped with a GoPro Hero™ 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 2022

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.

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 10-day intervals, monthly, for 2021.

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	14.9	+2.3	14.3	+6.3	27.3
August	14.1	+1.8	13.3	+5.3	27.3
September	12.8	+0.5	12.3	+4.3	22.4

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, 2022, with the average Hcomp and Hsat for each month presented in Table BB-1 above. The 2022 season was dominated by clear, dry weather resulting in high Hcomp and Hsat values, and surplus light, for Bullhead Bay throughout the season. Additionally, water clarity was high within the meadows, as had been observed in previous years, allowing sunlight to reach the bottom of the bay with minimal attenuation.

Water temperature loggers were deployed in Bullhead Bay from early May through early October, 2022, with the average monthly water temperatures recorded for Bullhead Bay for July-September 2022 presented in Table BB-1. The 2022 season was warmer than the 2021 season with the Bullhead Bay meadow experienced 67 days with water temperatures exceeding 25°C, compared to 57 days in 2021. The meadow recorded a record 37 days (vs. 23 days in 2021) with water temperatures averaging above 27°C. The highest recorded water temperature in Bullhead Bay was 31.1°C on 23 July.

Eelgrass Shoot Density

The 2022 eelgrass monitoring visit to Bullhead Bay was conducted on 31 August. Divers were expecting eelgrass to be present due to observations made in the meadow in late October 2021 that found eelgrass recovering from the almost complete dieback reported in the 2021 monitoring report. By May 2022, when the logger station was being installed for the season,

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
2018	100	+/-9
2019	230	+/-19
2020	161	+/-9
2021	0	+/- 0
2022	180	+/- 13

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

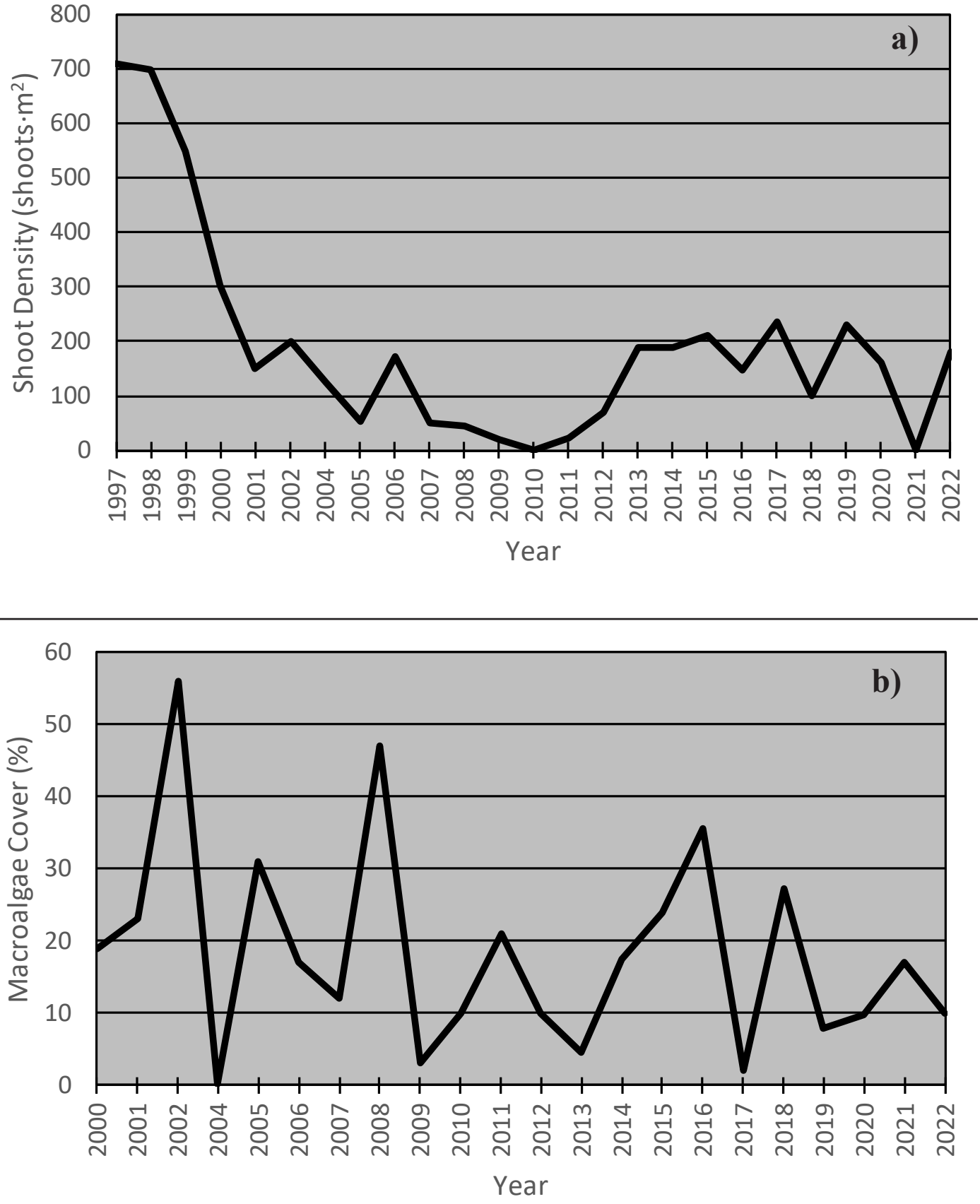


Figure BB-2. Graphs of average a) shoot density and b) macroalgae percent cover trends for all years of the PEP LTEMP conducted in Bullhead Bay.

Figure BB-3. The 2021 delineation of the Bullhead Bay eelgrass meadow. No aerial imagery was available for 2022.

eelgrass was readily evident once CCE personnel entered Bullhead Bay proper. By the monitoring visit in late August, there were no signs that the bay supported almost no live eelgrass just a year earlier. During the 2022 monitoring, divers found that eelgrass cover was relatively consistent with an average of 180 shoots·m^2 recorded for the meadow (Table BB-2; Figure BB-2a). This shoot density is similar to densities reported for 2019 and 2020. Divers did note that the a high percentage of the living eelgrass blades were covered with a cyanobacterial film, but this film was not evident when the site was visited later in September to deploy the light logger.

Macroalgae Cover

Macroalgae cover in the Bullhead Bay meadow remained relatively low in 2022 with an avaerage macroalgae cover of 10% (Figure BB-2b). This is a slight decrease from 2021 (17%). The macroalgae cover included only the macroalgae observed in the meadow. The cyanobacterial film observed during the monitoing visit was much more prevalent, covering close to 90% of the blades in the observed quadrats. Macroalgae species recorded included *Spyridia filamentosa*, *Gracilaria* sp., and *Sargassum filipendula.*

Bed Delineation and Areal Extent

At the time of this reporting, there are no 2022 aerial images available to complete delineations of the Bullhead Bay eelgrass meadow. If 2022 imagery becomes available at a later date, delineations will be completed and added to a revised monitoring report.

Conclusions

It is still unclear what caused the almost complete dieback of the Bullhead Bay eelgrass meadow in 2021, however, by late October 2021, the meadow was already showing signs of recovery with regenerated eelgrass shoots observed, in low densities, across the bay. Whatever the cause of this event, it seems like it stressed the eelgrass enough to cause sloughing of aboveground biomass, but did not result in mortality in the entire plant. Regeneration reported in the fall was likely from viable rhizomes, as water temperatures were still warm enough that seed germination ates would have been too low to account for the number and size of the shoots observed. By May 2022, there was no obvious indications that the meadow had suffered any dieback just 9 months earlier.

Table BB-3. Estimated areal coverage of the Bullhead Bay eelgrass meadow for select years from 2000-2022.

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.)
2018	56.12 acres (22.74 hect.)
2019	57.85 acres (23.41 hect.)
2020	60.1 acres (24.32 hect.)
2021	65.5 acres (26.5 hect.)
2022	ND

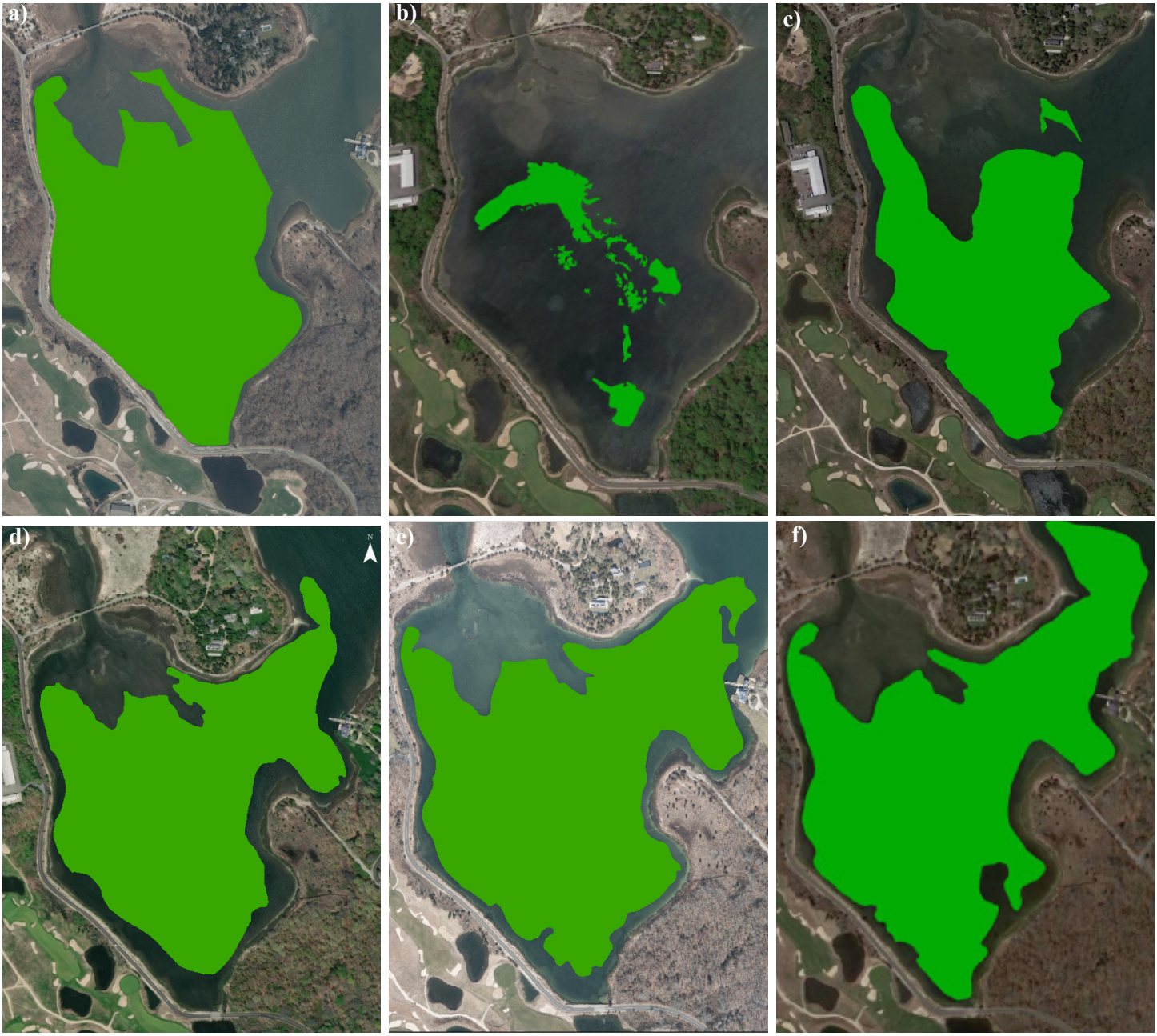


Figure BB-4. A series of aerial delineations of the Bullhead Bay eelgrass from 2000 through 2020. The years represented are a) 2000, b) 2010, c) 2016, d) 2019, e) 2020, and f) 2021.

One concern from the 2022 monitoring season was the presence of the cyanobacterial film on such a large proportion of the eelgrass shoots across Bullhead Bay. Cyanobacterial mats on the sediment surface have been observed and reported in this meadow previously, but this is the first time that eelgrass blades had been epiphytized by this organism. This could be a result of the high water temperatures, as cyanobacteria thrive under these conditions. This 'bloom' of cyanobacteria seemed to be short-lived and did not appear to result in an significant impact to the meadow, but if climate conditions continue to produce high temperatures, this 'bloom' could become prolonged and start to impact eelgrass health by shading the plants, similiar to Brown Tide. This situation will be monitored in the future.

The dieback, then subsequent recovery of the Bullhead Bay eelgrass meadow does provide some optimism regarding the rigor and regenerative ability of this meadow, at least to acute events. The relatively quick regeneration of aboveground biomass suggests that this eelgrass population is able to store enough energy in its rhizomes to survive negative impacts from short-term events.

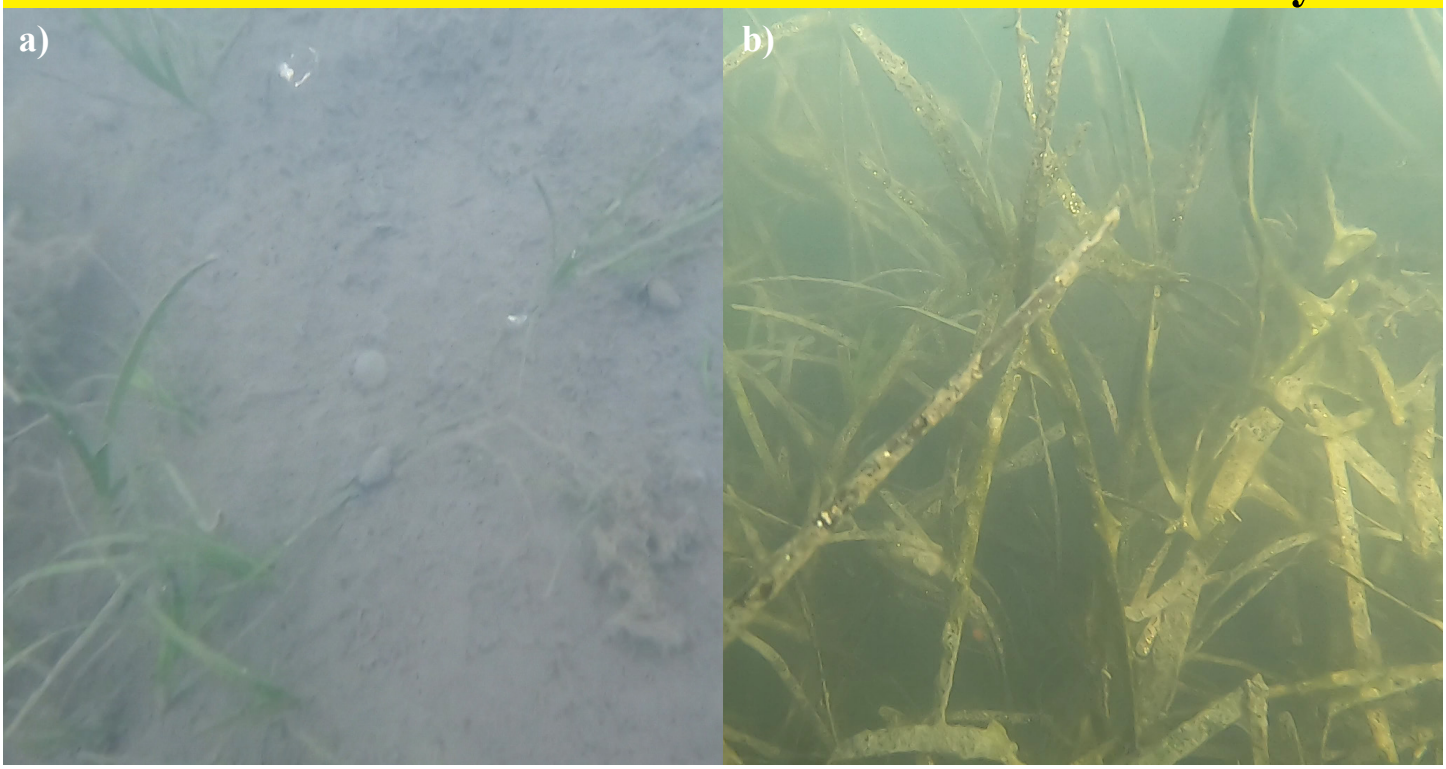


Figure BB-5. a) A photograph of the Bullhead Bay eelgrass meadow taken in May 2022 showing the recovery at Station 2 from the dieback event that occurred in August 2022. b) The same location in the meadow taken during the eelgrass survey visit in August 2022 with significantly increased shoot density, but shoots covered in layer of cyanobacteria.

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 2022

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 10-day intervals, monthly, for 2022.

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August	13.9	+1.6	13.0	+5.0	25.0
September	12.8	+0.3	12.2	+4.2	22.4

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

A light logger was installed by CCE divers in the Gardiners Bay eelgrass meadow for 10-day deployments, monthly for July-September 2022. Based on the light data presented in Table GB-1, the Gardiners Bay eelgrass meadow received more than enough light to exceed its minimum Hcomp and Hsat requirements for the months sampled. Hcomp and Hsat above minimum needs could be stored by plants for future use for reproduction and growth.

An Onset Hobo temperature logger was deployed in late-May, 2022 to continuous monitor water temperatures in the Gardiners Bay meadow. Table GB-1 includes the monthly averages recorded for the meadow for the period of July-September 2022. Water temperatures were warmer than the previous season with 21 days averaging over 25°C, compared to 5 days in 2021. The Gardiners Bay meadow did not record any average daily temperatures exceeding 27°C, but the site did record a high water temperature of 27.6°C on 9 August.

Eelgrass Shoot Density

The Gardiners Bay meadow's monitoring visit was

Table GB-2. The average annual eelgrass shoot density for Gardiners Bay from 1999 to 2022, 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
2018	96	+/-16
2019	151	+/-25
2020	113	+/-22
2021	98	+/-19
2022	127	+/-19

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

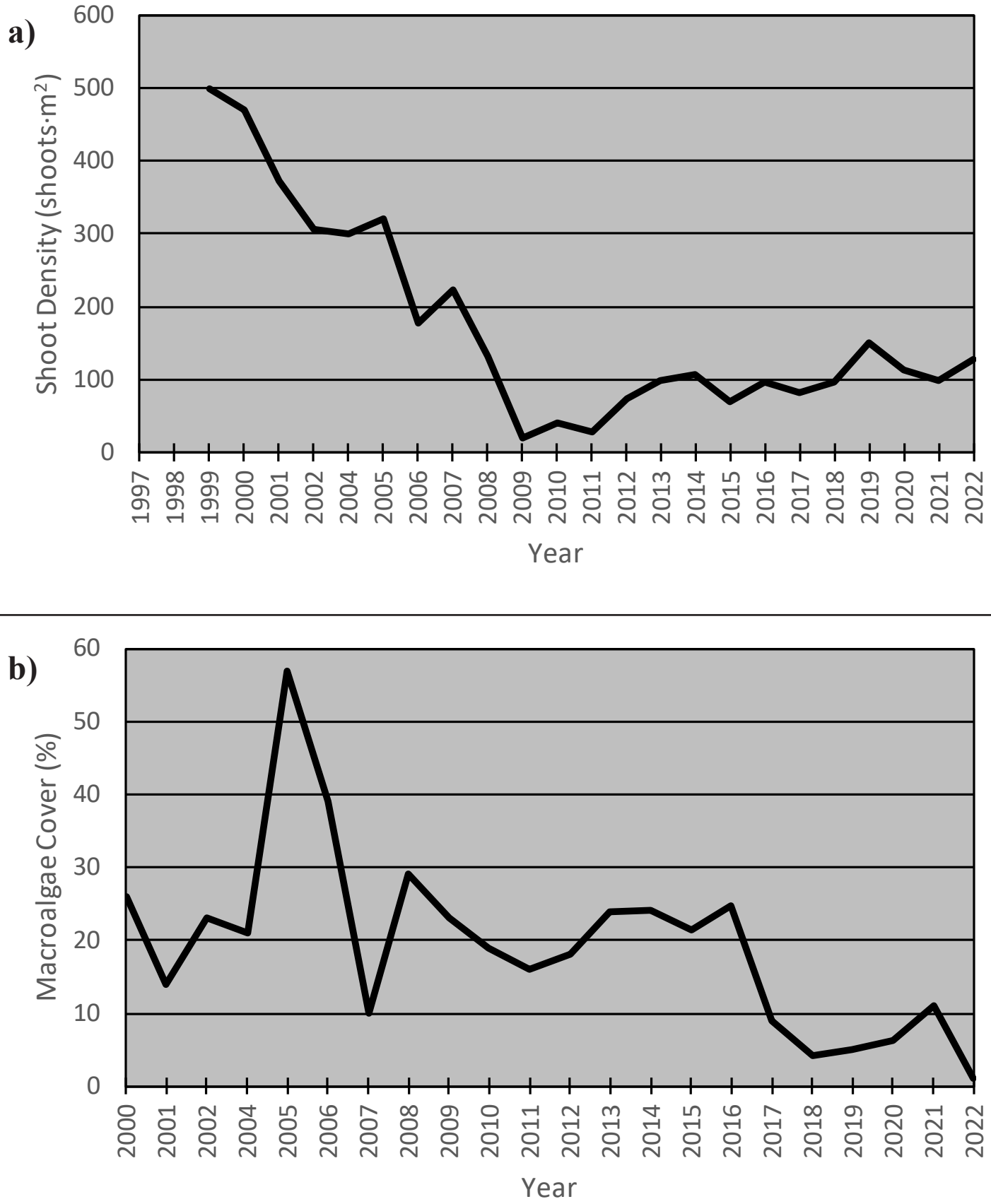


Figure GB-2. Graphs of average a) shoot density and b) macroalgae percent cover trends for all years of the PEP LTEMP conducted at the Gardiners Bay site.

