Peconic Estuary Program 2007 Eelgrass (*Zostera marina*) Long-Term Monitoring Program

Progress Report 9
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Submitted To:

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

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Summary

The Peconic Estuary Program's Long-Term Eelgrass Monitoring Program was continued by Cornell Cooperative Extension's Marine Program in 2007. The six monitoring beds were sampled during the period of 23 August 2007 to 29 August 2007. Divers conducted 60 quadrat counts of eelgrass shoot density and macroalgae percent cover at each monitoring site. Temperature data from data loggers were analyzed to elucidate annual temperature trends. There were no significant changes in the shoot density in 2007, although Northwest Harbor joined Southold Bay and Three Mile Harbor in the complete loss of eelgrass within the monitoring areas. Twenty-nine (29) out of a total of 36 stations (6 stations per each of the 6 sites) no longer supported eelgrass within the 10 m radius of the station coordinates. Macroalgal percent cover showed mixed results, with only Orient Harbor and Three Mile Harbor exhibiting significant increase. The areal extent of Bullhead Bay's meadow showed significant change, where 2 stations that had recovered in 2006 were lost in 2007. Gardiners Bay experienced minimal loss in areal extent. The temperature data continued to be a useful tool in monitoring annual trends and identifying localized periods of high water temperature which is important for eelgrass health and planning of restoration activities in the estuary.

No single causative factors have been directly linked to the losses that have continued at a majority of the monitoring sites. At this time, physical disturbance (both natural and anthropogenic) continues to be the most likely cause of the losses that have been documented. It is likely that no one source is responsible for the damage/losses in the monitoring sites, but rather a combination of stressors are responsible. When an extant eelgrass population is fragmented or reduced in size/density, as several of these beds had become over the last few years, they generally become more susceptible to disturbance and the rate of decline increases.

Eelgrass Introduction

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

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

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

Bullhead Bay (BH)	Southampton
Gardiners Bay (GB)	Shelter Island
Northwest Harbor (NWH)	East Hampton
Orient Harbor (OH)	Southold
Southold Bay (SB)	Southold
Three Mile Harbor (TMH)	East Hampton

Methods

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

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

decrease in the size of the quadrats to 0.0625 m^2 (12.5 x 12.5 cm).

In 2000, the methodology for the monitoring program was amended to increase the statistical significance of the data collected. The adjustments reflected an increase in the number of sampling stations per site (from 3 to 6), the number of replicate samples per station (from 4 to 10) and the size of the quadrats. However, the 2000 methodology included an increase number of destructively sampled quadrats (24 quadrats) for use in biomass estimations. The 2001 protocols maintained the higher number of replicate samples per bed (60 quadrats) but eliminated the destructive sampling aspect of the program. Beginning in 2004, water temperature was collected at several of the monitoring sites using submersible temperature loggers. The specific monitoring protocol for 2004 is outlined below.

Water Temperature Monitoring

In an effort to better describe the relationship between water temperature and the life cycle of eelgrass, temperature loggers were deployed in several eelgrass beds in the Peconics. The following sites were monitored for 2007: Sag Harbor, Northwest Harbor, Cornelius Point (Shelter Island), Red Cedar Bluff (Southampton) and Orient Point (near Cross Island Ferry). The year-long deployment of loggers at Cornelius Point, Northwest Harbor and Sag Harbor allowed for a complete view of the annual water temperature cycle for these areas. The summer deployments at Red Cedar Bluff and Orient Point was meant to focus on the summer temperature trends with the loggers set to record at 2hr intervals instead of the 6hr intervals for the other 3 sites (as was recommended at the Seagrass Experts Meeting, April 2007).

The loggers, Onset Tidbit® and Onset StowAway®, were deployed in January 2007 (Cornelius Point, Northwest Harbor and Sag Harbor; 6-hr interval), June 2007 (Red Cedar Bluff; 2-hr interval) and July 2007 (Orient Point; 2-hr interval) and retrieved October (Red Cedar Bluff and Orient Point) and December 2007 for the 6-hr loggers.