Gardiners Bay 2022

Figure GB-3. The 2021 areal delineation of the Gardiners Bay eelgrass meadow on the northeast shore of Shelter Island, NY. No aerial imagery was available for 2022.

Table GB-3. The estimated areal coverage of the Gardiners Bay eelgrass meadow from 2000-2021.

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.)
2018	19.45 acres (8.42 hect.)
2019	19.6 acres (7.93 hect.)
2020	20.67 acres (8.37 hect.)
2021	20.48 acres (8.29 hect.)
2022	ND

conducted on 14 September, 2022. The 2022 season found significant expansion of eelgrass with shoots being recorded in six of the eight monitoing stations within the Gardiners Bay eelgrass meadow. In 2021, only 4 monitoring station reported eelgrass. The average eelgrass shoot density was up slightly in 2022 over the 2021 density (Table GB-2; Figure GB-2a), from 98 shoots·m^2 (2021) to 127 shoots·m^2 (2022). The eelgrass at most of the newly colonized stations consisted of small patches, but their establishment at previously unvegetated location at the site is encouraging, especially at the offshore stations (Stations 1 and 2; see Figure GB-1) .

Macroalgae Cover

The macroalgae percent cover in the Gardiners Bay eelgrass meadow for 2022 (1%), was the lowest ever recorded for the site (Figure GB-2b). While macroalgae cover was low, divers reported eight species of macroalgae, predominantly reds, including: *Spyridia filamentosa*, *Gracilaria* sp., *Sargassum filipendula, Ceramium rubrum, Polysiphonia* sp., *Ulva lactuca*, *Codium fragile*, and *Dasya baillouviana*.

Bed Delineation and Areal Extent

At the time of this reporting, there are no 2022 aerial images available to complete delineations of the Gardiners Bay eelgrass meadow. If 2022 imagery becomes available at a later date, delineations will be completed and added to a revised monitoring report.

Conclusions

The 2022 monitoring visit to the Gardiners Bay eelgrass meadow found the meadow to be healthy, and even expanding; a situation that has not been reported for this site in recent years. The recolonization observed is interesting in that it is occurring in offshore stations that were first to be lost in the mid to late 2000s. These stations (1, 2, and 4) are some of the deeper areas of the site and they experience moderate to high currents. These conditions would make natural recruitment by seed difficult. Currently, the eelgrass established in these stations consist of small scattered patches of eelgrass, and it is still to be seen whether small patches can survive and expand given the currents and potential light limitation due to depth.

There continues to be impact from human activities

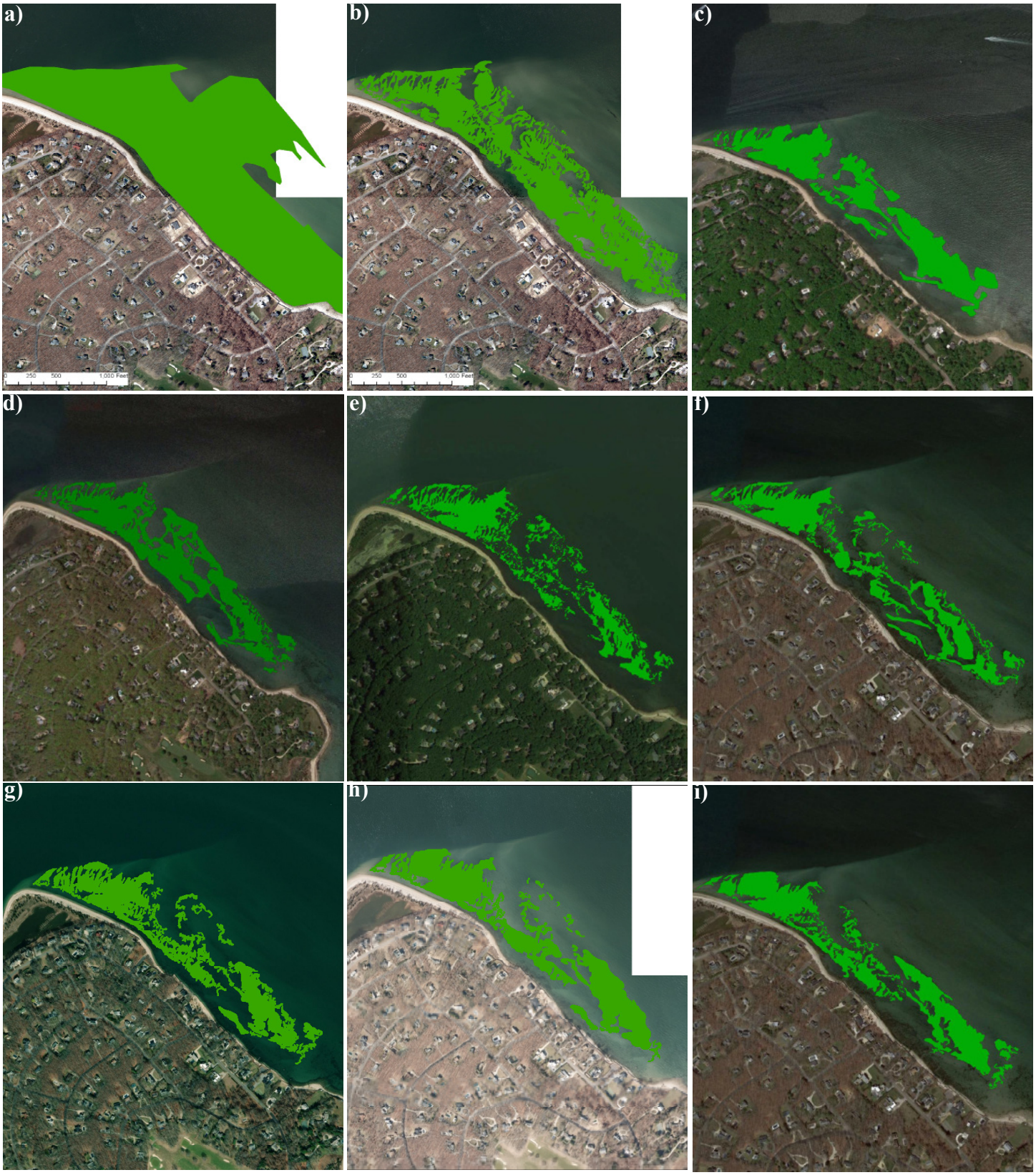


Figure GB-4. A series of aerial delineations of the Gardiners Bay eelgrass from select years from 2000 through 2016. The years represented are a) 2000, b) 2010, c) 2015, d) 2016, e) 2017, f) 2018, g) 2019, h) 2020, and i) 2021.

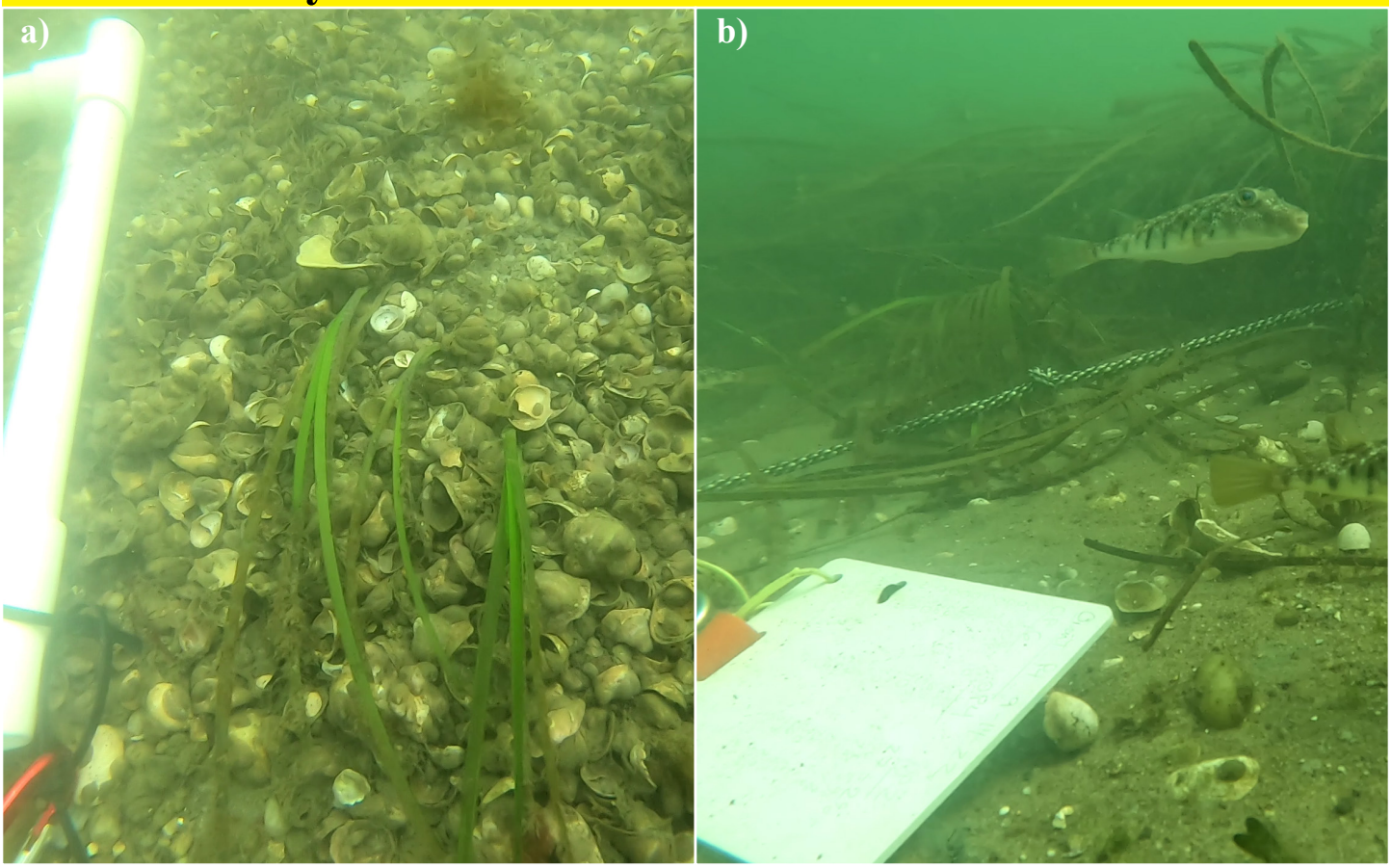


Figure GB-5. Underwater photographs taken by CCE divers while conducting the 2022 eelgrass monitoring at the Gardiners Bay LTEMP site. a) Eelgrass recorded growing for the first time in several years at Station 2. b) Northern puffers keeping diver company during quadrat count at Station 7.

at the site. Boat moorings, while reduced in number, still may be impacting the meadow if they are placed within, or immediately adjacent to the edge of the eelgrass. Boats transitting the site, outside of the navigational channel, also impact the meadow by leaving prop scars which expose the eelgrass roots and rhizomes increasing the fragmentation and erosion of the meadow.

Three Mile Harbor 2022

Following the 2014 Peconic Estuary aerial eelgrass survey, small meadows of eelgrass were identified in the headwaters of Three Mile Harbor, East Hampton. The larger of the meadows was added to the LTEMP program and had two monitoring stations assigned to the meadow (Figure TMH-1). With the retirement of the original Three Mile Harbor LTEMP site (located near Hands Creek), the headwaters meadow is now the only active eelgrass monitoring site in the harbor complex. 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 2022, as was the quadrat survey.

Figure TMH-1. An aerial photograph showing the location of the new Three Mile Harbor eelgrass meadow and its two monitoring stations.

Site Characteristics

The new Three Mile Harbor eelgrass meadow grows along the western edge of the channel that connects the headwaters of the harbor to the main harbor. The meadow starts close to shore, and extends into the deeper water of the channel. This area includes four marinas, so boat traffic during the season is high, although impact from boating is minimal due to the enforced 'No Wake' zone. Considering the location of the meadow and its distance from the mouth of the harbor, water temperatures have the potential to reach dangerous levels, however, it appears that there may be some submarine groundwater discharge at the site which may mitigate high water temperature.

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

Table TMH-1. H_{comp}, H_{sat} and temperature data calculated from the deployment of Odyssey PAR loggers and TidBit temperature loggers for the 'new' Three Mile Harbor site for 2022.

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	14.9	+2.6	14.2	+6.2	24.8
August	13.9	+1.6	13.1	+5.1	25.6
September	12.9	+0.6	12.4	+4.4	22.5

Odyssey PAR loggers were deployed for 10 days during July, August, and September, 2022 at the meadow at the head of Three Mile Harbor. The results are presented in Table TMH-1 and include average daily Hcomp and Hsat, as well as monthly average temperatures. The 2022 season was dominated by clear sunny weather, and this was reflected in the high levels of light that the Three Mile Harbor meadow received. Throughout the season, the eelgrass met and exceeded its minimum requirements for both Hcomp and Hsat. The surplus light would also have provided extra energy to be stored, or used to support growth and reproduction.

An Onset Hobo water temperature logger was deployed to Three Mile Harbor in late-May, 2022. The average monthly temperatures for July-September for the 2022 season are presented in Table TMH-1. The 2022 season proved to be hotter than 2021 with July water temperatures approaching 25°C, while August's monthly average exceeded that threshold. The Three Mile Harbor meadow experienced 38 days with water temperatures exceeding 25°C, compared to only 25 days in 2021. The 27°C threshold was exceeded one day during 2022 and the highest recorded temperature was 27.8°C reported on 23 July.

Table TMH-2. The average annual eelgrass shoot density for Three Mile Harbor (new site) from 2015 to 2022, including standard error.

Year	Mean Density	S.E.
2015	177	+/- 17
2016	209	+/- 20
2017	120	+/- 17
2018	79	+/- 20
2019	42	+/- 13
2020	90	+/- 14
2021	15	+/- 5
2022	88	+/- 16

Eelgrass Shoot Density

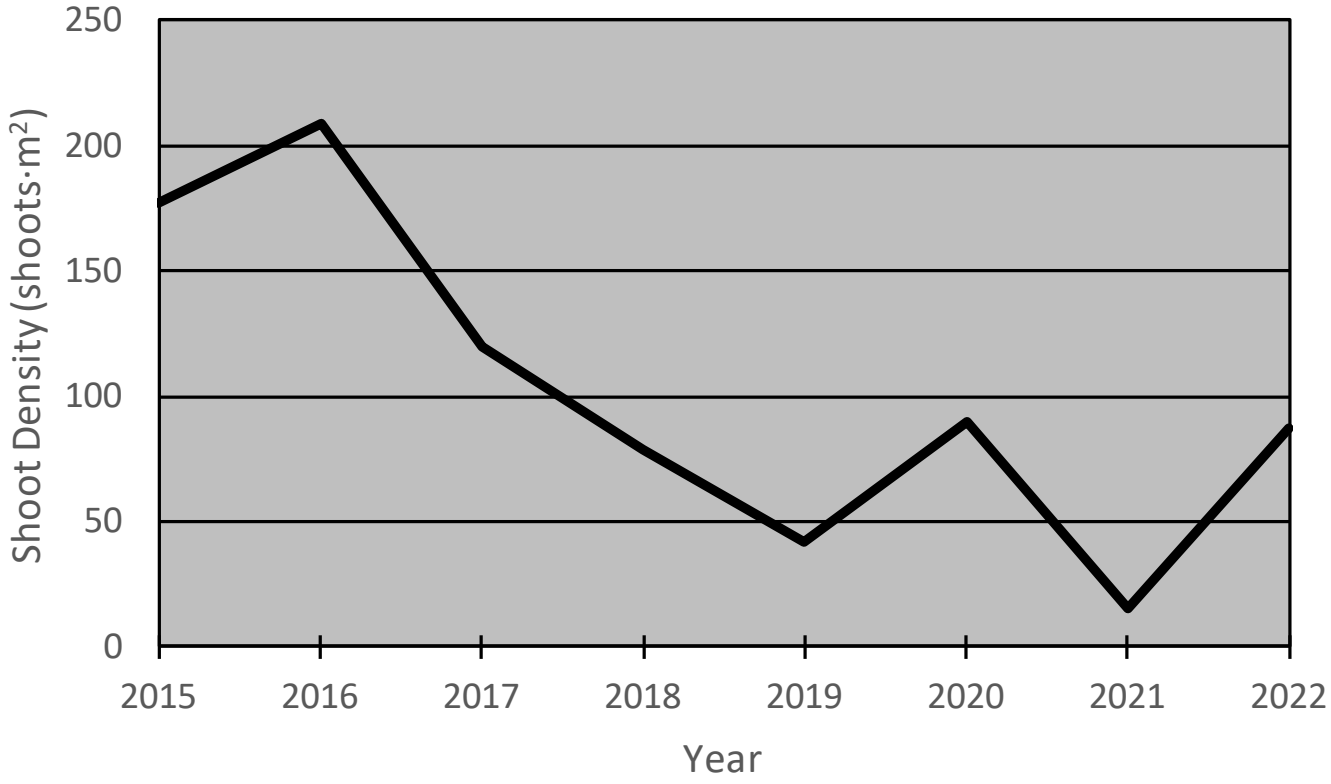
Three Mile Harbor was visited on 30 August, 2022. The monitoring survey was conducted at the two stations in the 'new' site at the head of the harbor (Figure TMH-1). The eelgrass meadow showed significant recovery from a low 15 shoots·m^2 in 2021. Divers found the eelgrass rebounded to an average shoot density of

Table TMH-3. The estimated cover of eelgrass in Three Mile Harbor for all years surveyed.

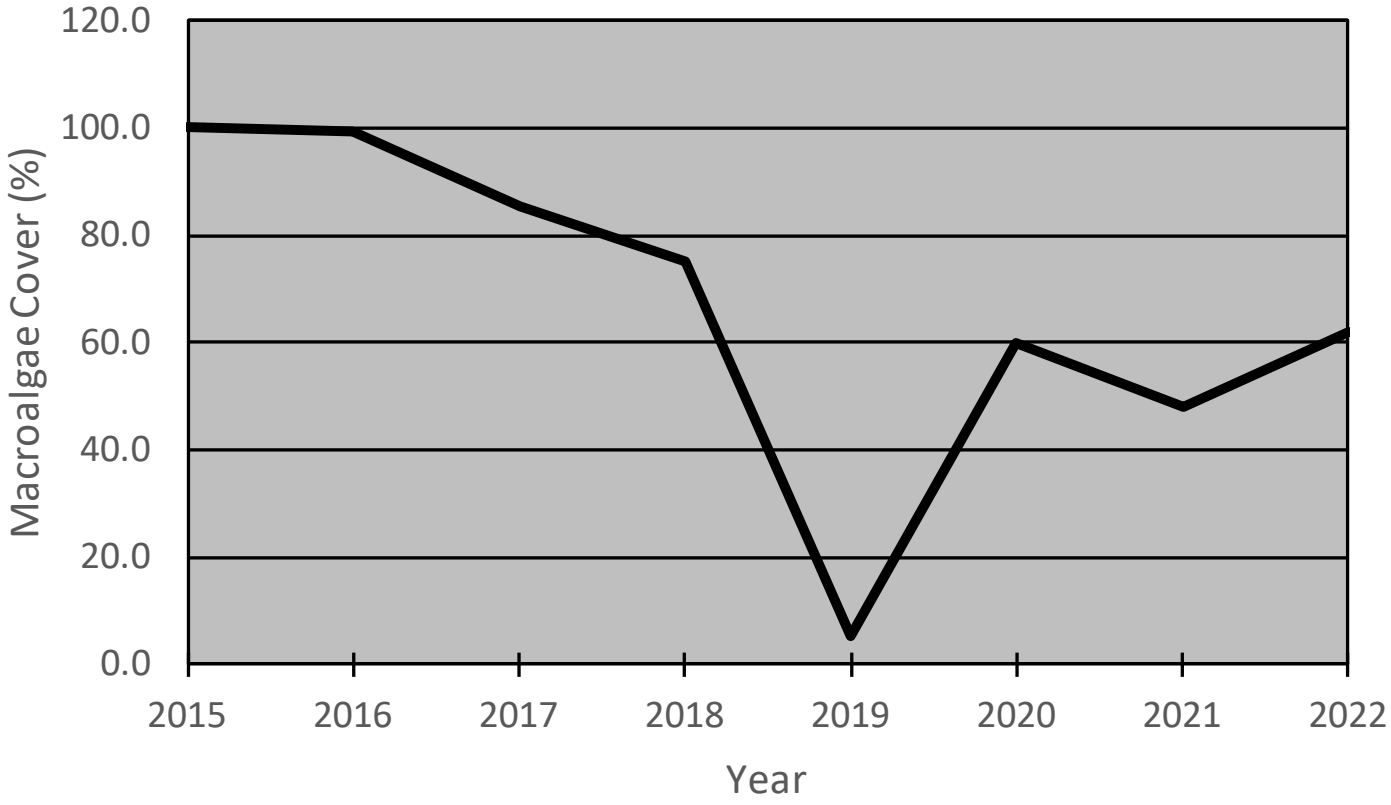
Year	Estimated Area
2014	0.66 acres (0.27 hect.)
2015	0.67 acres (0.27 hect.)
2016	0.68 acres (0.28 hect.)
2017	0.81 acres (0.33 hect.)
2018	0.67 acres (0.27 hect.)
2019	1.4 acres (0.57 hect.)
2020	3.1 acres (1.25 hect.)
2021	3.74 acres (1.51 hect.)*
2022	ND

*Meadow extent at time of monitoring was significantly smaller.