Temperature data was exported from the loggers into spreadsheets. The data was analyzed and graphed using SigmaStat® and SigmaPlot® (SPSS Inc., 1997) software.

Eelgrass Monitoring

The 2007 monitor was initiated on 23 August and completed on 29 August.

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

Data was incorporated into a spreadsheet and statistically analyzed using SigmaStat software (SPSS Inc., 1997). The trends, within sites, were analyzed by comparing the 2006 data with the data from the previous years.

Bed Delineation

Table 2. Descriptive statistics for eelgrass stem density for 2007.

Location	Sample Size (n)	# Stations w/ No Grass	Mean Stem Density (shoots/m^2)	Standard Error
Bullhead Bay (BH)	60	4	51	±12.1
Gardiner's Bay (GB)	60	2	224	±39.5
Northwest Harbor (NWH)	60	6	0	±0.0
Orient Harbor (OH)	60	5	47	±21.5
Southold Bay (SB)	60	6	0	±0.0
Three Mile Harbor (TMH)	60	6	0	±0.0

The deep edge delineations for the 2006 season was based on the 2007 Suffolk County Aerial Imagery. The 2007 delineations were incorporated into GIS layers that included the 2002, 2004, 2005 and 2006 delineations and were overlaid on the 2007 true-color aerial imagery for each monitoring site.

Results

Statistical analysis reports are included as a separate set of appendices and include basic descriptive statistics as well as one-way ANOVAs. *P*-values, when not stated, may be found in these appendices. The attached appendices (Appendices 1-4) present graphical data directly referred to in this report.

Water Temperature Monitoring

The graphs for the water temperature data are included in Appendix 1. The data represented in the graphs are the mean daily water temperature (°C) at each site.

For the second straight year, the temperature logger in Bullhead Bay could not be found at the end of the season for offloading of the data. The loss of the logger and TERF frame that anchored it could only be attributed to human interference/removal.

The remaining loggers were recovered and offloaded with the data represented in the graphs (1a-1e) in Appendix 1. The water temperatures generally peaked in the first week of August 2008, with the exception of Cornelius Point, which experienced its summer peak of 24.8°C in mid-July (Appendix 1a). Red Cedar Bluff experienced the highest water temperature of 26.6°C (Appendix 1e), with Northwest Harbor and Sag Harbor a bit lower at 25.8°C and 25.4°C (Appendices 1b and 1d), respectively. Orient Point, as expected, had the lowest peak summer temperature only reaching 23.4°C (Appendix 1c).

Eelgrass Shoot Density and Areal Extent

The basic descriptive statistics for the eelgrass shoot densities for the 2007 season are represented in Table 2. Included in the table are the sample sizes (replicates), number of stations without eelgrass, mean stem density, and standard error of the means. Appendix 2 includes trend analysis

graphs of the mean shoot density data for the six monitoring sites from 1997 (1999)-2007.

Bullhead Bay

The 2007 mean shoot density for Bullhead Bay was found to be 50 shoots/m^2 (Table 2), which did not represent a significant decrease in mean shoot density from 2006. The increases in the area of the meadow observed in 2006 either were lost entirely or at least became very patchy as indicated by the loss of eelgrass from the 2 stations (Stations 2 and 6) that had been regained in 2006 (Appendix 3a).

Gardiners Bay

Gardiners Bay saw an increase in shoot density from 2006 to 2007. The 2007 mean shoot density was 224 shoots/m^2 (Table 2), an increase from 178 shoots/m^2 in 2006 (Appendix 2b). However, this increase was not statistically significant.

This site remains highly dynamic in regards to its areal extent. Between 2006 and 2007, there was a loss of the outer most "fingers" eelgrass close to Stations 1 and 2, but the near-shore portion of the bed appears to have filled in and expanded slightly since 2006 (Appendix 3b).

Northwest Harbor

Northwest Harbor showed a total loss of eelgrass from 2006 to 2007. The eelgrass population in 2006 was virtually extinct (shoot density of 8 shoots/m^2) and did not survive through to the 2007 season, when no eelgrass was found at any of the monitoring stations in Northwest Harbor (Table 2).

While no eelgrass was observed at any of the monitoring stations or adjacent areas in 2007, the 2007 aerial imagery suggests that small populations may still exist in the far north of the harbor and around a "hole" inshore of Station 4 (Appendix 3c).

Orient Harbor

The eelgrass remaining around Station 5 in Orient Harbor experienced a minor increase in shoot density in 2007. The mean shoot density for 2007 was 47 shoots/m^2 (Table 2), and was an insignificant gain from the 2006 density 27 shoots/m^2 (Appendix 2d). Station 5 continues to be the only station that supports eelgrass (Appendix 3d).

Southold Bay

Southold Bay has not supported eelgrass at any of the monitoring stations since 2006 (Appendix 2e). Whereas eelgrass was not counted at any of the monitoring stations in 2006, plants were observed still growing at this site. The 2007 season not only failed to record eelgrass in any of the monitoring stations, but no eelgrass was observed anywhere at this site.

The eelgrass appears to have completely collapsed. The 2007 aerial imagery did not show evidence of an extant eelgrass population in Southold Bay (Appendix 3f) and field monitoring did not identify even one individual plant.

Three Mile Harbor

The Three Mile Harbor monitoring site supported no eelgrass in 2007 (Table 2). Eelgrass first disappeared at the site in 2005, but extant eelgrass meadows were found in the vicinity in 2006. Scouting of areas adjacent to the monitoring site found no eelgrass nearby in 2007. Fresh eelgrass shoots were observed floating in the Harbor, indicating that there is an extant population in the area. Scouting in the immediate vicinity of the monitoring site yielded no eelgrass.

Table 3. Mean macroalgal percent coverage (m^{-2}).

Eelgrass Bed	Percent Macroalgae Cover
Bullhead Bay	12.4
Gardiners Bay	10.0
Northwest Harbor	4.7
Orient Harbor	19.0
Southold Bay	5.6
Three Mile Harbor	28.3

Macroalgal Percent Cover

Macroalgal percent cover was quantified for each quadrat within the six beds. Table 3 contains the mean percent coverage of macroalgae for each bed. Graphs for the individual sites are included in Appendix 4.

Bullhead Bay

The macroalgal percent cover for 2007 showed almost no change from 2006 (Appendix 4a). The macroalgal population continued to be dominated by the red filamentous alga, *Spyridia filamentosa* and the green filamentous alga, *Cladophora*. Unvegetated areas were covered with diatomaceous and cyanobacterial mats.

Gardiners Bay

Gardiners Bay showed a trend of decline in macroalgal percent cover that started in 2006 and continued in 2007 (38.8% to 10%) (Appendix 4b). The 2007 macroalgal cover represented the lowest cover recorded at the site. While the overall abundance of macroalgae at the site was low, the species diversity at this site displayed no significant change from previous years.

Northwest Harbor

Northwest Harbor's macroalgae cover for the 2007 season declined by only 3.2% from 7.9% in 2006 to 4.7% in 2007 (Appendix 4c). As was found in 2006, the macroalgal population at this site was observed to be only two species, *Spyridia filamentosa* and *Agardhiella subulata*.

Orient Harbor

The macroalgal community in Orient Harbor was found to have increased slightly from 2006 to 2007, but not significantly. The 2007 mean percent macroalgal cover was 19% and consisted of *Spyridia filamentosa, Codium fragile* and *Agardhiella subulata*. For the second year, a *Cochlodinium* bloom was observed near Station 4. Presence of this species is becoming more common in the Peconic Estuary.