Three Mile Harbor 2022



a)



b)

Figure TMH-2. Graphs of average a) shoot density and b) macroalgae percent cover trends for all years of the PEP LTEMP conducted at the 'new' Three Mile Harbor site.

Figure TMH-3. Aerial views of the eelgrass meadow (new Three Mile Harbor) at the head of Three Mile Harbor presenting the a) 2014, b) 2019, c) 2020, and d) 2021 meadow delineations.

88 shoots·m^2 (Table TMH-2; Figure TMH-2a). While this density is still low compared to the shoot density recorded in 2016, the 2022 results indicate that this meadow maintains the ability to recover from setbacks and provides a bit of optimisim regarding its resilience.

Figure TMH-4. Visibility was low during the 2022 survey in the Three Mile Harbor meadow, but divers found both eelgrass (white arrow) and widgeongrass (*Ruppia maritima*) (black arrow) occupying the inshore edge of the meadow.

Macroalgae Cover

With the rebound of the eelgrass meadow in Three Mile Harbor, came a resurgence of macroalage. Macroalgae cover increased from 48% (2021) to 62% (2022) (Figure TMH-2b) a monoculture of the red seaweed *Spyridia filamentosa*. No other species were recorded occurring within the meadow, but a mat of *Ulva lactuca* was observed inshore of the meadow's edge.

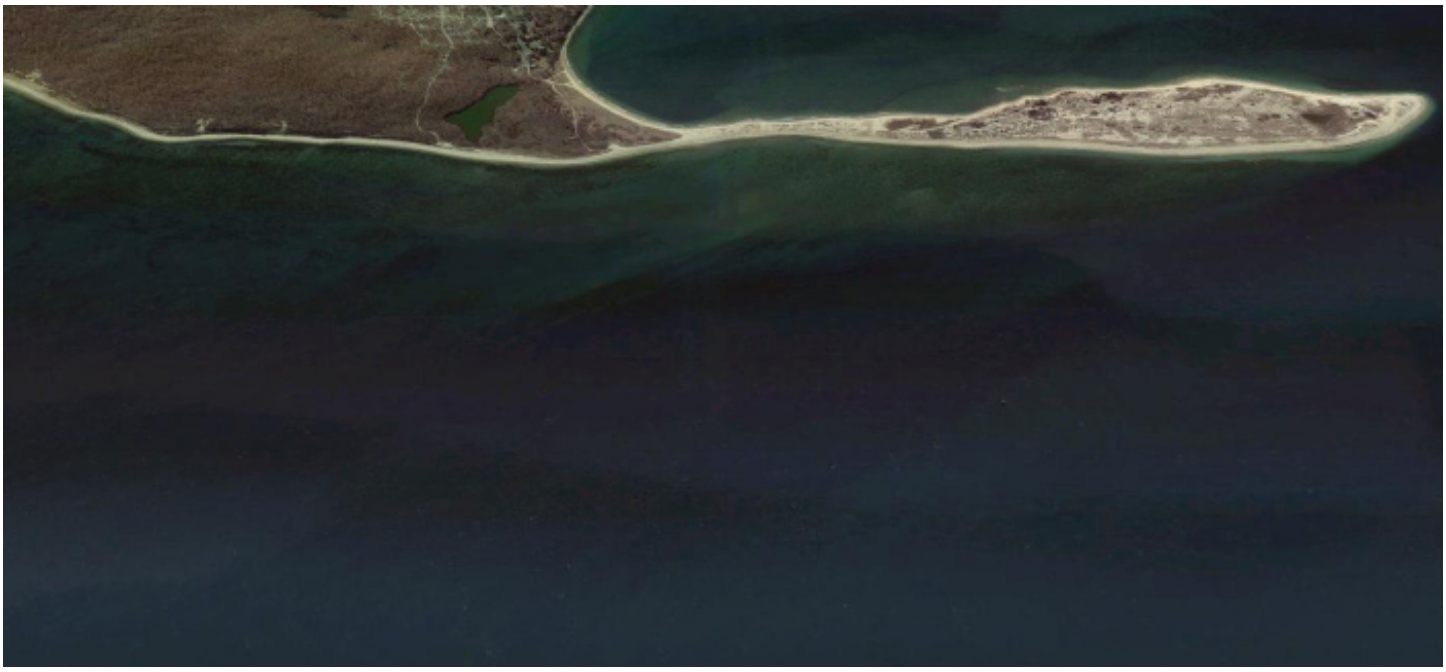
Bed Delineation and Areal Extent

At the time of this reporting, there are no 2022 aerial images available to complete delineations of the Three Mile Harbor eelgrass meadow. If 2022 imagery becomes available at a later date, delineations will be completed and added to a revised monitoring report.

Conclusions

The Three Mile Harbor meadow was found to have rebounded from its low eelgrass density in 2021 to its former density of close to 90 shoots·m^2 in 2020. The recovery of the meadow was not readily evident in late-May, when the temperature logger was deployed for the season, but on subsequent visits to the site to deploy the light logger, it became more obvious. With high summer water temperatures impacting this meadow for longer periods of time, some concern should be given as to how long the eelgrass will be able to persist. However, that eelgrass has continued to survive at the site suggests that there may be some factor helping to mitigate the high water temperature, possibly submarine groundwater discharge (SGD), in these two locations in Three Mile Harbor. As the potential for SGD to provide temperature refugia for eelgrass meadows has a growing interest in the region, this site might be a viable location to identify and quantify the influence, if any, of SGD on this eelgrass population. If SGD mitigating water temperatures were to be ruled out, then it could be possible that this eelgrass population could harbor a natural heat tolerance that could be transferred into other populations through culture or outplantings.

Cedar Point 2022



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 2022 at Cedar Point, East Hamp-

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 2022.

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	14.9	+2.6	14.0	+6.0	22.9
August	13.7	+2.4	12.7	+4.7	24.2
September	12.7	+1.4	11.8	+3.8	22.0

ton. The Cedar Point eelgrass meadow has generally maintained high water clarity in the past, and the 2022 season continued this trend. The light data (Table CP-1), shows that the site received an abundant amount of light over the monitoring period allowing the eelgrass to meet its minimum metabolic needs. Additionally, the additional net light will drive reserve energy production to support future metabolic needs in this meadow.

The water temperature logger for Cedar Point was deployed late-May 2022, near monitoring station 3. The monthly average temperatures for the site are found in Table CP-1, and while 2022 proved to be a warmer year that 2021 for most LTEMP sites, the Cedar Point site only recorded one day with average daily water temperatures above 25°C. The highest recorded water temperature for 2022 was 25.9°C, reported on 8 August.

Eelgrass Shoot Density

The Cedar Point monitoring visit was conducted on 13 September, 2022. The average eelgrass shoot density in 2022 was up from 2021 by 74 shoots·m^2, from 252 shoots·m^2 to 326 shoots·m^2 (Table CP-2; Figure CP-2). The meadow continues to show recovery from the decline recorded in 2020 and the 2022 shoot density places the meadow around the average density of the meadow over the 15-years of monitoring the site.

Macroalgae Cover

The 2022 monitoring visit to Cedar Point found that the macroalgae cover increased slightly from the 2021 cover of 11%, but still remained low compared to other years (Figure CP-3). A total of eight specices of macroalgae were recorded during the 2022 monitoring survey. *Sargassum filipendula* continues to be the codominant macrophyte species at Cedar Point. The

Table CP-2. The annual average eelgrass shoot density for Cedar Point for 2008 through 2022, 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
2018	225	+/-36
2019	221	+/-33
2020	181	+/-24
2021	252	+/-27
2022	326	+/-32

Table CP-3. The estimated cover of the eelgrass meadow at Cedar Point for select years from 2000-2022.

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.)
2018	73.6 acres (29.80 hect.)
2019	69.8 acres (28.25 hect.)
2020	76.6 acres (31.00 hect.)
2021	81.0 acres (32.78 hect.)
2022	ND

Cedar Point 2022

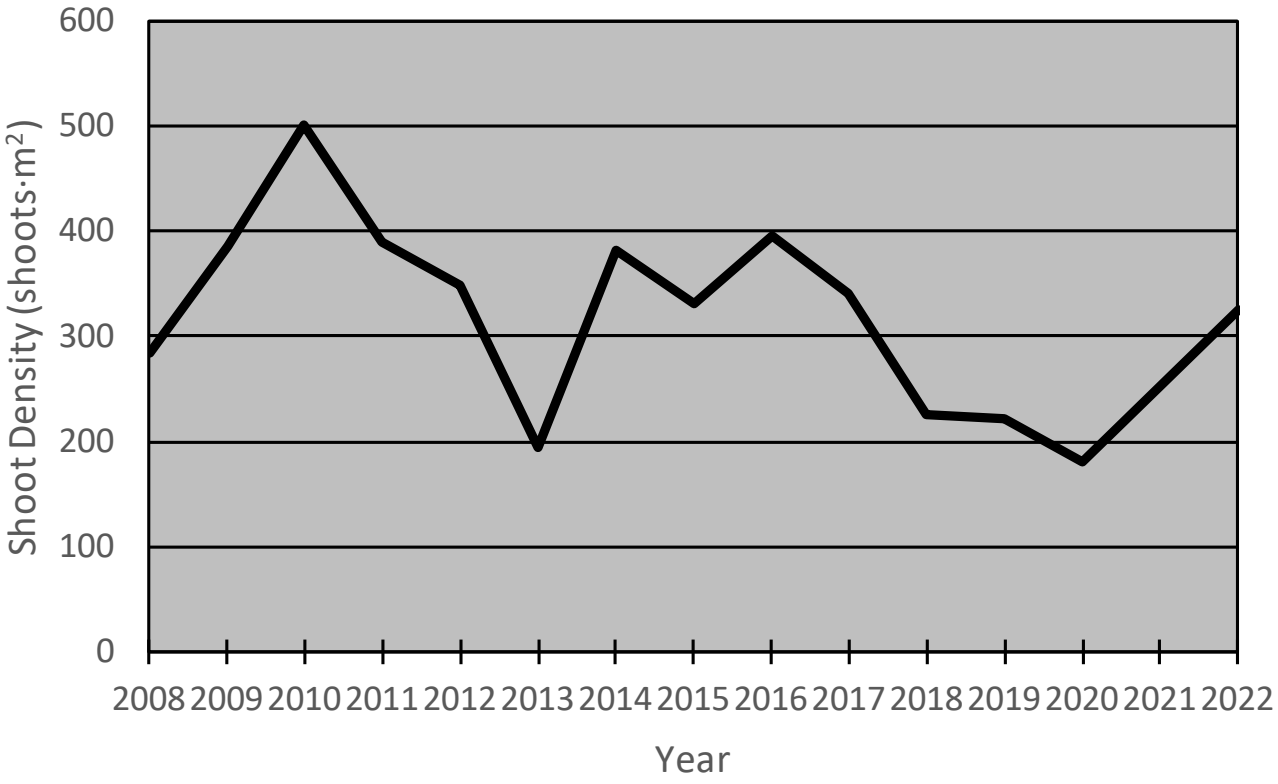


Figure CP-2. The average annual eelgrass shoot density for Cedar Point for 2008-2021.

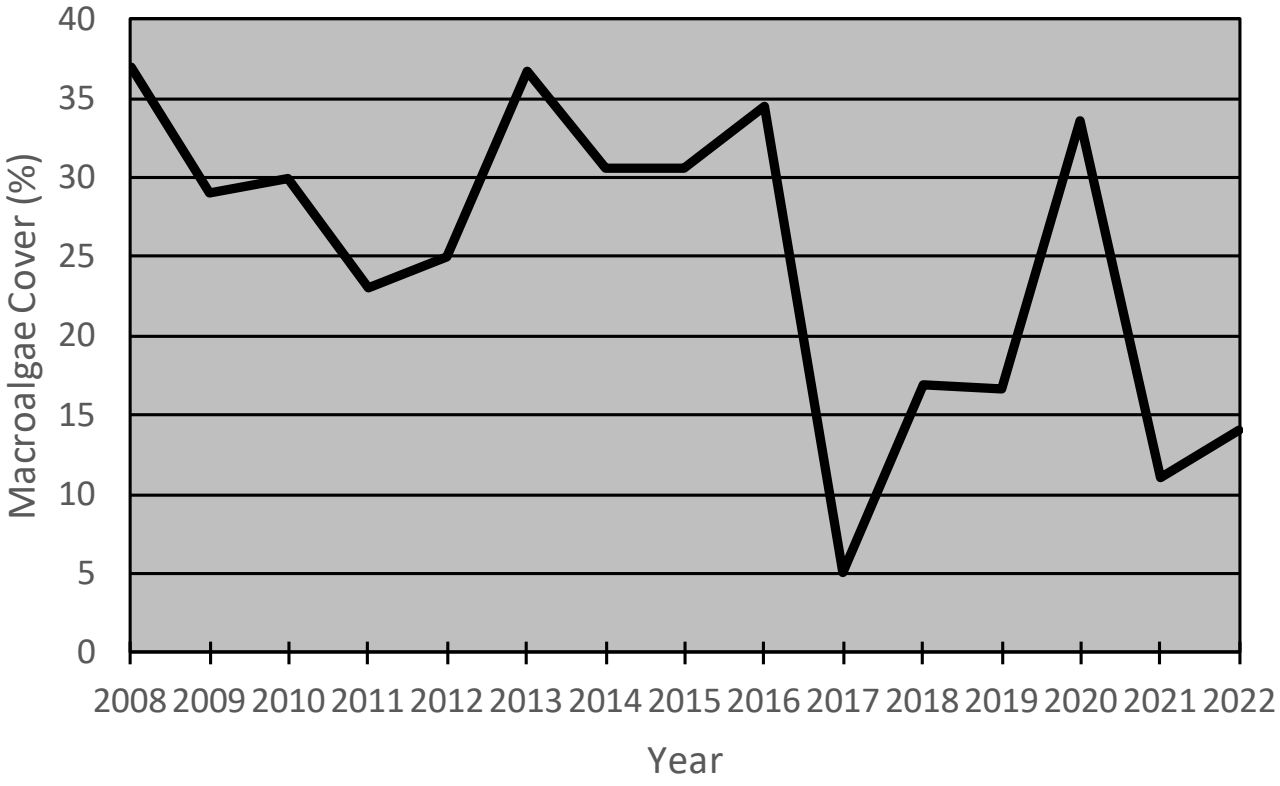


Figure CP-3 Annual mean macroalgae cover for Cedar Point, East Hampton from 2008 to 2022.

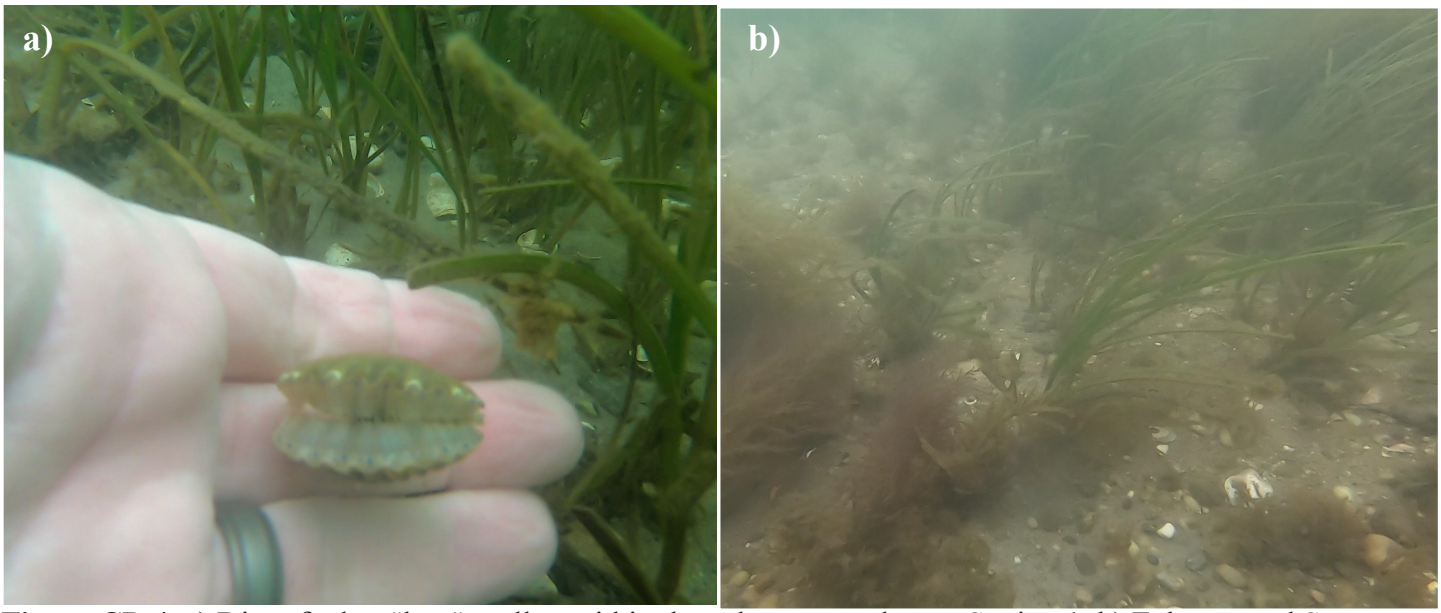


Figure CP-4. a) Diver finds a "bug" scallop within the eelgrass meadow at Station 1. b) Eelgrass and Sargassum co-exist at Station 5.

other species observed included *Fucus* species, *Halosiphon tomentosus*, S*pyridia filamentosa*, *Chondrus crispus*, Polysiphonia species, *Grinnellia americana*, *Codium fragile* and *Ulva* species.

Bed Delineation and Areal Extent

At the time of this reporting, there are no 2022 aerial images available to complete delineations of the Cedar Point eelgrass meadow. If 2022 imagery becomes available at a later date, delineations will be completed and added to a revised monitoring report.

Conclusions

Based on the 2022 annual eelgrass monitoring at Cedar Point, the meadow has maintained healthy shoot densities, even while the meadow continues to show annual fluctuations in areal extent and patchiness. Environmental conditions at Cedar Point, and the other LTEMP meadows that are located on our open shores have remained in the optimal range for eelgrass with few days during the season reaching 25ºC and high water clarity. The most significant impact to the Cedar Point eelgrass meadow comes from physical disturbance caused by the increased frequency and intensity of storm-generated waves. This meadow suffered significant physical damage from Super Storm Sandy 10 years ago that it has still not fully recovered from and future changes to climate may prevent a full recovery of lost meadow areas and lead to increase erosional danage to the meadow going forward. The annual changes due to storm damage are difficult to pick up on infrequent aerial surveys, however the use of drones to provide more frequent imagery could be used to better characterize the impacts of the changing climate on an open coast eelgrass meadow like Cedar Point.

Cedar Point 2022

Figure CP-5. Delineations of the Cedar Point eelgrass meadow from aerial photographs for a) 2004, b) 2010, c) 2014, d) 2019, e) 2020, and f) 2021 (continued on next page).