Southold Bay

The percent cover of macroalgae in Southold Bay showed no statistical change from 2006 to 2007 (Appendix 4e). *Codium fragile* dominated the macroalgae community in the eastern area of the site, while macroalgal mats were prevalent in the in western areas near Stations 5 and 6.

Three Mile Harbor

Three Mile Harbor has maintained a relatively stable macroalgal population since 2004 and this trend continued in 2007. The percent cover was up from 2006 by almost 10%, but this was not a significant increase. Species included *Spyridia filamentosa*, *Codium fragile* and *Gracilaria tikvahiae*.

Discussion

Water Temperature

Water temperature continues to follow a predictable pattern in the Peconic Estuary with the warmest waters located in the western Estuary and the cooler areas located to the east. The highest mean daily temperature recorded was at Red Cedar Bluff with the lowest temperature recorded at Orient Point. The 2007 summer water temperatures were cooler than previous years where high water temperatures regularly approached and exceeded 28°C, which may reduce temperature stress on eelgrass populations allowing for some recovery of lost areas. The upper temperature tolerance of eelgrass in the Peconics is assumed to be around 30°C, but an exact limit is not known. Brief periods of high water temperature would likely have little effect on the eelgrass populations, however, extended durations in high water temperatures could have a significant detrimental effect on eelgrass. Eelgrass loss due to high water temperatures, like those experienced in the Chesapeake Bay, warrant the continued monitoring of water temperatures throughout the Estuary.

Long-Term Eelgrass Monitoring

Bullhead Bay

Where Bullhead Bay had demonstrated a significant expansion in 2006, the bed was found to have drawn back toward the center of the Bay in 2007. The gains in Station 2 and 6 in 2006 were lost in 2007, but the loss was not to the same extent as the initial loss recorded in 2002. Bullhead Bay has shown the potential to recover from acute episodes of disturbance in the past, and recovery from the 2007 setback is possible. This bay is benefitted by its sheltered nature which may allow for a higher seedling recruitment and vegetative expansion that is not supported at other sites with higher currents or wave action. Bullhead Bay is also closed for shellfishing, for at least part of the year, and it is not a popular boating area. Both of these factors minimize the anthropogenic impacts on the meadow. Bullhead Bay is also relatively crab-free, specifically spider crabs. Spider crabs have been identified as one of the most significant sources of bioturbation in eelgrass in the Peconic Estuary. Full regeneration of the lost acreage since 2002 is still possible, but may take several years.

Gardiners Bay

Gardiners Bay has shown signs of decline over the last few years, but in 2007, there are signs of possible recovery of the eelgrass population. Although the increase in shoot density was not statistically significant, it does suggest that the bed is healthy and likely regenerating. This is supported by the 2007 aerial imagery in Appendix 3b. The offshore "fingers" of eelgrass have eroded away over time, but the inshore portion of the meadow has filled in and expanded offshore slightly, based on the 2007 photo.

Physical disturbance at the site continues to be the most significant factor influencing the eelgrass population. Shellfishing activities (*i.e.*, clamming) and prop scars from boat traffic appear to have increased in frequency.

Northwest Harbor

The Northwest Harbor eelgrass has been completely lost around the monitoring stations at this site. In 2006, the eelgrass population had declined to an unsustainable level, so the complete loss observed in 2007 was not unexpected. No eelgrass was observed around any of the six monitoring stations, but the 2007 aerial imagery indicated that there may still be small,

isolated patches of eelgrass remaining in Northwest Harbor. Due to the lateness of the aerial imagery acquisition (made available in Summer 2008), the suspected eelgrass patches identified in the 2007 imagery have not be ground-truthed. However, a field survey is planned for the Fall 2008.

As recorded in previous years, disturbance by crabs (particularly spider crabs), whelks and clamming activities have contributed to the decline and eventual loss of this bed.

Orient Harbor

The eelgrass at Station 5 continues to be the last population of eelgrass in the monitoring area. The shoot densities have shown a slight increasing trend, especially if the shoot density at station 5 is considered by itself (the dashed line in the graph in Appendix 2d). As the population remaining at Station 5 has been showing an increase in shoot density, there remains the possibility that there could be some recovery of eelgrass in adjacent areas due to seedling recruitment and vegetative expansion. However, the overall reduced nature of this population, in both density and area, reduce the odds of a complete recovery.

Southold Bay

Where eelgrass was still present in areas adjacent to the monitoring stations in 2006, no eelgrass was observed at all at this site in 2007. This leads to the conclusion that the eelgrass population has become extinct in Southold Bay. There is no possibility of recovery of eelgrass in Southold Bay without active restoration, as there is not a nearby eelgrass population to provide propagules for recruitment.

Three Mile Harbor

The eelgrass in Three Mile Harbor outside of Hand's Creek has lost its eelgrass population. Many factors have likely attributed to this loss, but human activity was the most obvious factor influencing the health and extent of the eelgrass population here. The presence of a mooring field, and its expansion in successive years, presented a significant disturbance source for the inshore areas of the former eelgrass bed. Dragging mooring chains and prop dredging were likely factors influencing the decline of the inshore portion of the bed. Outside of the mooring field, eelgrass was subjected to boat traffic from the designated water skiing area, which was expanded into the eelgrass bed. With water depths of 5-7 feet, boats did not directly impact the eelgrass by prop dredging/scarring, but with the mucky sediment at this site being easily resuspended, eelgrass could potentially have faced periods of light limitation that could have contributed to its decline.