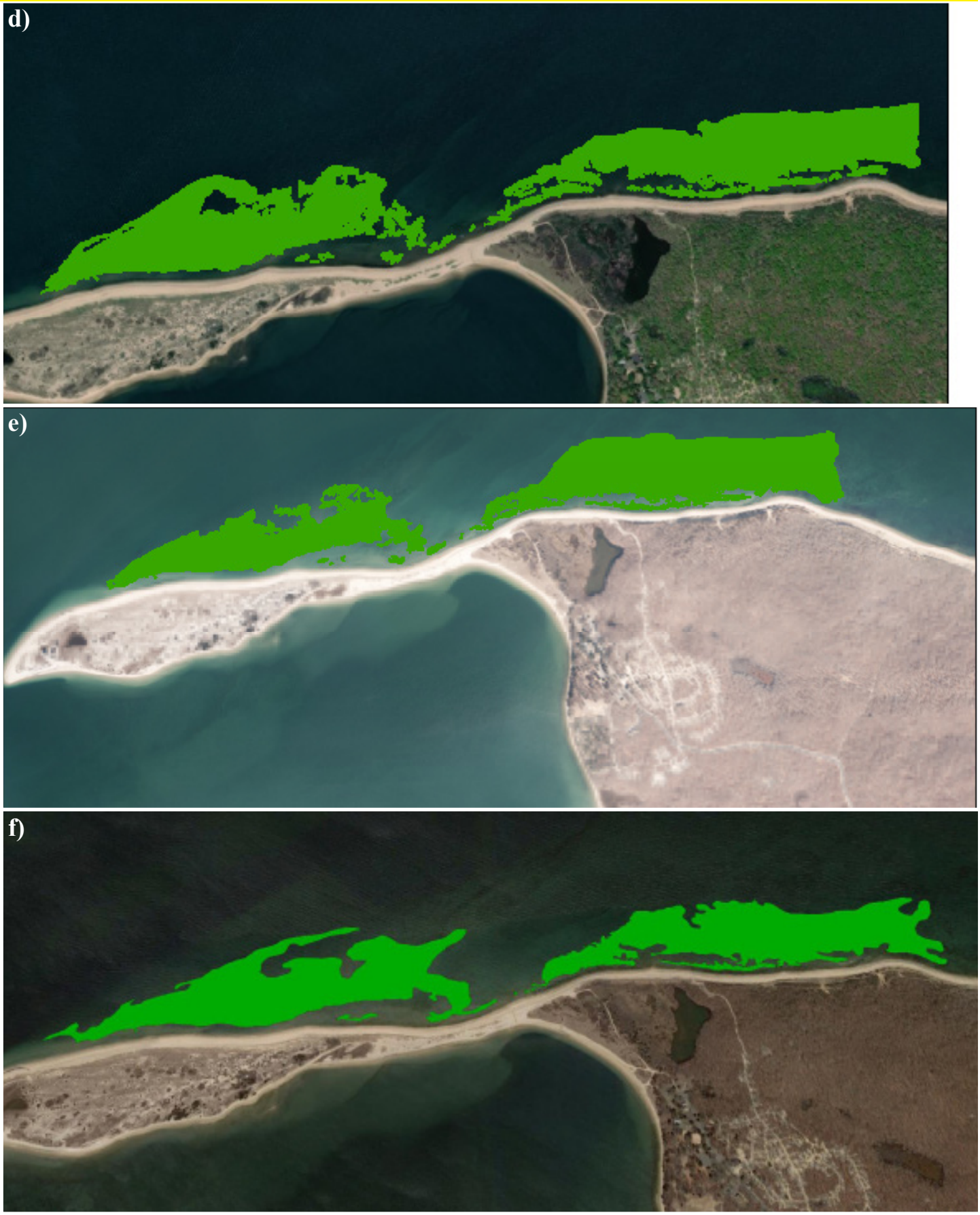


Figure CP-4. Continued.

Orient Point 2022

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 10-day intervals, monthly, for 2022. There is no light data for September due to the loss of the light logger prior to retrieval.

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	15.0	+2.7	14.2	+6.2	21.6
August	14.1	+1.8	13.2	+5.2	23.2
September	12.8	+0.5	12.1	+4.1	22.2

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

The Orient Point light logger was deployed for 10-day periods, once monthly from July-September 2022. Light availability exceeded the minimum threshold for both Hcomp and Hsat in the Orient Point meadow for all months sample (Table OP-1). Water clarity was extemely high during the summer of 2022, as mentioned for other LTEMP sites, and lead to abundant light reaching eelgrass blades on the bottom. The high Hsat levels would have generated significant energy resources that the plants would use for growth or store in their rhizomes.

Water temperature was monitored by deploying an Onset Hobo temperature logger in the Orient Point meadow in mid-May 2022. The Orient Point eelgrass meadow has not experienced issues with high summer water temperatures since its inclusion in the program, and the 2022 continued this trend. Monthly average water temperature (Table OP-1) remained well below 25ºC and the meadow did not record any days where average daily water temperatures exceeded this threshold. The highest water temperature recorded in 2022 for the Orient Point meadow was reported on 29 August when water temperatures reached 25.5ºC.

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
2018	97	+/-18
2019	128	+/-33
2020	91	+/-24
2021	146	+/-25
2022	138	+/-21

Eelgrass Shoot Density

The 2022 eelgrass monitoring visit to Orient Point was conducted on 14 September, 2022. There was no significant change in eelgrass shoot density in the Orient Point eelgrass meadow between 2021 and 2022 (Table OP-2; Figure OP-2). The average eelgrass shoot density for 2002 was 138 shoots·m^2, which was down slightly from 146 shoots·m^2 in 2021 (Table OP-2; Figure OP-2). Monitoring stations 4 and 6 (Figure OP-1) continue to be devoid of eelgrass, but station 1, which reported no eelgrass in 2021, recorded eelgrass in two of the 10 quadrats. Divers also noted that more eelgrass patches were observed in otherwise bare bottom adjacent to the monitoring station.

Macroalgae Cover

The Orient Point site maintains a healthy macroalgae community. In 2022, the average macoralgae cover for the Orient Point meadow was reported to have increased from 22% in 2021, to 36% in 2022(Figure OP-3). Divers identified nine species of macroalgae in 2022. Similar to Cedar Point, Orient Point hosts a healthy population of the brown seaweed *Sargassum*

Orient Point 2022

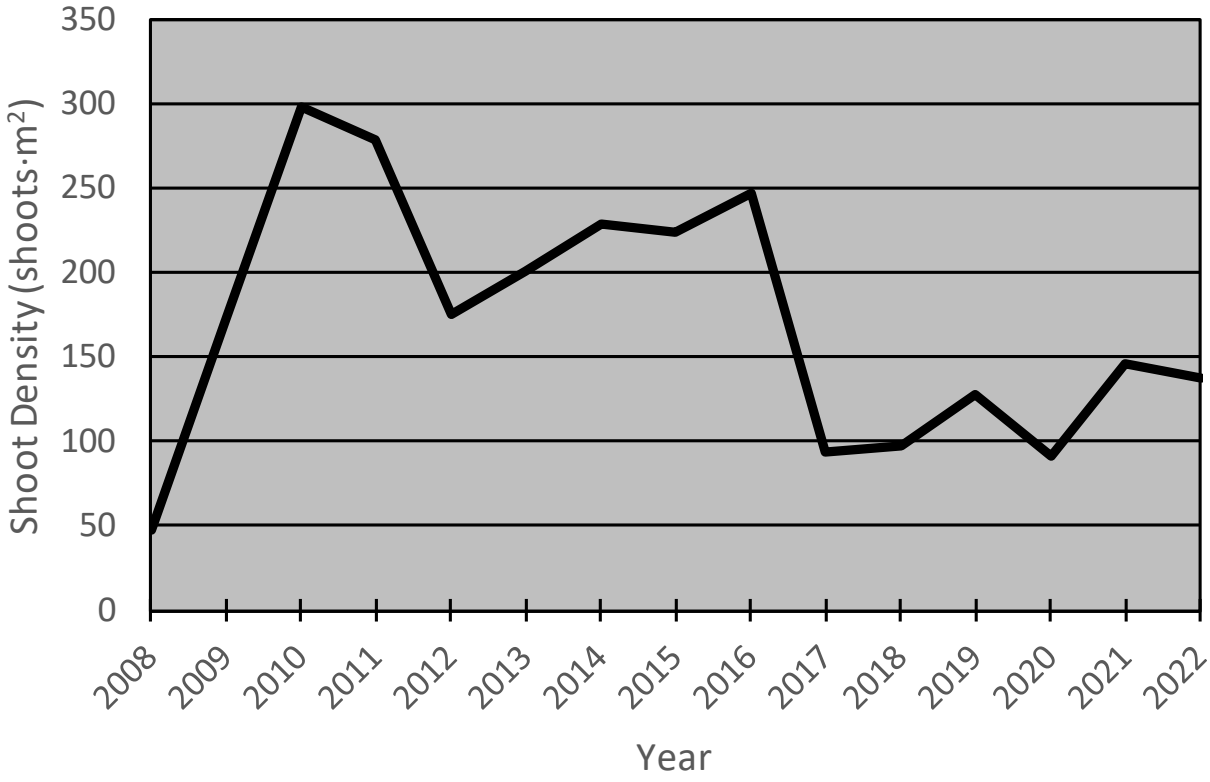


Figure OP-2. Graph of the annual mean eelgrass shoot density for Orient Point from 2008-2022.

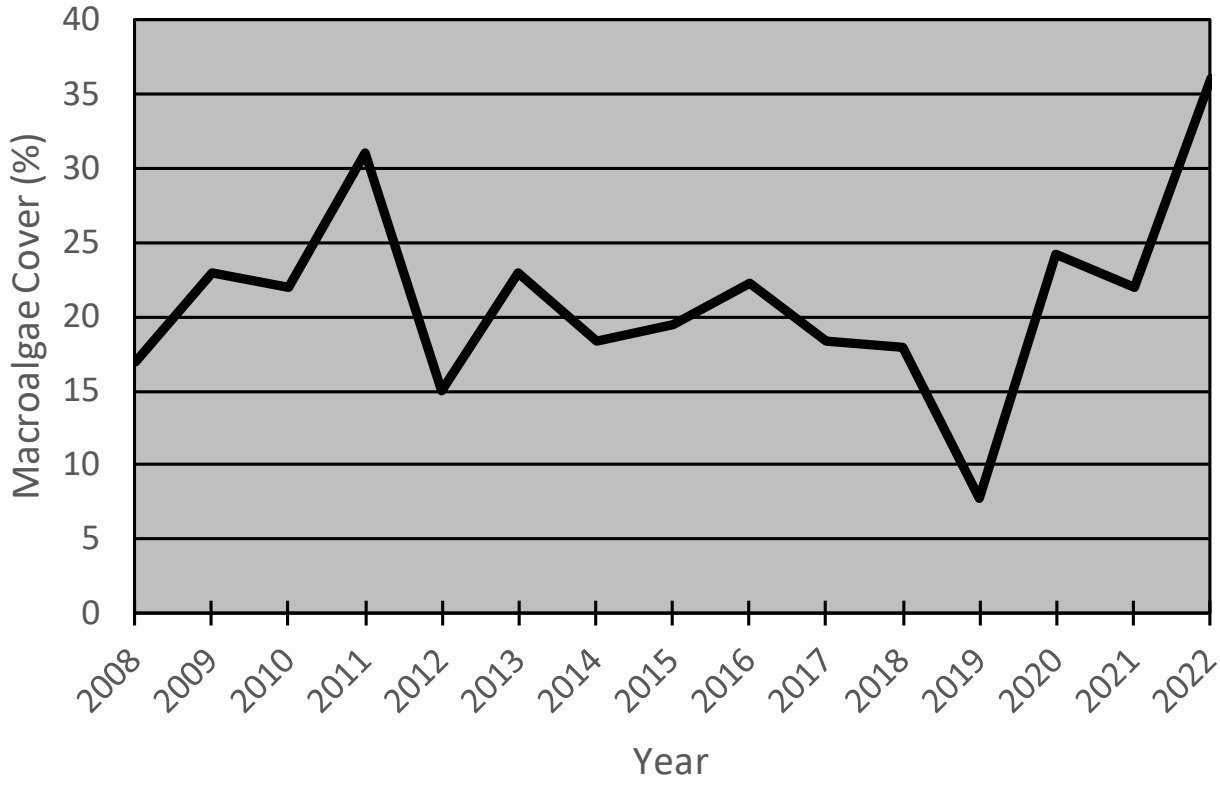


Figure OP-3. The annual mean macroalgae percent cover for Orient Point from 2008-2022.

Table OP-3. Trend analysis of the estimated area of the Orient Point meadow as determined from aerial photographs from 2000 to 2022.

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.)
2018	10.8 acres (4.37 hect.)
2019	13.1 acres (5.30 hect.)
2020	16.6 acres (6.72 hect.)
2021	12.87 acres (5.21 hect.)
2022	ND

*Area of meadow was significantly underestimated in aerial survey.

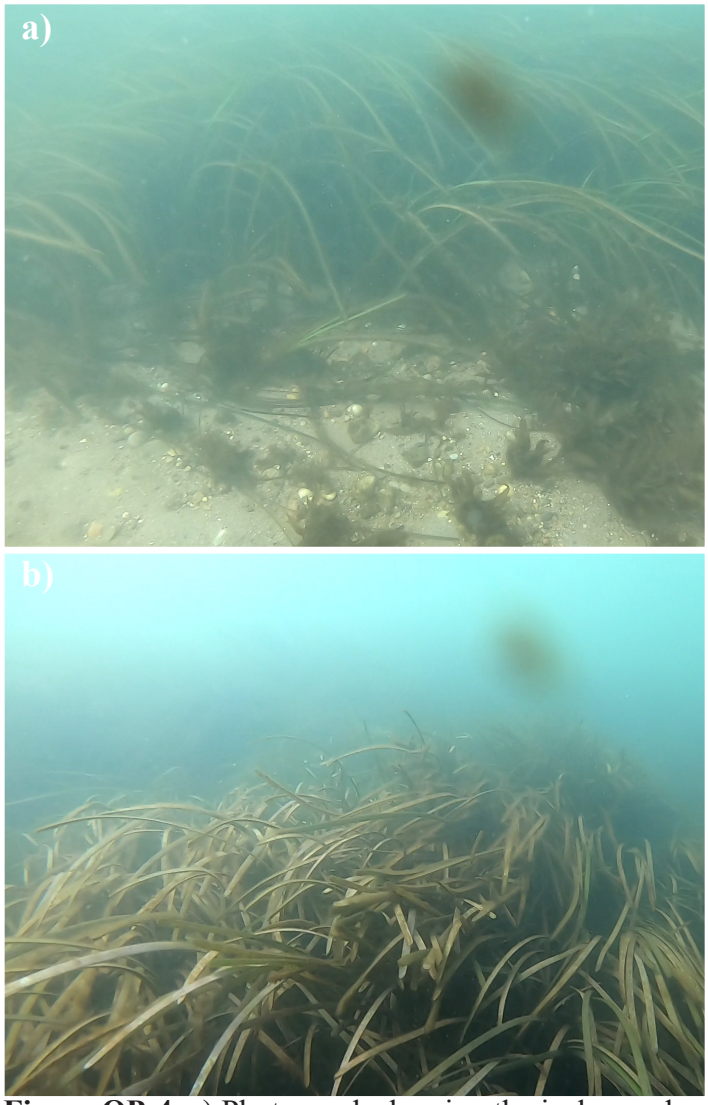


Figure OP-4. a) Photograph showing the inshore edge at Station OP3. b) Consistent, dense eelgass cover found Station 5.

*filipendula*as, which is the dominant species on site. Secondary species recorded at the site in 2022 included *Chondrus crispus*, *Spyridia filamentosa*, *Fucus* sp., multiple *Polysiphonia* species, *Dasya baillouviana*, and *Ulva lactuca*. Two invasive, non-native species, *Codium fragile* and *Grateloupia turuturu*, were reported within the meadow.

Bed Delineation and Areal Extent

At the time of this reporting, there are no 2022 aerial images available to complete delineations of the Orient Point eelgrass meadow. If 2022 imagery becomes available at a later date, delineations will be completed and added to a revised monitoring report.

Conclusions

The Orient Point eelgrass meadow continues to maintain a stable population at the site. Shoot density has trended higher since its decline in 2017, and the areal extent of the meadow appears to relatively stable. The increase in frequency and intensity of storms, due to climate change are having an observable effect on the shoreline along the meadow. Erosion of the low bluff has moved sediment into the shallow, nearshore areas of the meadow, which could result in burial of eelgrass. The loss of eelgrass in station 1 in 2021 pointed to the coastal erosion as a possible cause. The appearance of patches of eelgrass within station 1 in 2022 suggests that the meadow has the potential to recolonize lost areas, at least in the shallower sections of the meadow. In contrast, there has been no observed recruitment of eelgrass to stations 4 and 6, indicating that current conditions, likely light availability, don't support eelgrass at this time. Besides the physical disturbance produced by storms, the Orient Point eelgrass meadow experiences optimal conditions for growth, similar to the conditions at Cedar Point, which should allow it to maintain its presence at the site into the future.

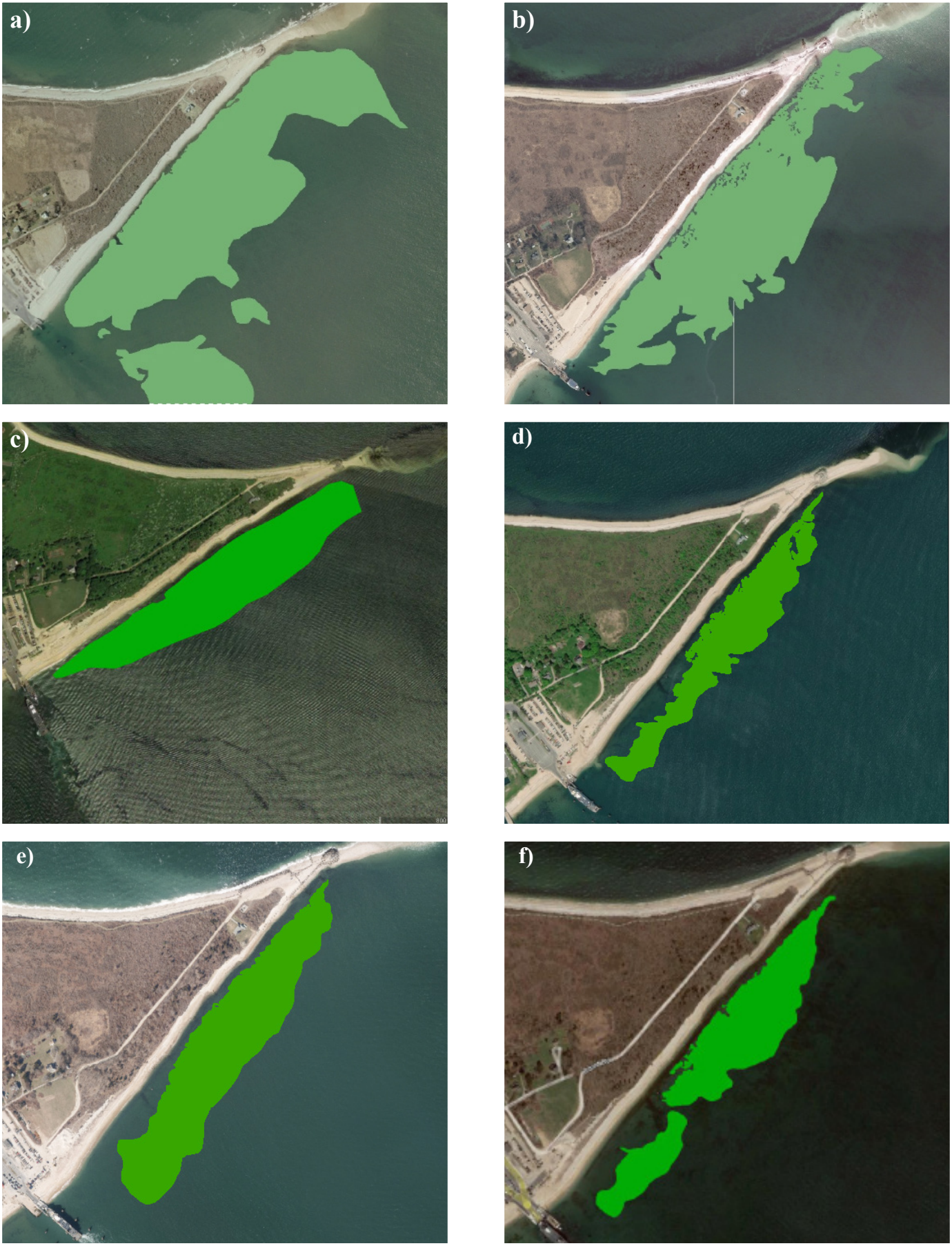


Figure OP-5. Delineations of the Orient Point, Southold, NY eelgrass meadow from aerial imagery for a) 2004, b) 2010, c) 2014, d) 2019, e)2020, and f) 2021.

Coecles Harbor 2022

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 observations 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 *Margalefidinium 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

An Odyssey PAR light logger was deployed to Coecles Harbor for 10-day intervals, monthly (July-September) for the 2022 season. The daily average Hcomp and Hsat for the 2022 season is presented in Table CH-1. Water clarity in Coecles Harbor was not as high as other LTEMP sites in 2022, but the meadow received enough light to meet its needs regarding Hcomp and Hsat throughout the season. In terms of Hsat, the eelgrass in Coecles Harbor received surplus light that would have resulted in production of extra carbohydrate reserves that the plants could use for growth and reproduction.

An Onset HOBO temperature logger was deployed

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-day intervals, monthly, for 2022.

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	15.0	+2.7	14.1	+6.1	25.0
August	12.9	+0.6	12.0	+4.0	25.8
September	12.8	+0.5	12.1	+4.1	22.2

to Coecles Harbor in late-May 2022. Table CH-1 includes the monthly average water temperatures for 2022. High water temperatures began in July for Coecles Harbor and continued into August. The eelgrass meadow experienced 39 days with average daily water temperatures greater than 25°C. For 2022, this was the second longest period above this threshold behind Bullhead Bay. Coecles Harbor did not record any days with daily average water temperature above 27°C in 2022. The highest recorded water temperature for the meadow was 27.5°C on 7 August 2022.

Eelgrass Shoot Density

Coecles Harbor was visited for the eelgrass survey on 1 September, 2022. The average eelgrass shoot density increased significantly in 2022, from 25 shoots·m^2 in 2021 to 84 shoots·m^2 (Table CH-2; Figure CH-2). Divers reported eelgrass at every monitoring station visited in 2022, including station 1 which had no eelgrass recorded in 2021.

Macroalgae Cover

Coecles Harbor saw a small decrease in macroalgae cover in 2022 from 2021(Figure CH-3). The 2022 macroalgae cover in the meadow was 11%, compared to 20% in 2021 (Figure CH-3). The macroalgae community in Coecles Harbor was dominated by *Spyridia filimentosa.* Divers also identified *Gracilaria* species and *Champia parvula*.

Bed Delineation and Areal Extent

At the time of this reporting, there are no 2022 aerial images available to complete delineations of the Coecles Harbor eelgrass meadow. If 2022 imagery becomes available at a later date, delineations will be completed and added to a revised monitoring report.

Conclusions

The Coecles Harbor eelgrass meadow continues to be the lowest density eelgrass meadow in the LTEMP, but shoot density is relatively uniform over the entire meadow, suggesting that environmental conditions

Table CH-2. The average annual eelgrass shoot density for Coecles Harbor from 2017 to 2022, including standard error.

Year	Mean Density	S.E.
2017	78	+/-8
2018	41	+/-5
2019	100	+/-6
2020	54	+/-4
2021	25	+/-4
2022	84	+/-10

Table CH-3. The estimated cover of eelgrass in Coecles Harbor for all years surveyed.

Year	Estimated Area
2017	102 acres (41.28 hect.)
2018	88.2 acres (35.69 hect.)
2019	119.8 acres (48.48 hect.)
2020	163.9 acres (66.32 hect.)
2021	175 acres (70.82 hect.)*
2022	ND

*Meadow extend at time of monitoring was smaller than delineated from April 2021 imagery.

Coecles Harbor 2022

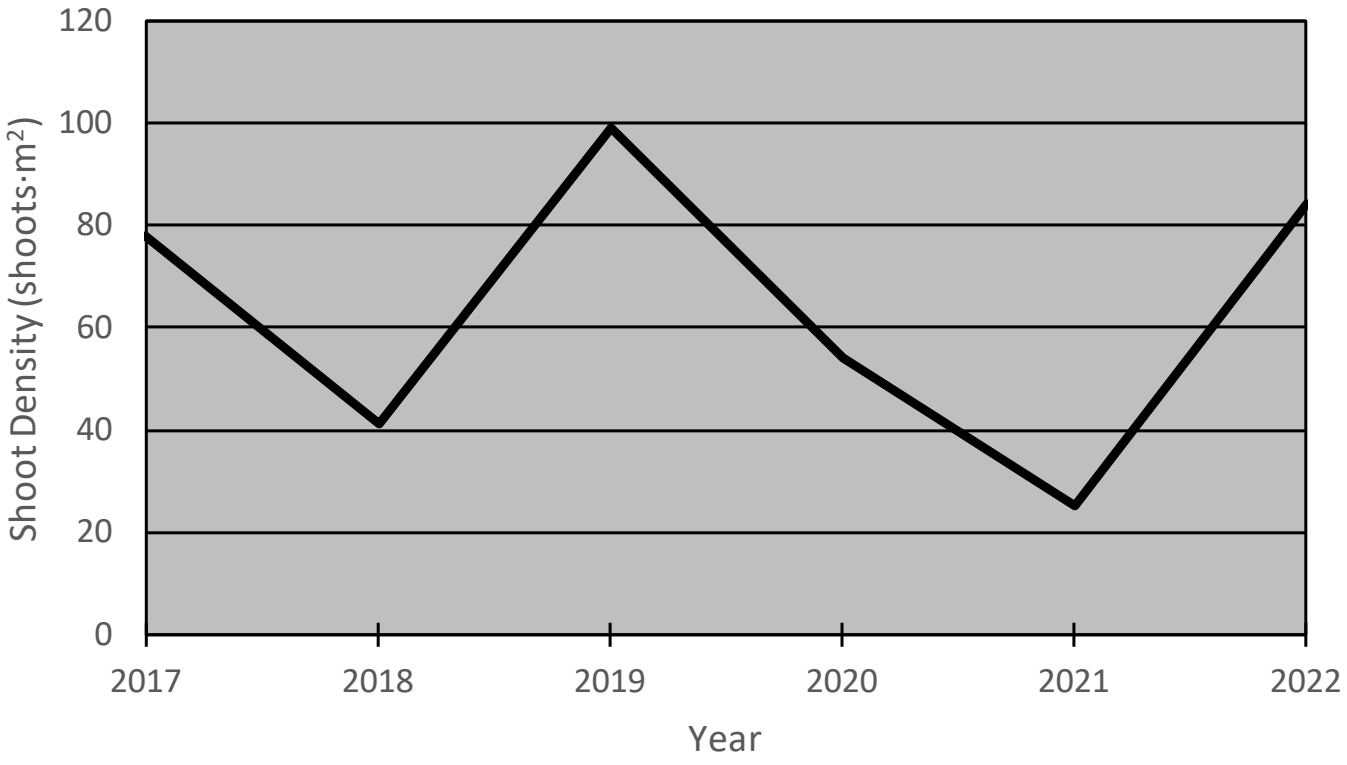


Figure CH-2. Graph of the annual mean eelgrass shoot density for Coecles Harbor from 2017-2022.

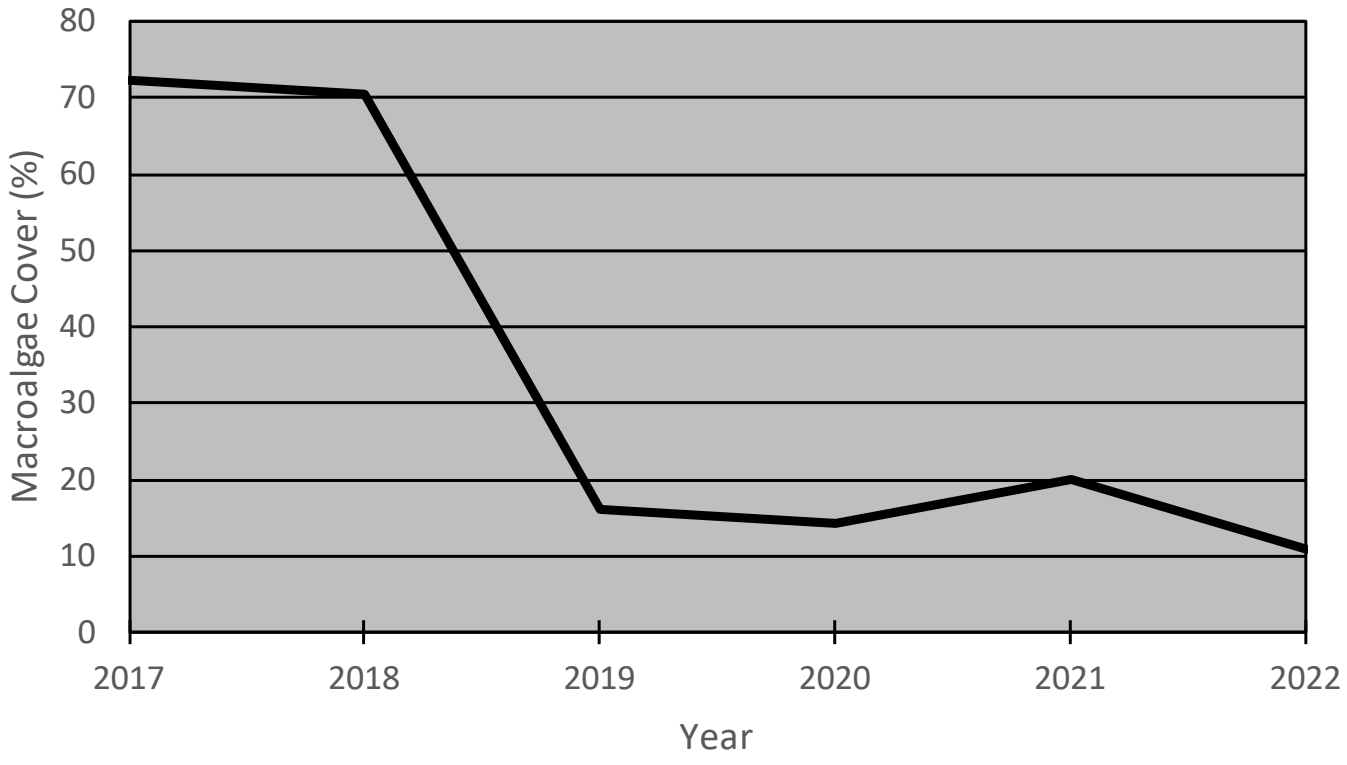


Figure CH-3. The annual mean macroalgae percent cover for Coecles Harbor from 2017-2022.

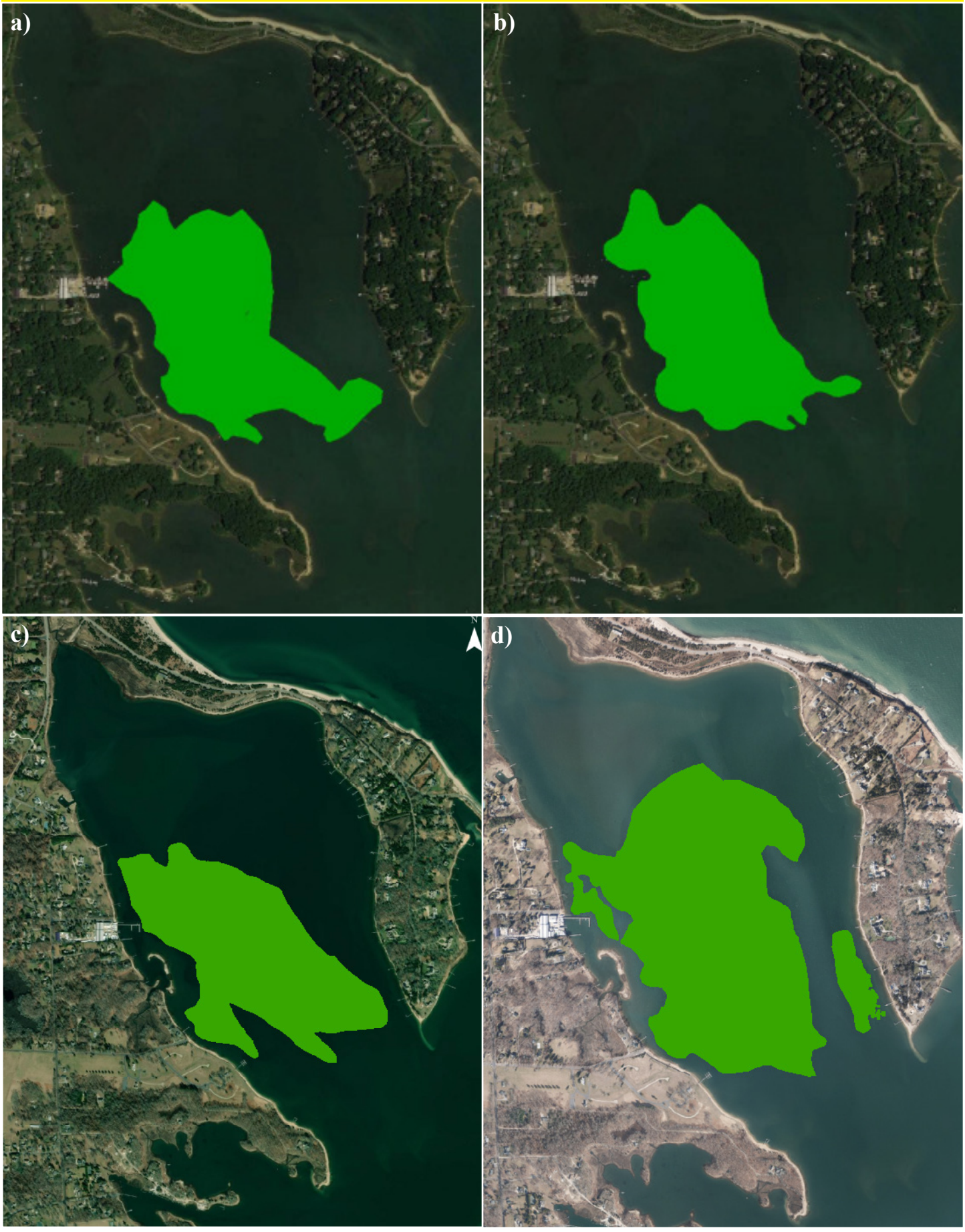


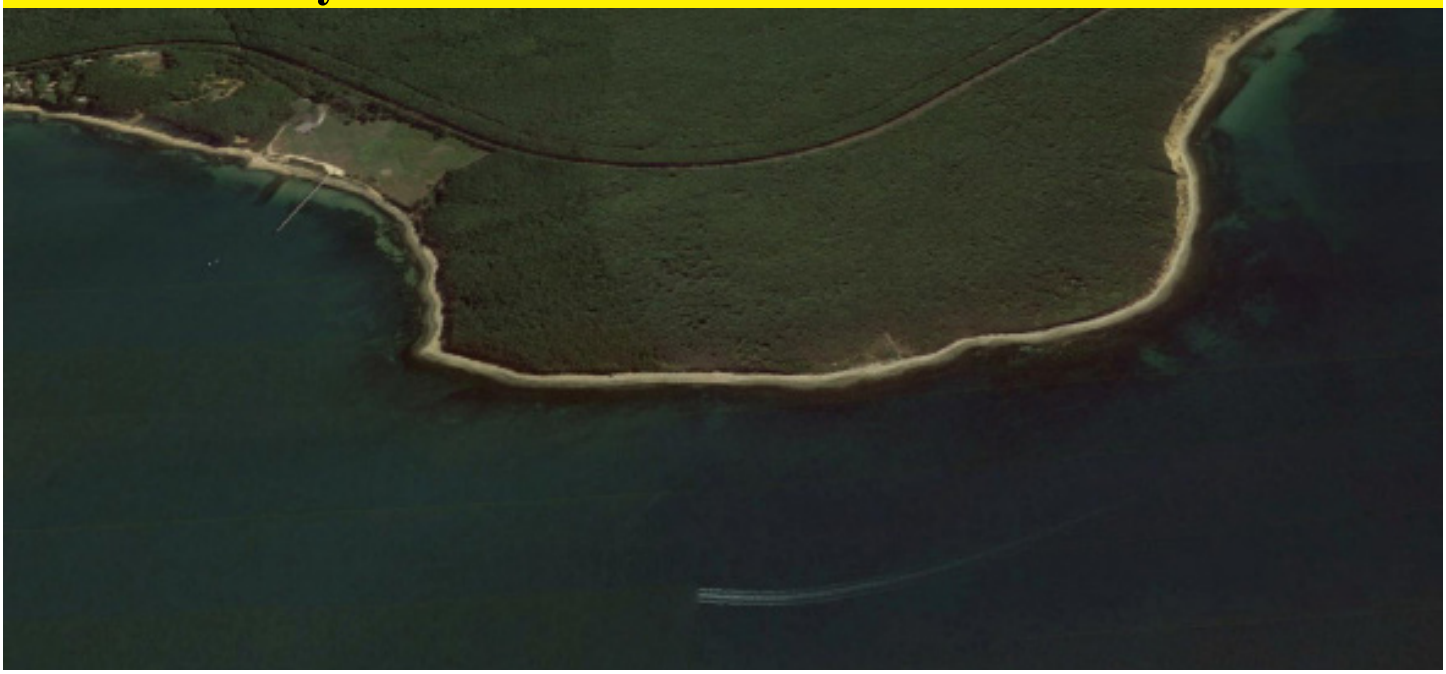
Figure CH-4. The Coecles Harbor eelgrass meadow delineations completed in a) 2014, b) 2017, c) 2019 and d)2020 for the LTEMP monitoring site.

Figure CH-5. Photographs showing the observed conditions at a) station CH1 with very low eelgrass shoot density compared to b) station CH6 which has consistently supported the highest shoot densities in the meadow, year after year.

may be influencing population density at this site. Coecles Harbor consistently has the lowest water clarity and experiences a high number of days above the temperature threshold, which leaves the population

living under conditions that are near the high end of the optimal range for eelgrass. With a low population density, the meadow may not have the biomass or seed production capacity to recover from a major disturbance event in the future.

Fort Pond Bay 2022



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, from July through September for the 2022 season. A summary of the light data collected from the Fort Pond site is presented in Table FP-1. The light availability for the

Fort Pond Bay 2022

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-day intervals, monthly, for 2022.

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	15.1	+2.8	14.3	+6.3	20.9
August	13.8	+1.5	13.1	+5.1	22.4
September	12.3	0.0	11.4	+3.4	21.7

Fort Pond eelgrass meadow was relatively high for July, with both Hcomp and Hsat returning significantly high surplus hours. By August, the site experienced a greater decrease in light availability than would be expected for its location in the estuary and compared to other similar sites (e.g., Cedar Point and Orient Points). However, even with this decline, the meadow still received excesss light, allowing it to meet its basic metabolic needs, while still having surplus light to store for later use.

An Onset Hobo temperature logger was deployed late-May, 2022. Due to its location near the eastern end of the Peconic Estuary, the Fort Pond Bay eelgrass meadow is influenced by the cool waters from Gardiners Bay and Block Island Sound and its water temperatures maintain a level below the 25ºC threshold throughout the season (Table FP-1). Temperature data collected for the 2022 season found that the site experienced no day where the average daily water temperature reached 25ºC, and the highest temperature recorded in the meadow was 24.7ºC on 10 August.

Table FP-2. The average annual eelgrass shoot density for Fort Pond Bay from 2017-2022, including standard error.

Year	Mean Density	S.E.
2017	584	+/- 58
2018	483	+/- 49
2019	348	+/- 43
2020	297	+/- 34
2021	351	+/- 36
2022	370	+/- 31

Eelgrass Shoot Density

The Fort Pond Bay monitoring visit was completed on 30 August 2022. The average eelgrass shoot density across the meadow was 370 shoots·m^2 (Table FP-2; Figure FP-2), which was up almost 20 shoots·m^2 from the average density reported for 2021. The higher shoot densities recorded in 2022 came from stations 5 and 6, within Fort Pond Bay, where the eelgrass is more sheltered and the bay bottom is characterized by large expanses of sandy bottom, and is a stark contrast to the boulder-strewn, exposed coast on which the other station are located.

Macroalgae Cover

The macroalgae cover in the Fort Pond Bay eelgrass meadow in 2022 was slightly lower than the cover reported in 2021. Macroalgae cover was 33% for 2022, compared to 35% in 2021. The brown seaweed, *Sargassum filipendula*, continues to dominate the algae community at this site. Other species reported

Table FP-3. The estimated area of eelgrass at the Fort Pond for all years surveyed.

Year	Estimated Area
2017	35.8 acres (14.49 hect.)
2018	14.8 acres (5.99 hect.)*
2019	21.2 acres (8.58 hect.)*
2020	48.19 acres (19.50 hect.)
2021	42.91 acres (17.37 hect.)
2022	ND

*Aerial imagery quality prevented complete delineation of meadow.

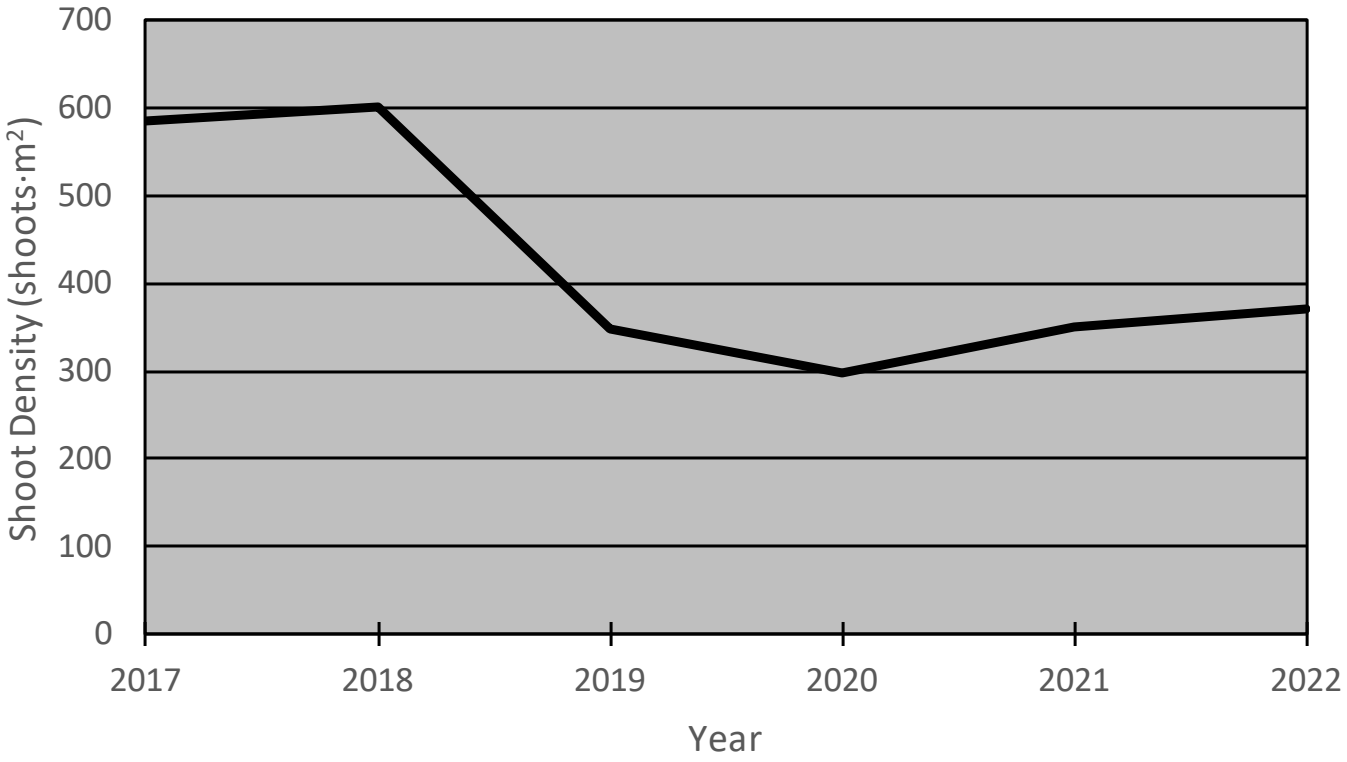


Figure FP-2. Graph of the annual mean eelgrass shoot density for Fort Pond Bay from 2017-2022.