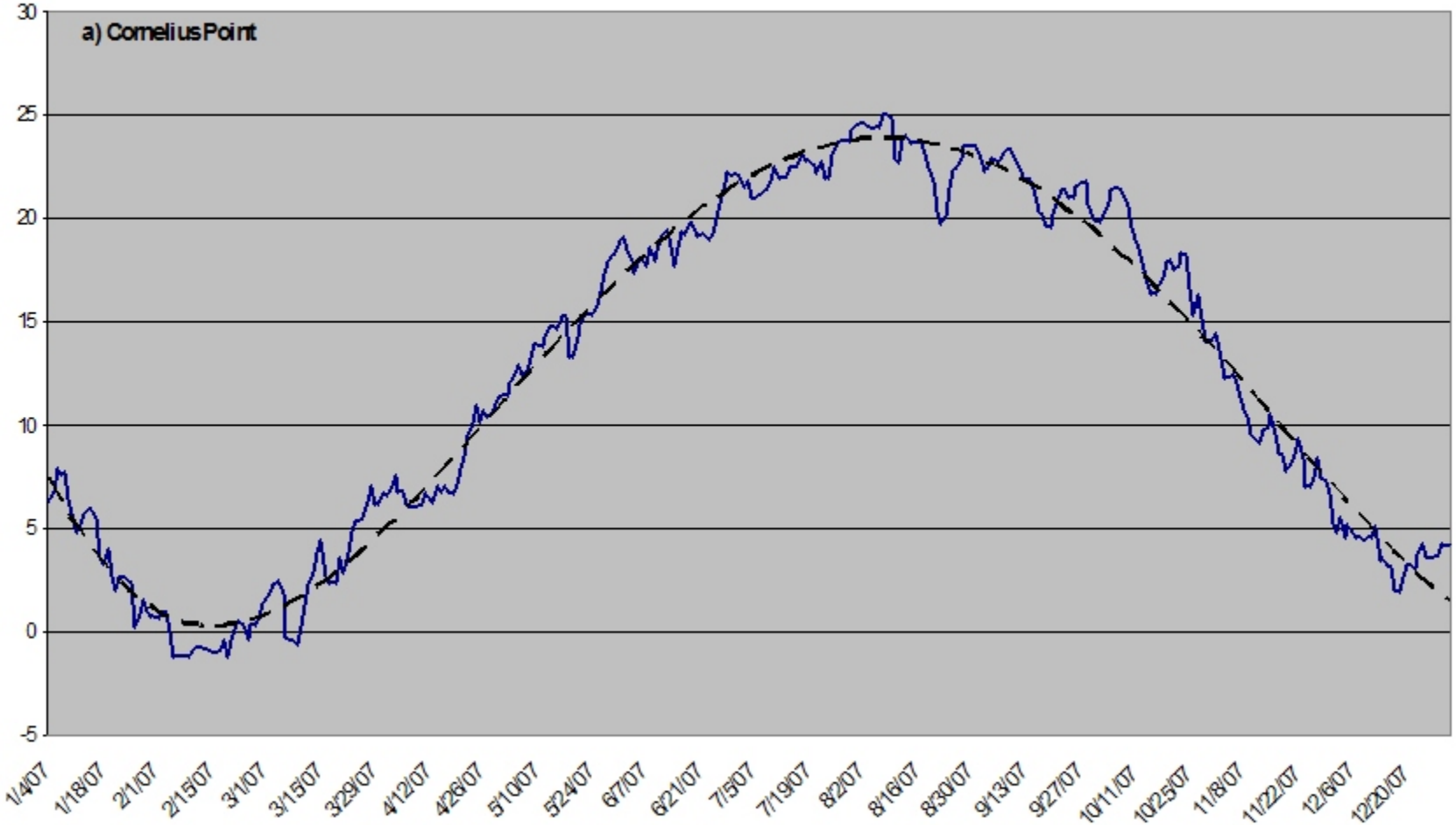
Overview

Since the 2006 monitoring season, there has been complete loss of eelgrass in three out of the six LTEMP sites. Southold Bay and Three Mile Harbor were lost in 2006 and Northwest Harbor was lost in 2007. While the loss of the last of the remaining eelgrass population at Northwest Harbor was a significant event, there was no other significant change in the remaining eelgrass populations in terms of shoot density. Bullhead Bay did experience a loss in areal extent with eelgrass retreating from Stations 2 and 6. Orient Harbor continues to maintain a small population of eelgrass, but has shown no signs of recovery since its decline in 2002-2003.

The primary cause(s) of the declines observed during monitoring have not all been identified, but physical disturbance, both natural and anthropogenic, rank high. Bioturbation by crabs, whelks and moon snails, can have a large impact on an eelgrass bed by uprooting plants and causing fragmentation. Grazing by swans and geese could have an impact on shallow eelgrass beds by both uprooting plants and consumption of eelgrass seeds needed for regeneration of the beds.

Human activities, specifically shellfishing and boating, potentially pose the greatest threat to eelgrass meadows in the Estuary. A single clammer digging in an eelgrass bed not only digs up plants, but also creates openings in the bed that can lead to erosion or serve to fragment the beds. Damage from boats results in disturbance similar to that of clamming, with the initial impact on the eelgrass bed being loss of plants, but prop scars also open up the bed to erosional processes and fragmentation. Physical disturbance should be considered one of the top factors in eelgrass loss in the Peconic Estuary.

Appendix 1. Water temperature (°C) graphs for selected sites within the Peconic Estuary. Datasets are represented as daily mean temperatures for 2007. The dashed lines represent the trend of the individual graph.