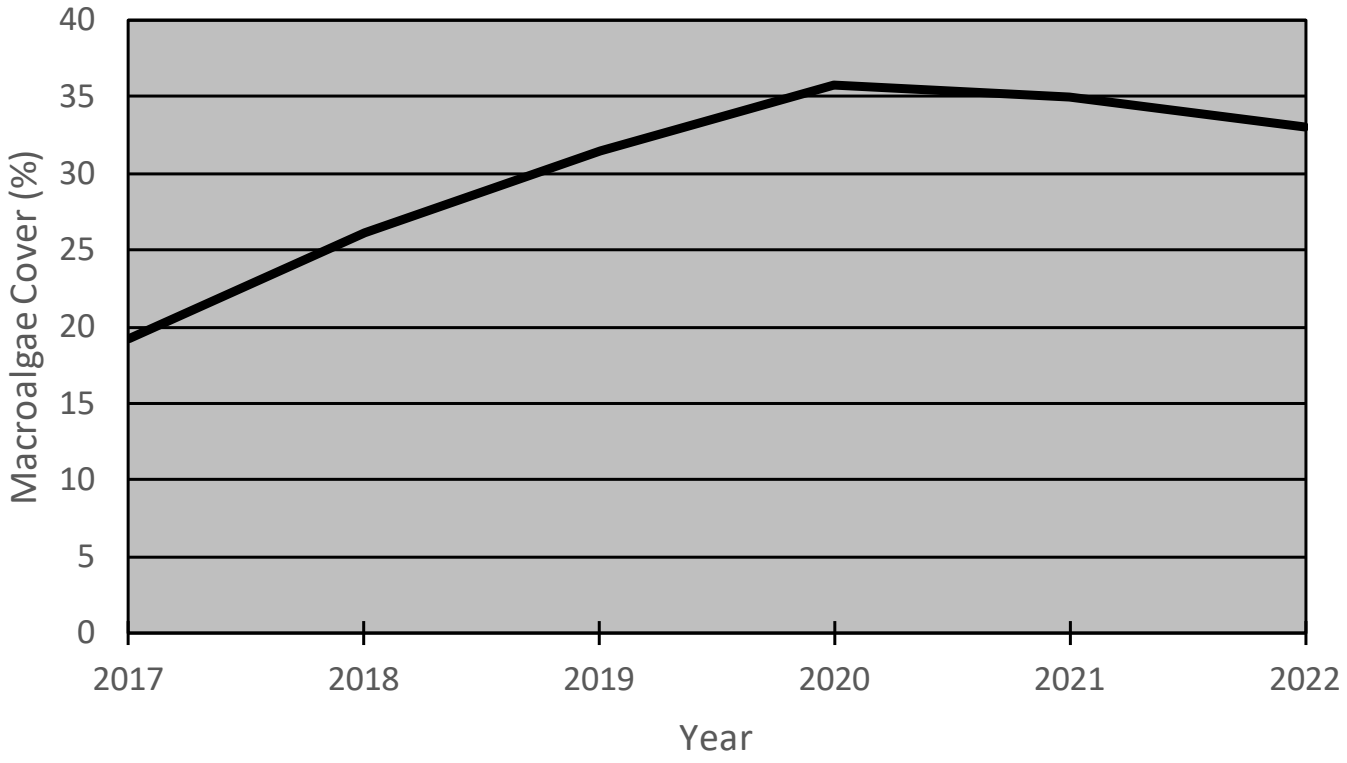


Figure FP-3. The annual mean macroalgae percent cover for Fort Pond Bay from 2017-2022.

Fort Pond Bay 2022

Figure FP-4. A comparison of Fort Pond Bay eelgrass meadow delineations completed in a) 2014, b) 2020 and c) 2021.

by CCE divers included the brown seaweeds *Halosiphonia*, *Fucus*, *Ascophyllum*, and *Cladostephus*; red seaweeds *Chondrus*, *Agardhiella, Grateloupia* (non-native), *Dasysiphonia* (non-native), *Spermothamnion,*

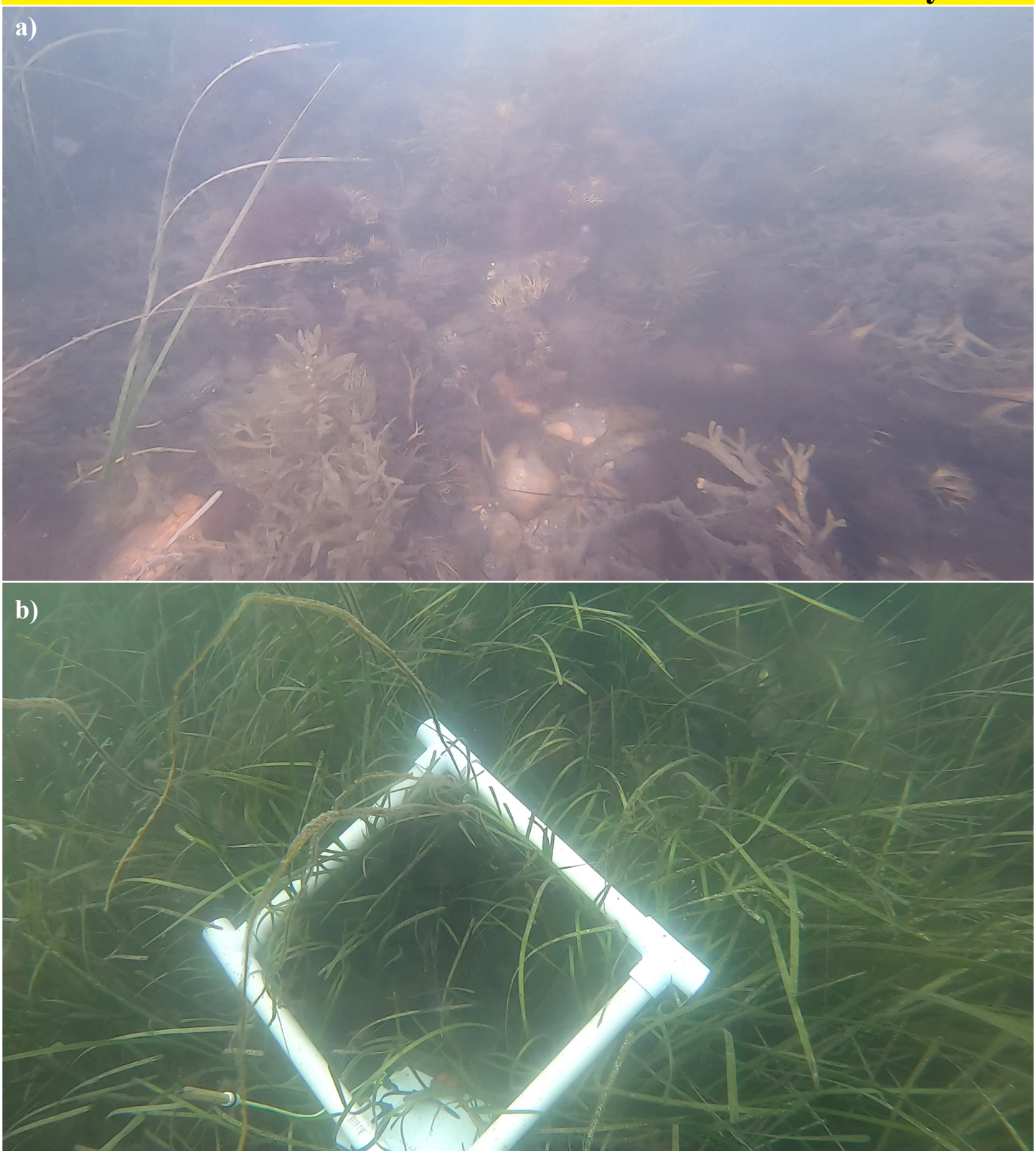


Figure FP-5. Underwater photographs taken during the 2022 eelgrass monitoring survey at the Fort Pond Bay eelgrass meadow. a) Eelgrass expanding into an open area in the boulder field at Station 3. b) The meadow around Station 5 is sheltered from some of the winter storms, resulting in a dense meadow of large (>5ft) plants.

and *Polysiphonia* species; grean seaweeds *Codium* and *Ulva*. A total of 13 species of macroalgae were identified during the 2022 survey at Fort Pond.

Bed Delineation and Areal Extent

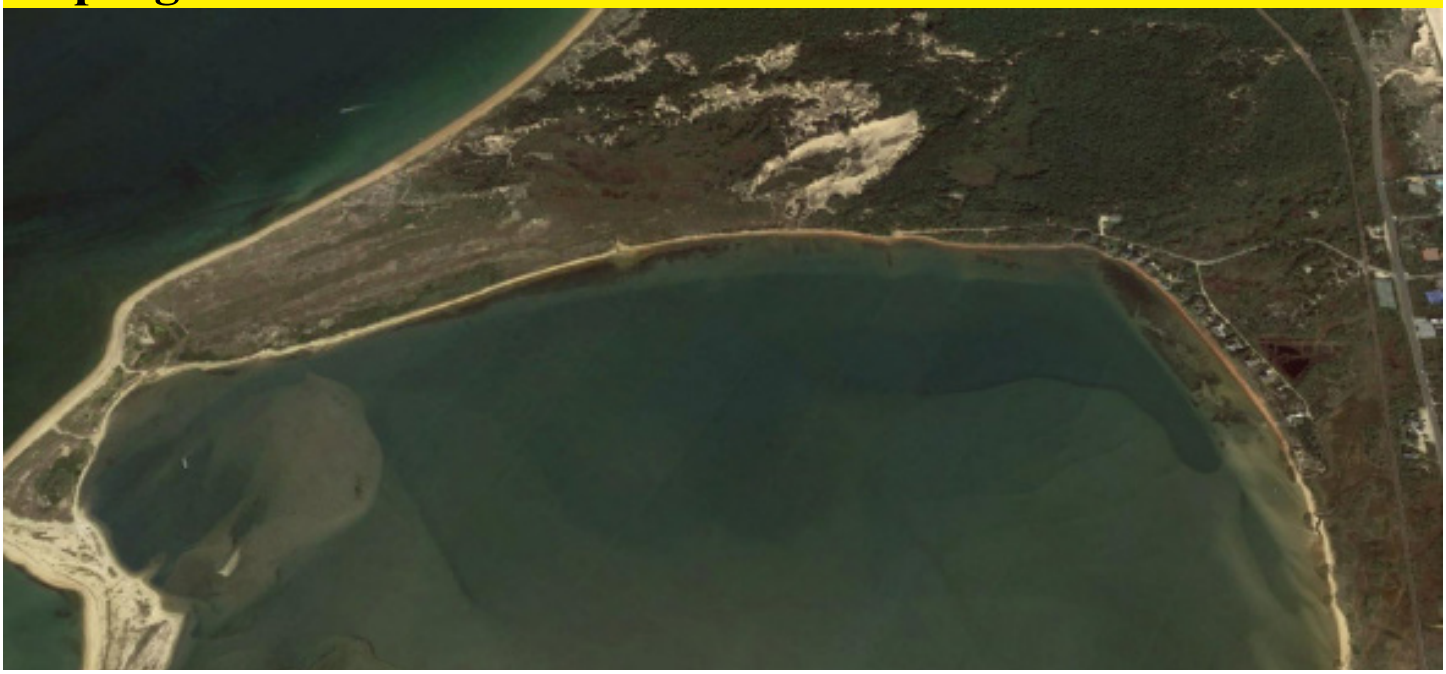
At the time of this reporting, there are no 2022 aerial images available to complete delineations of the Fort

Pond Bay eelgrass meadow. If 2022 imagery becomes available at a later date, delineations will be completed and added to a revised monitoring report.

Conclusions

The Fort Pond Bay eelgrass meadow remains one of the healthiest meadows in the monitoring program. Environmental conditions are comfortably within the optimal range for eelgrass and there are few factors that could negatively impact the meadow. The primary disturbance factor influencing the meadow is storm events, and storm-generated waves. For the open coast sections of this meadow, erosional loss due to increasing storm frequency and intensity could result in declines over time, however, with light and temperature conditions at the site, recovery and recolonization of impacted sections of the meadow may be able to mitigate these 'seasonal' losses.

Napeague Harbor 2022



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

Odyssey PAR light loggers were deployed monthly (July-September) for 10-day periods for the 2022 season to the Napeague Harbor eelgrass meadow. The average daily Hcomp and Hsat values for the 2022 season arepresented in Table NAP-1. Due to the shallow nature of the Napeague eelgrass meadow, the probability that the plants experience any long-term impact from low-light conditions is minimal. The light data from 0

The Onset HOBO TidBit v2 water temperature logger was deployed to the meadow in late-May 2021. Average monthly water temperature are recorded in Table NAP-1. The Napeague meadow did not record an average monthly temperature over 25°C for 2021. The 2021 season recorded cooler temperatures for the season compared to 2020 with only 5 days with water temperatures over 25°C. The highest temperature

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-day intervals, monthly, for 2022.

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	15.0	+2.7	14.0	+6.0	24.1
August	13.7	+1.4	12.7	+4.7	24.9
September	12.5	+0.2	11.9	+3.9	21.6

recorded for the site in 2021 was 25.7°C on 27 August, almost 2.5°C cooler than 2020's high temperature.

Eelgrass Shoot Density

The 2022 eelgrass monitoring visit to Napeague Harbor took place on 30 August. The average eelgrass shoot density calculated for the meadows was 553 shoots·m^2 for 2022 (Table NAP-2; Figure NAP-2). The 2022 shoot density was up almost 70 shoots·m^2 from 2021, which is a good sign for the future of the meadow. The highest shoot density counted in a quadrat in 2022 was 1350 shoots·m^2.

Macroalgae Cover

Macroalgae cover in Napeague Harbor saw an increase to 13% in 2022, from a low of 2% in 2021 (Figure NAP-3). With this increase in algal cover came a corresponding increase in seaweed diversity. Where only 3 species of seaweed were reported in the Napeague meadow during the 2021 survey, divers identified 7 species in 2022. *Spyridia filamentosa* continues to be the most common seaweed in the eelgrass meadow, but divers also observed *Gracilaria* species, *Spermothamnion repens, Champia parvula, Sargassum filipendula, Fucus* sp., and *Codium fragile*.

Bed Delineation and Areal Extent

At the time of this reporting, there are no 2022 aerial images available to complete delineations of the Napeague Harbor eelgrass meadow. If 2022 imagery becomes available at a later date, delineations will be completed and added to a revised monitoring report.

Conclusions

The Napeague Harbor eelgrass meadow had shown little significant change between the 2021 and 2022 monitoring surveys. Eelgrass shoot density was, on average, up across the meadow with several sampled quadrats yielding shoot densities greater than 1,000 shoots·m^2 . The southern extent of the meadow continues to show increased patchiness. Some of the eelgrass loss can be attributed to the few boat moorings that are located within the meadow, but these are isolated instances. The southwestern edge of the meadow

Table NAP-2. The average annual eelgrass shoot density for Napeague Harbor from 2017 to 2022, including standard error.

Year	Mean Density	S.E.
2017	806	+/-63
2018	479	+/-44
2019	560	+/-44
2020	554	+/-50
2021	484	+/-39
2022	553	+/-50

Table NAP-3. The estimated cover of eelgrass in Napeague Harbor for all years surveyed.

Year	Estimated Area
2017	17.6 acres (7.12 hect.)
2018	13.4 acres (5.42 hect.)
2019	15.5 acres (6.27 hect.)
2020	13.9 acres (5.63 hect.)
2021	15.38 acres (6.22 hect.)
2022	ND

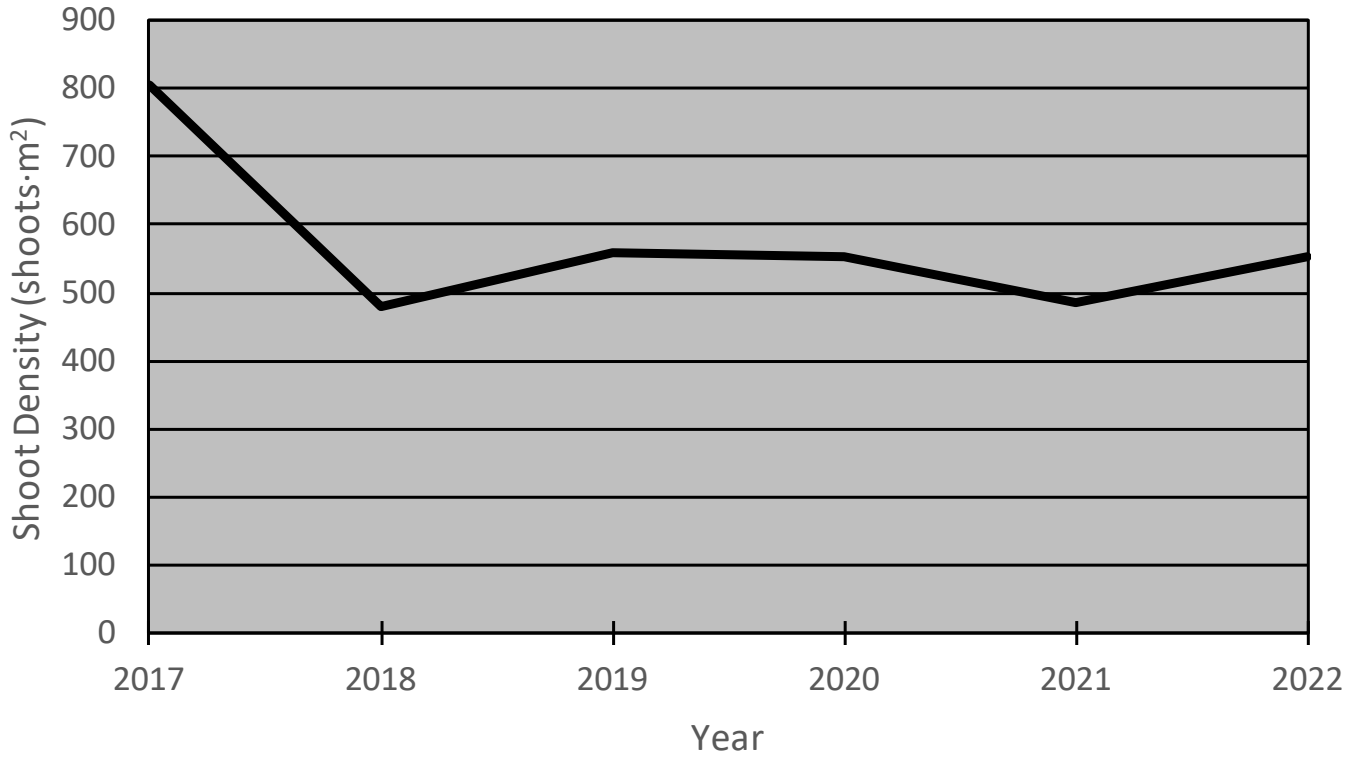


Figure NAP-2. Graph of the annual mean eelgrass shoot density for Fort Pond Bay from 2017-2021.

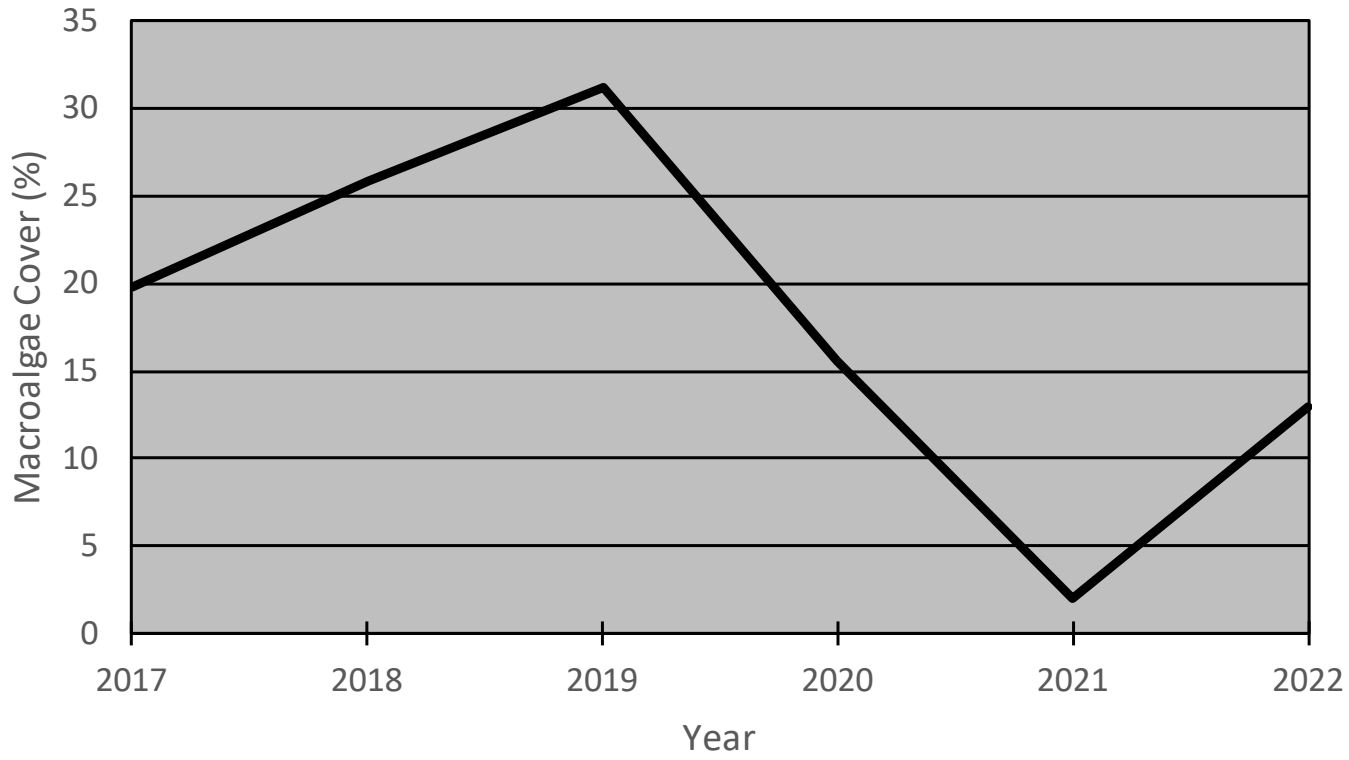


Figure NAP-3. The annual mean macroalgae percent cover for Fort Pond Bay from 2017-2021.

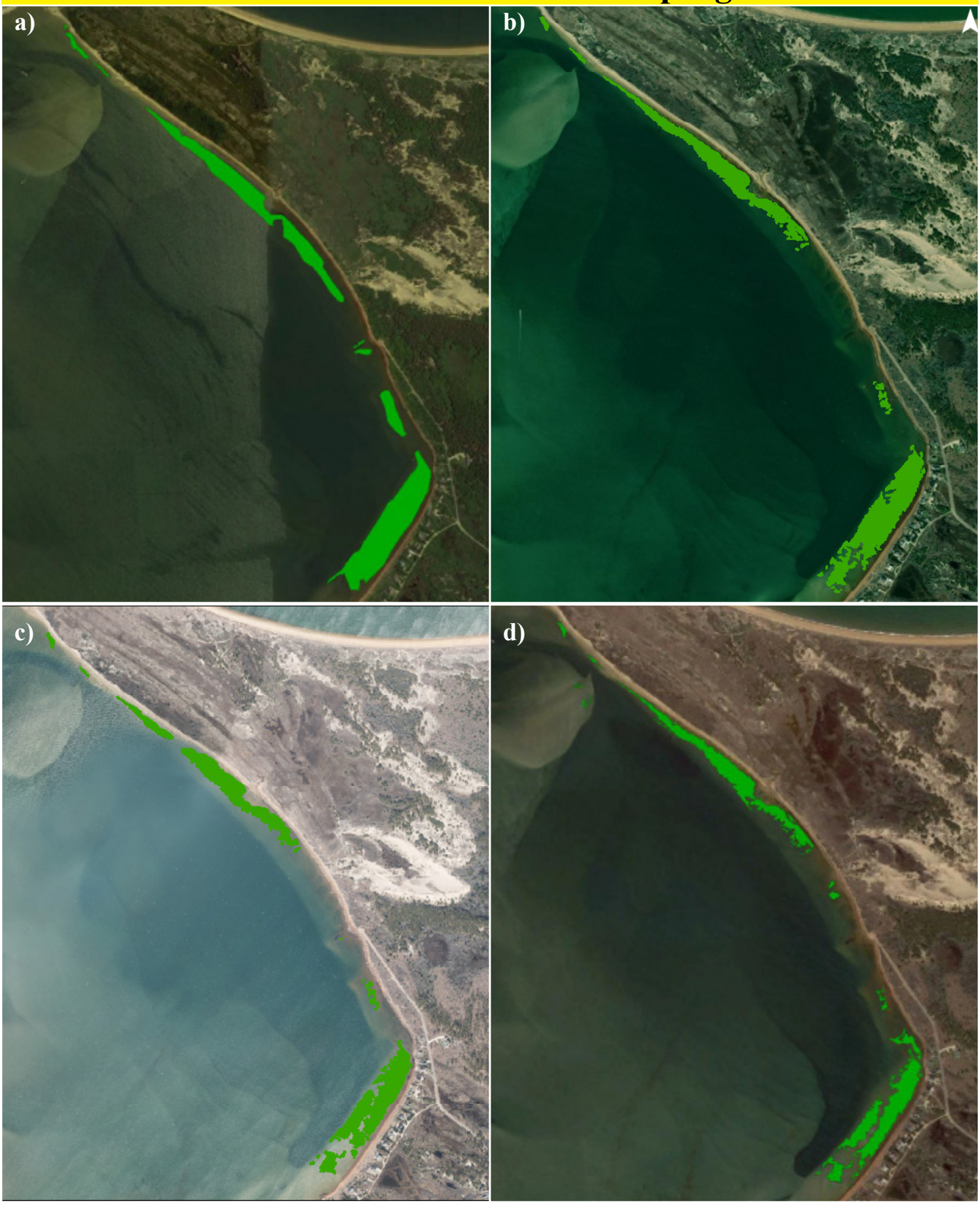


Figure NAP-4. A comparison of Napeague Harbor eelgrass meadow delineations completed in a) 2014, b) 2019, c) 2020, and d) 2021.

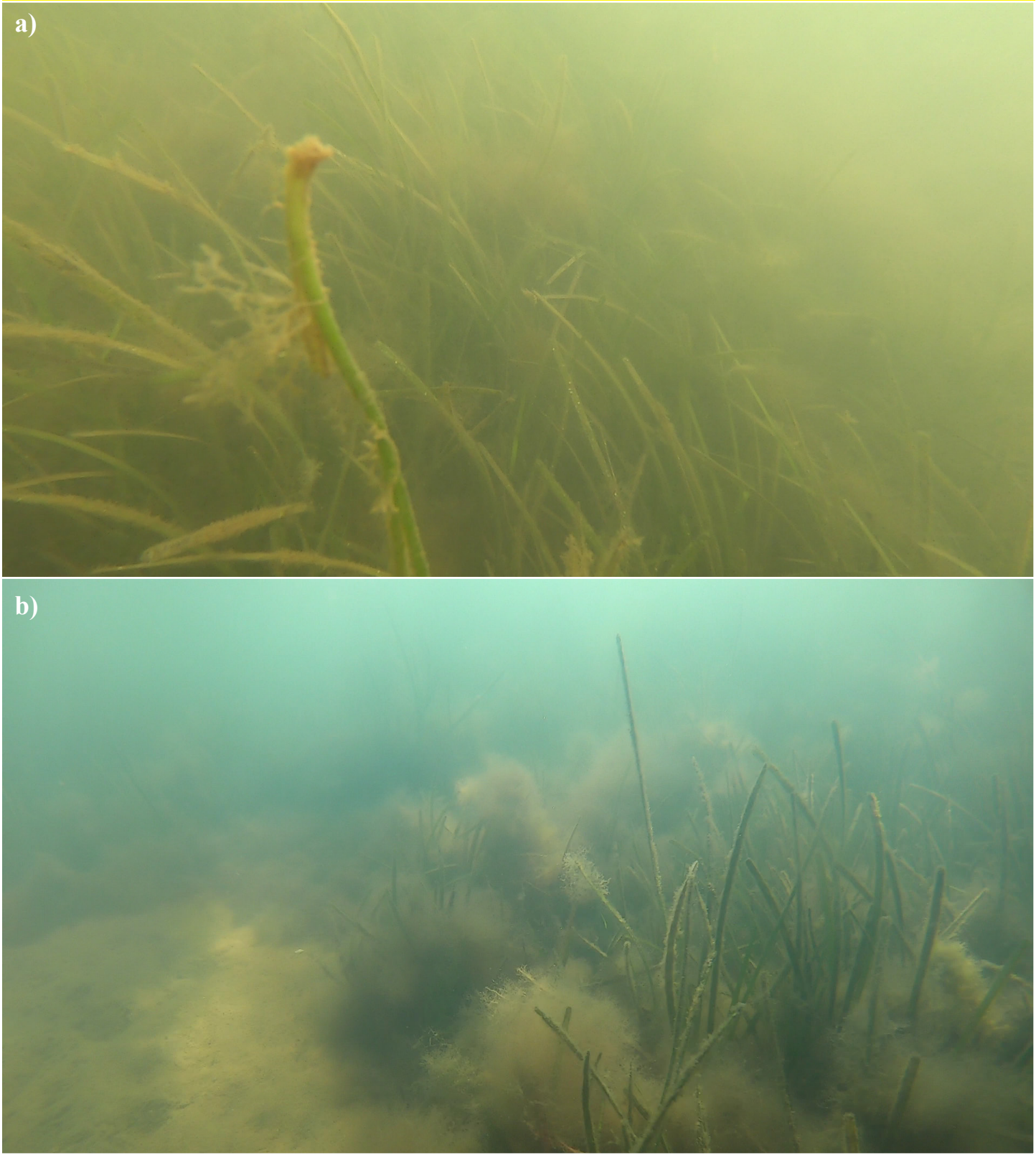


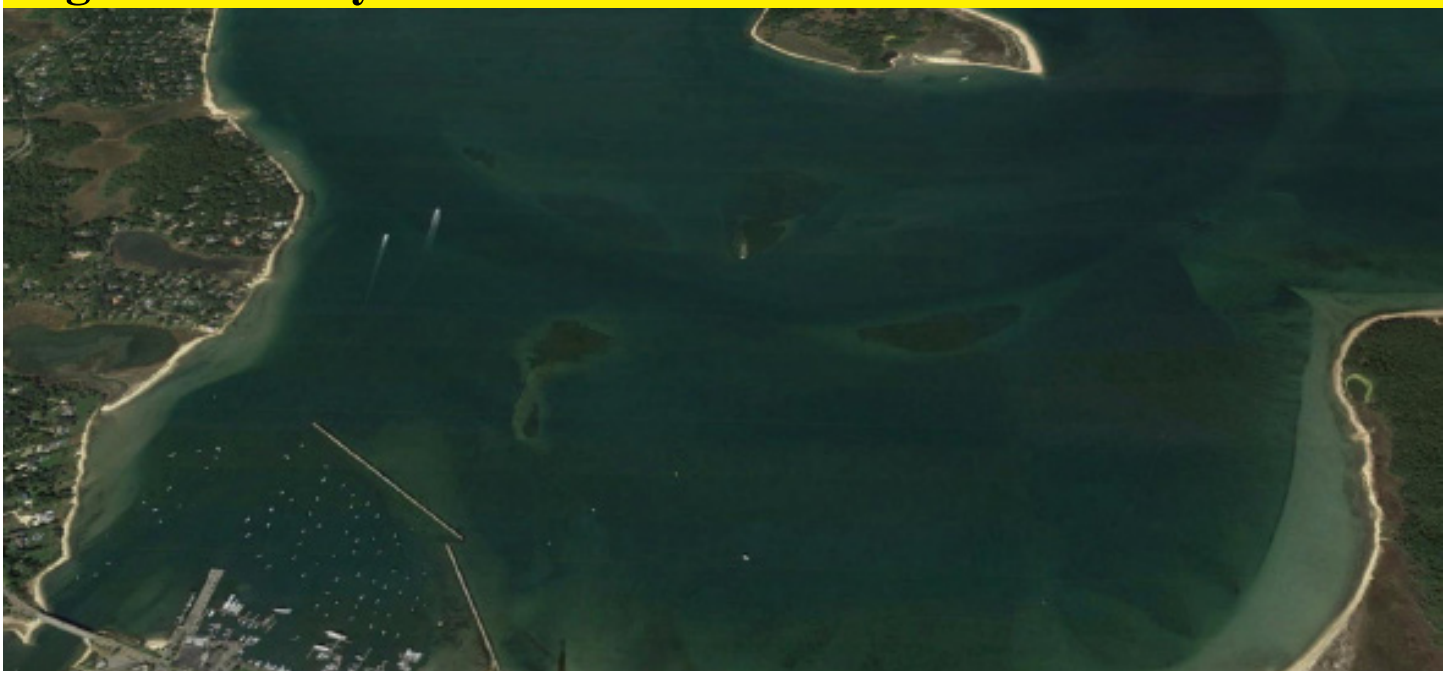
Figure NAP-5. a) When the iron-rich sands are stirred up by waves, it tints the waters around Station 2 red. b) The southern extent of the Napeague eelgrass meadow covers the largest area and has the highest shoot densities in the harbor.

near Station 6 has shown the most loss of meadow in Napeague Harbor over the last several seasons. It is unclear what factors are responsible for the increase patchiness, but it could be related to the increased frequency of storms that would generated relatively large waves along this section of the eelgrass meadow.

Combined with bioturbation by crabs, other burrowing invertebrates (e.g. whelks and horseshoe crabs), and possibly waterfowl, this could account for the ondition of the meadow is this area of Napeague Harbor. Another observation of note from the 2022 eelgrass monitoring survey was the first sighting of cownose rays near an eelgrass meadow in the Peconic Estuary. These rays could also be contributing to bioturbation in the Napeague Harbor eelgrass meadow as they forage for shellfish. While no forage pits were observed in 2022, if the presence of cownose rays becomes more common in the estuary, it can be expected that they will start to have some impact on the integrity of meadows in the Peconic Estuary eventually.

Without a aerial image from 2022, at this time there is no way to quantify differences in areal extent of the meadow. However, the planned 2023 eelgrass aerial survey should provide the imagery needed to compare the changes in the southern extent of the Napeague meadow from 2021 to the present.

Sag Harbor Bay 2022



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 of disctinct eelgrass beds within the bay. The LTEMP monitors three of these beds with 6 monitoring stations divided among the beds (Figure SH-1). The three individual eelgrass beds are referred to as Beds1-3 with Bed1 including stations SH1 and SH2, Bed2 containing SH3 and SH4, and Bed3 consisting of SH5 and SH6.

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

Site Characteristics

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 (Figure SH-1) monitoring station monthly, from July-September 2022. The results from the 2022 season are summarized in Table SH-1 in terms of Hcomp and Hsat. The light data presented in the table shows that the Sag Harbor eelgrass meadows received sufficient light throughout the monitoring period to meet or provide a surplus for both Hcomp and Hsat. This was a shared trend for light availability across all monitoring sites for 2022.

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-day intervals, monthly, for 2022.

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	14.8	+2.5	13.6	+5.6	24.2
August	13.9	+1.6	13.0	+5.0	25.2
September	12.8	+0.5	12.2	+4.2	22.4

Water temperatures during the 2022 season in Napeague Harbor were higher, on average than temperatures in 2021. The monthly average water temperatures presented in Table SH-1, show that Napeague Harbor was already averaging temperatures over 24°C in July, then increased in August to just over 25°C. By September, the average temperature in the meadow had declined to under 23°C. In 2021, Sag Harbor Bay only recorded 11 days of daily average temperatures over 25°C, but the 2022 season experienced 33 days over 25°C. For 2022, the Sag Harbor meadow did not record any days with water temperaturs over 27°C, with the highest water temperature recorded being 26.0°C on 10 August, 2022.

Eelgrass Shoot Density

Eelgrass monitoring for Sag Harbor Bay was conducted on 12 September, 2022. The average eelgrass shoot density for the Sag Harbor meadow was 370 shoot·m² (Table SH-2; Figure SH-2). This was a significant increase from the 137 shoot·m² reported in 2021.Evaluating each of the three individual meadows found that the shoot density had increased in all meadows from 2021 to 2022. Bed1 increased from 247 shoot·m² (2021) to 333 shoot·m² (2022). Bed2 increased from 124 shoot·m² (2021) to 309 shoot·m² (2022), and Bed3 increased from 222 shoot·m² (2021) to 470 shoot·m² (2022).

Macroalgae Cover

Macroalgae cover in the Sag Harbor meadows increased from 2021 to 2022. The total average macroalgae cover was 4% in 2021, but was reported at 14% in 2022 (Figure SH-3). Across the three individual meadows the macoralgae cover varied. Bed1 recorded an average cover of 12%, while Bed2 had a lower cover at 4%. Bed3 supported the highest macroalgae cover at 24%. As reported in past LTEMP reports, Bed1 was dominated by arger macroalgae species like *Sargassum* and *Codium* due to the rocky substrate, while

Table SH-2. The average annual eelgrass shoot density for Sag Harbor from 2017 to 2022, including standard error.

Year	Mean Density	S.E.
2017	249	+/-16
2018	331	+/-25
2019	223	+/-15
2020	247	+/-17
2021	197	+/-12
2022	370	+/-20

Table SH-3. The estimated cover of eelgrass in Sag Harbor for all years surveyed.

Year	Estimated Area
2017	50.3 acres (20.36 hect.)
2018	12.7 acres (5.14 hect.)*
2019	37.6 acres (15.22 hect.)
2020	48.0 acres (19.42 hect.)
2021	50.12 acres (20.28 hect.)
2022	ND

*Aerial image quality for this meadow was poor, resulting in anincomplete delineation of the meadow

Sag Harbor Bay 2022

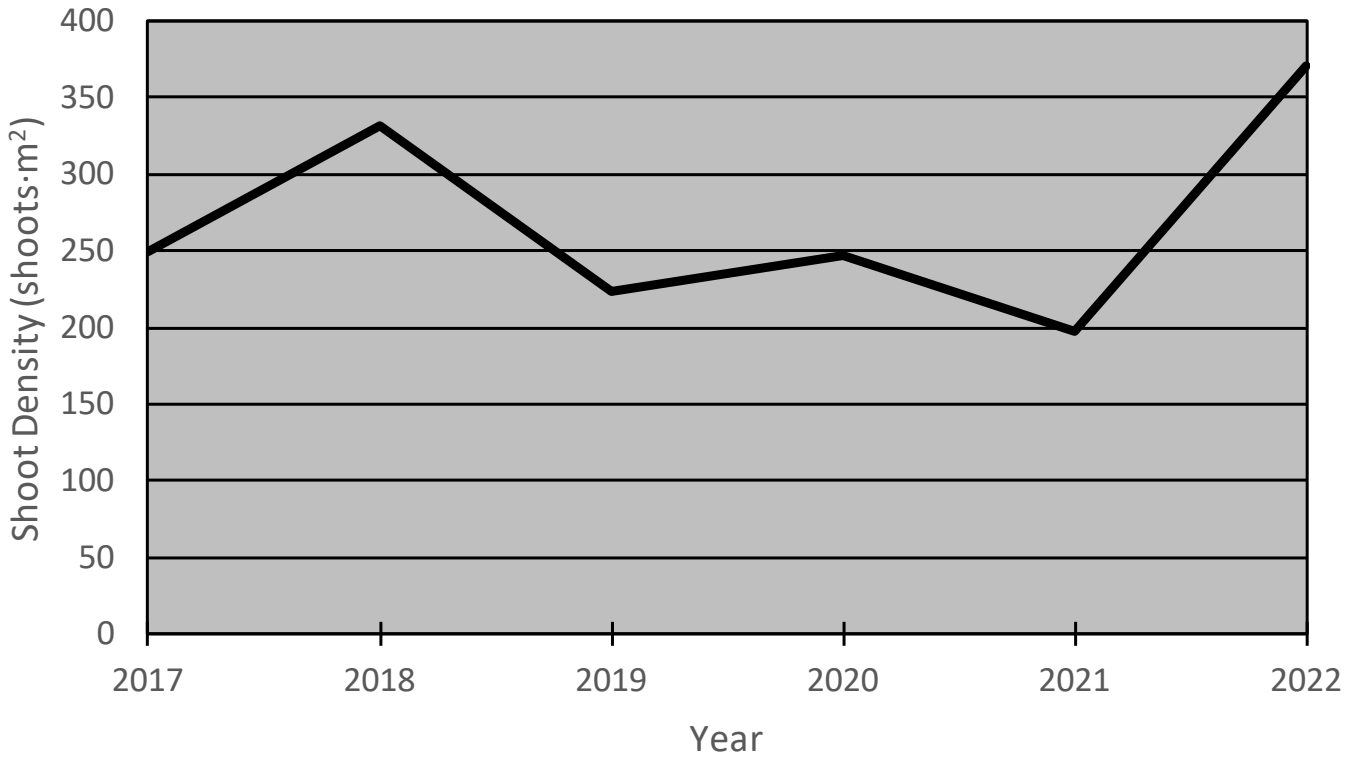


Figure SH-2. Graph of the annual mean eelgrass shoot density for Fort Pond Bay from 2017-2022.