a) Cornelius Point
30
25
20
15
10
5
0
-5
1/4/07
1/18/07
2/1/07
2/15/07
3/1/07
3/15/07
3/29/07
4/12/07
4/26/07
5/10/07
5/24/07
6/7/07
6/21/07
7/5/07
7/19/07
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8/16/07
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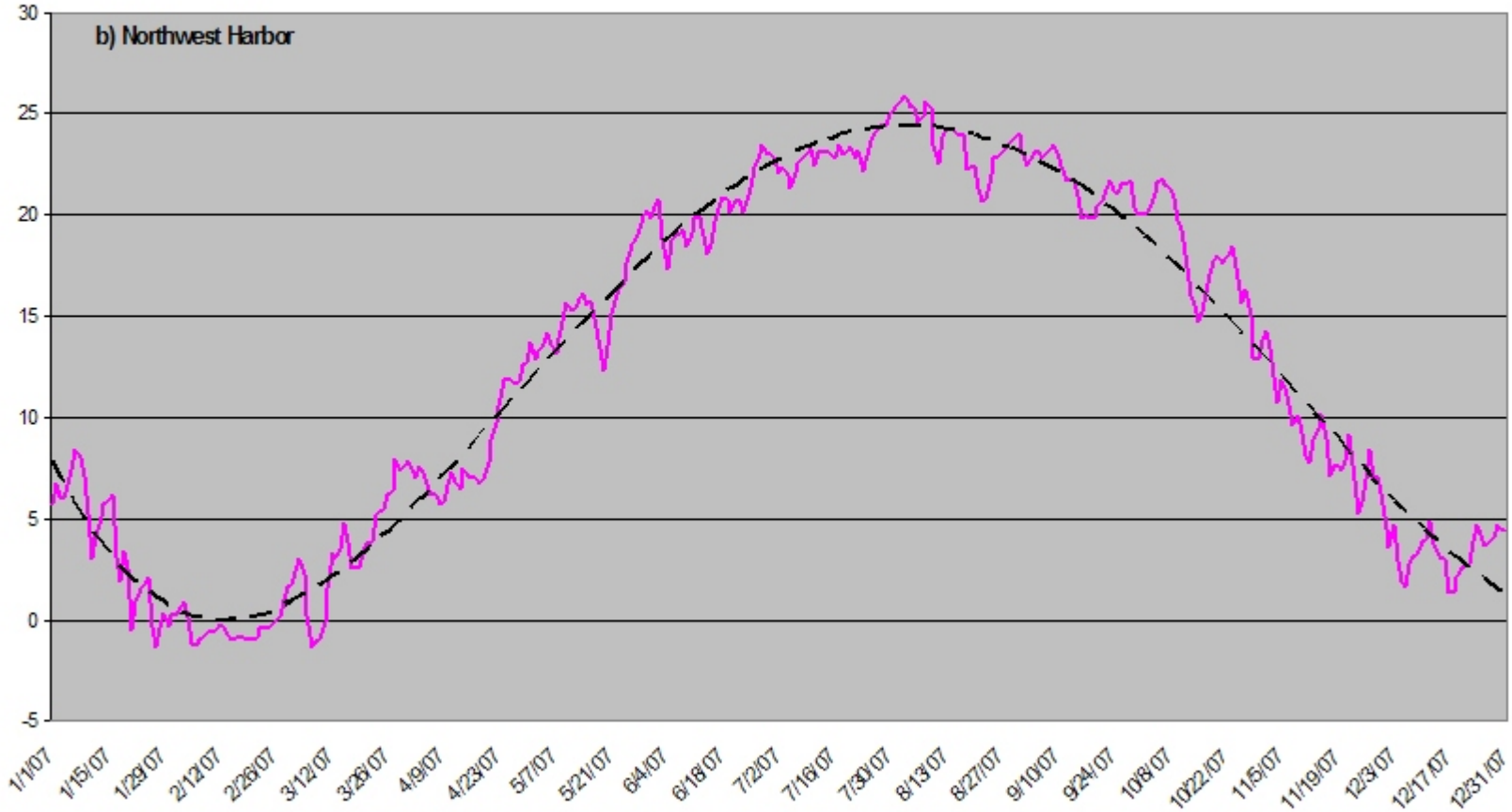
11/22/07
12/6/07
12/20/07