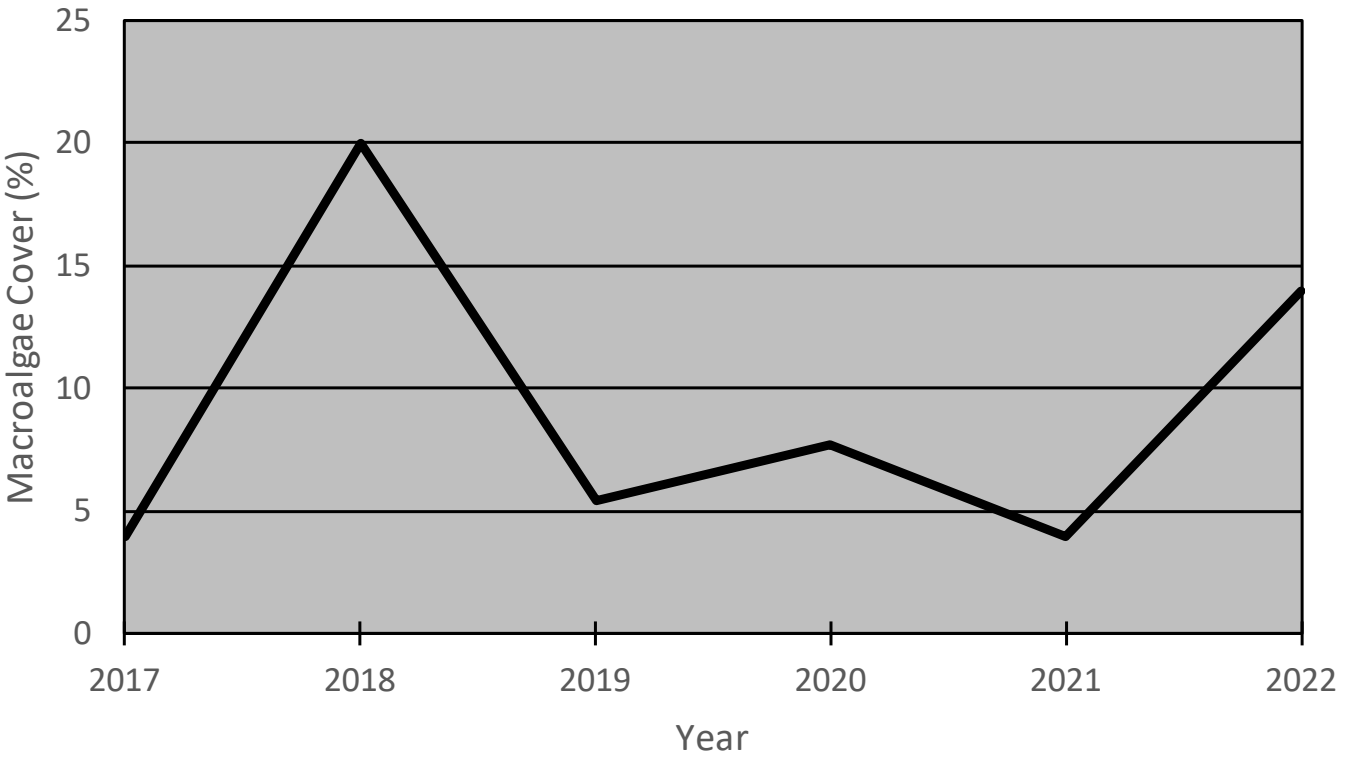


Figure SH-3. The annual mean macroalgae percent cover for Fort Pond Bay from 2017-2022.

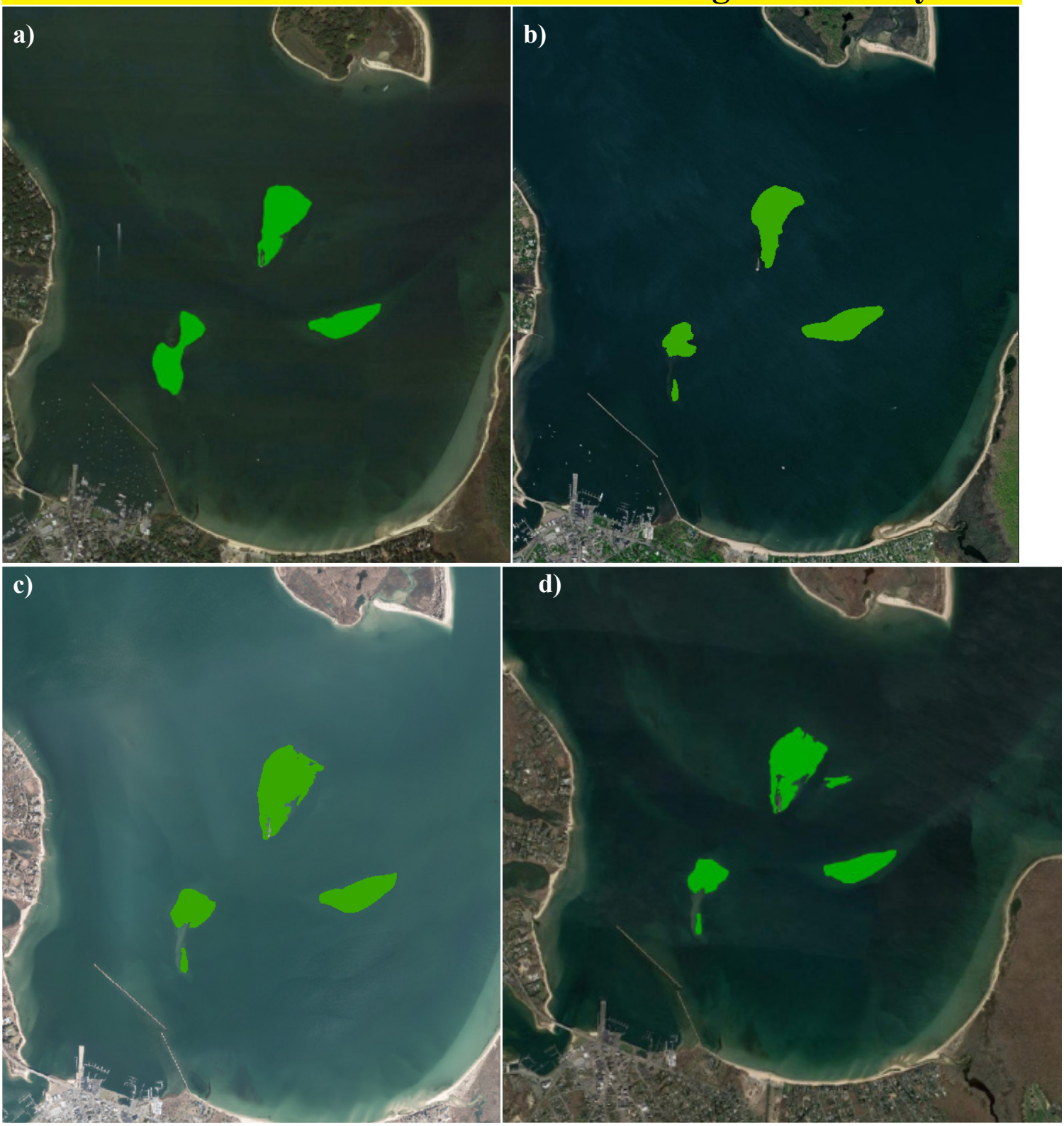


Figure SH-4. Comparison of delineations between a) 2014, b) 2019, c) 2020 and d) 2021 for the Sag Harbor Bay eelgrass meadow complex.

Beds 2 and Bed3 are dominated by smaller seaweeds (e.g., *Gracilaria, Spyridia,* and filamentous species).

Bed Delineation and Areal Extent

At the time of this reporting, there are no 2022 aerial images available to complete delineations of the Sag Harbor Bay eelgrass meadow. If 2022 imagery becomes available at a later date, delineations will be completed and added to a revised monitoring report.

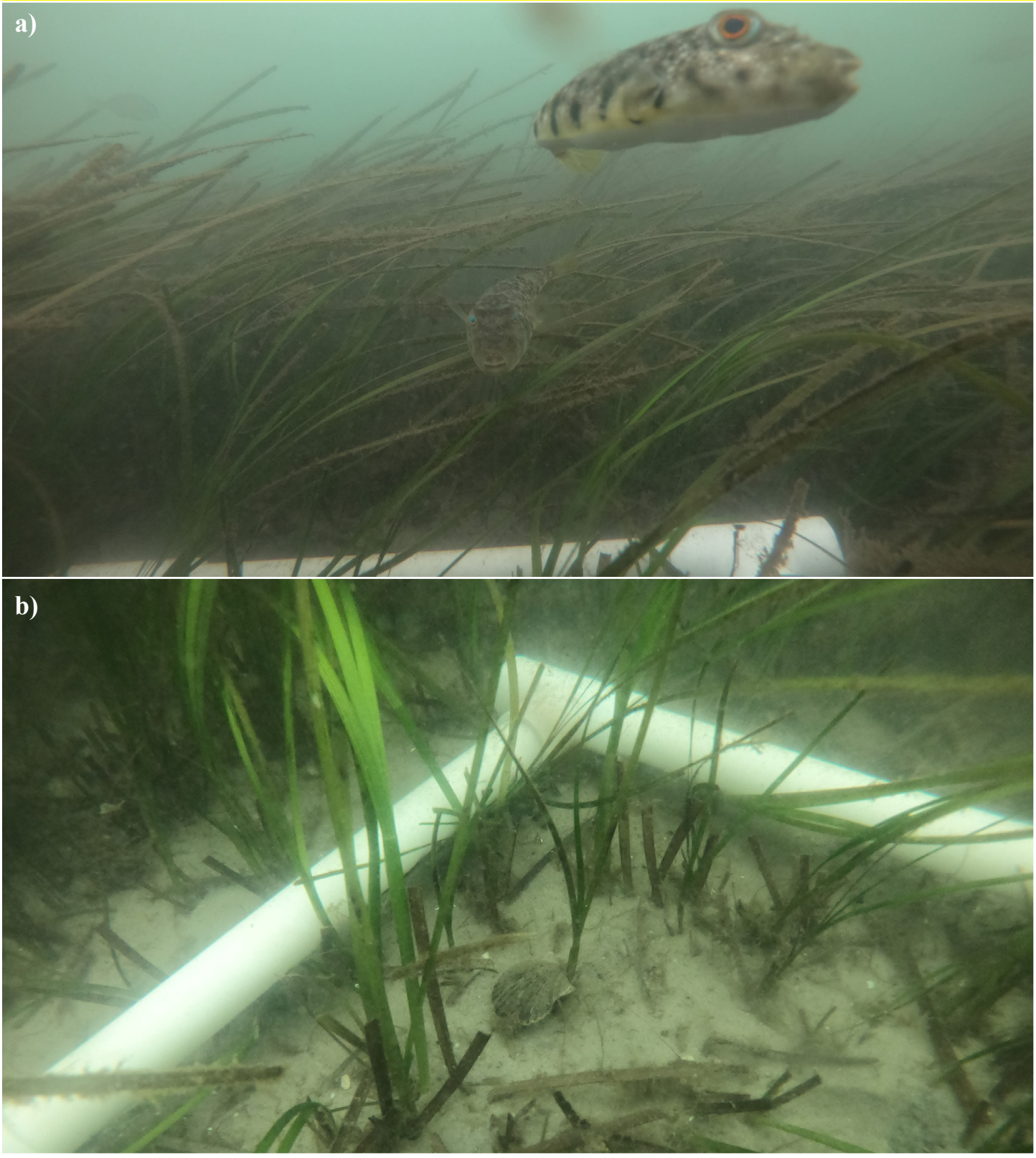


Figure SH-5. a) Norther puffers looking for food stirred up by the divers quadrat counting at SH6. b) A bug scallop discovered in a quadrat while monitoring at station SH4.

Conclusions

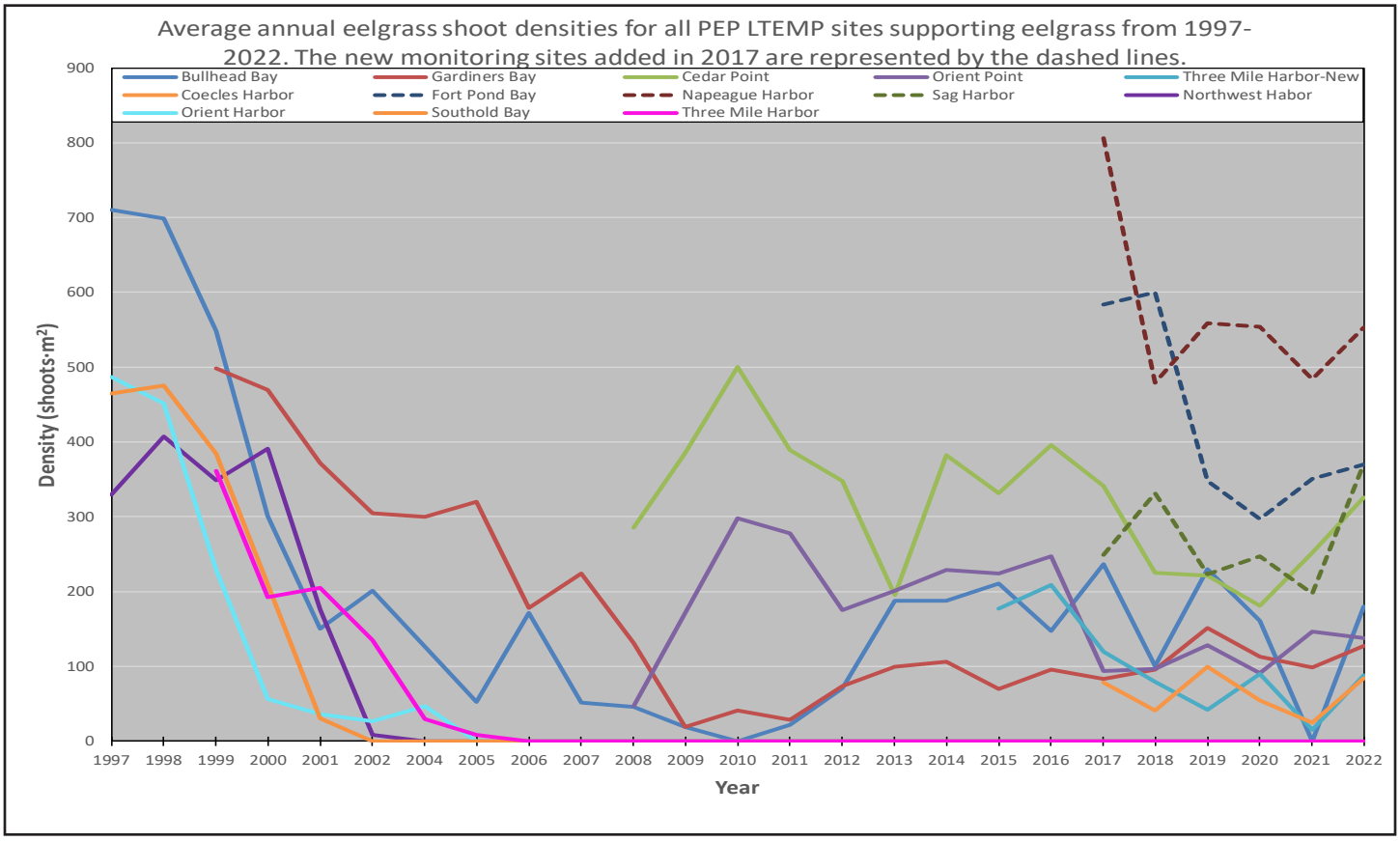
Conditions within the Sag Harbor Bay eelgrass meadows were found to be healthy during the 2022 monitoring survey. Across all meadows, the average shoot density had increased from densities reported for 2021. Shoot density significantly increased in 2022 both overall and for individual meadows at this site. Divers reported only minor instances of disturbance

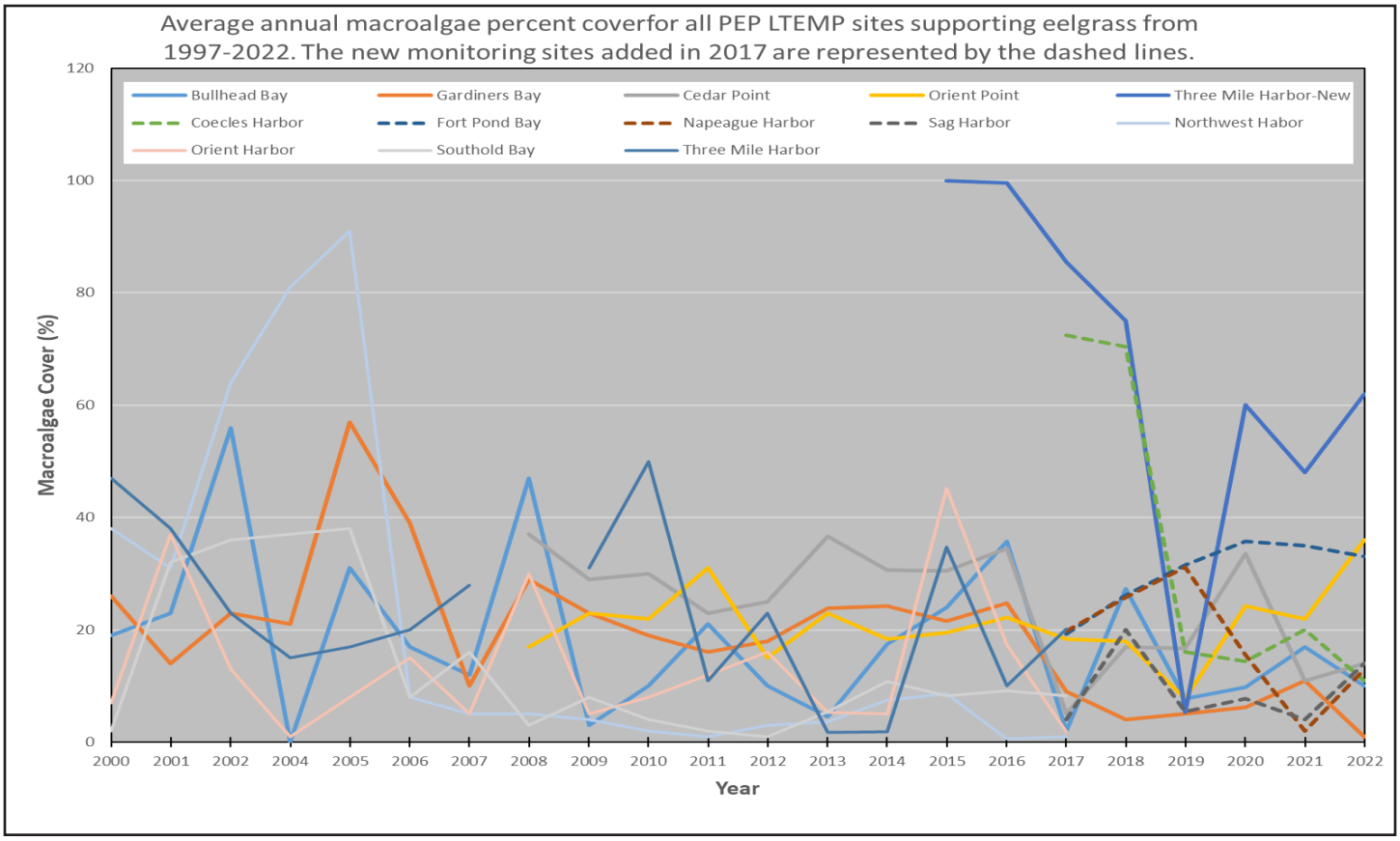
across the site, suggesting that the winter of 2022 had The restoration planting area that CCE has been expanding over the past few years along the southern edge of Bed2 continues to consolidate and has expanded outside of the original planting footprint, based on the amount of eelgrass that has extended past the marker stakes that were installed at the time of planting. CCE plans to continue to work at this site as funding becomes available.

CCE also worked with the Sag Harbor Harbor Committee to apply for a PEP Mini-Grant to purchase marker buoys to delineate the eelgrass meadow (Bed2) that is located within the Sag Harbor mooring field. The goal of installing these buoys is to prevent large yachts from inadvertently anchoring in the meadow during transient visits. The Harbor Master's office would be responsible for the installation and maintenance of these markers. This effort, if funded, would be the first buoy markers deployed in the Peconic Estuary making boaters aware of the presence of eelgrass and could lead to an expansion of eelgrass meadow marking throughout the estuary, similar to efforts in Florida and other southern states.

Appendix

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





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