b) Northwest Harbor
30
25
20
15
10
5
0
-5
1/1/07
1/15/07
1/29/07
2/12/07
2/26/07
3/12/07
3/26/07
4/9/07
4/23/07
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5/21/07
6/4/07
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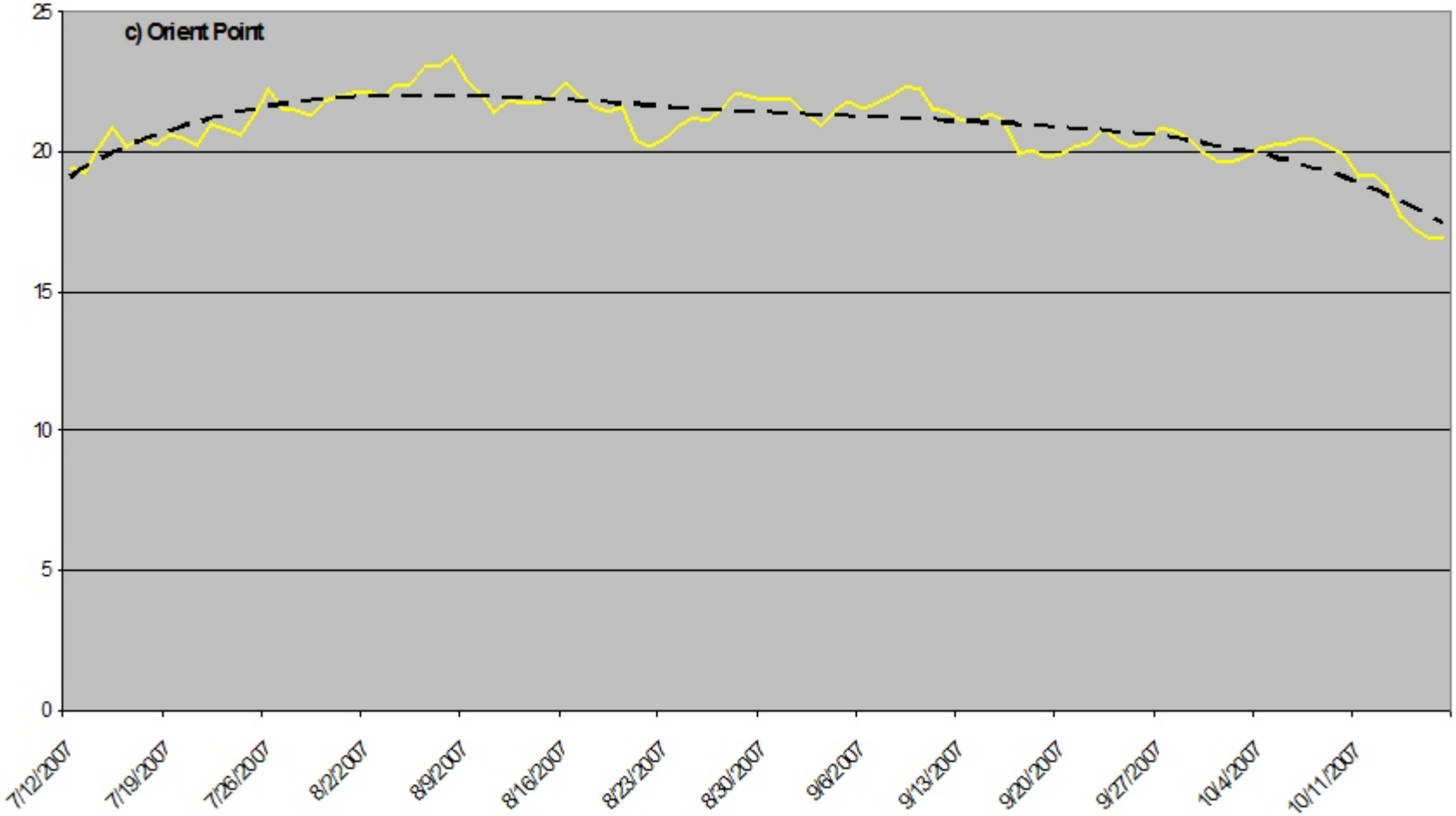
c) Orient Point
25
20
15
10
5
0
7/12/2007
7/19/2007
7/26/2007
8/2/2007
8/9/2007
8/16/2007
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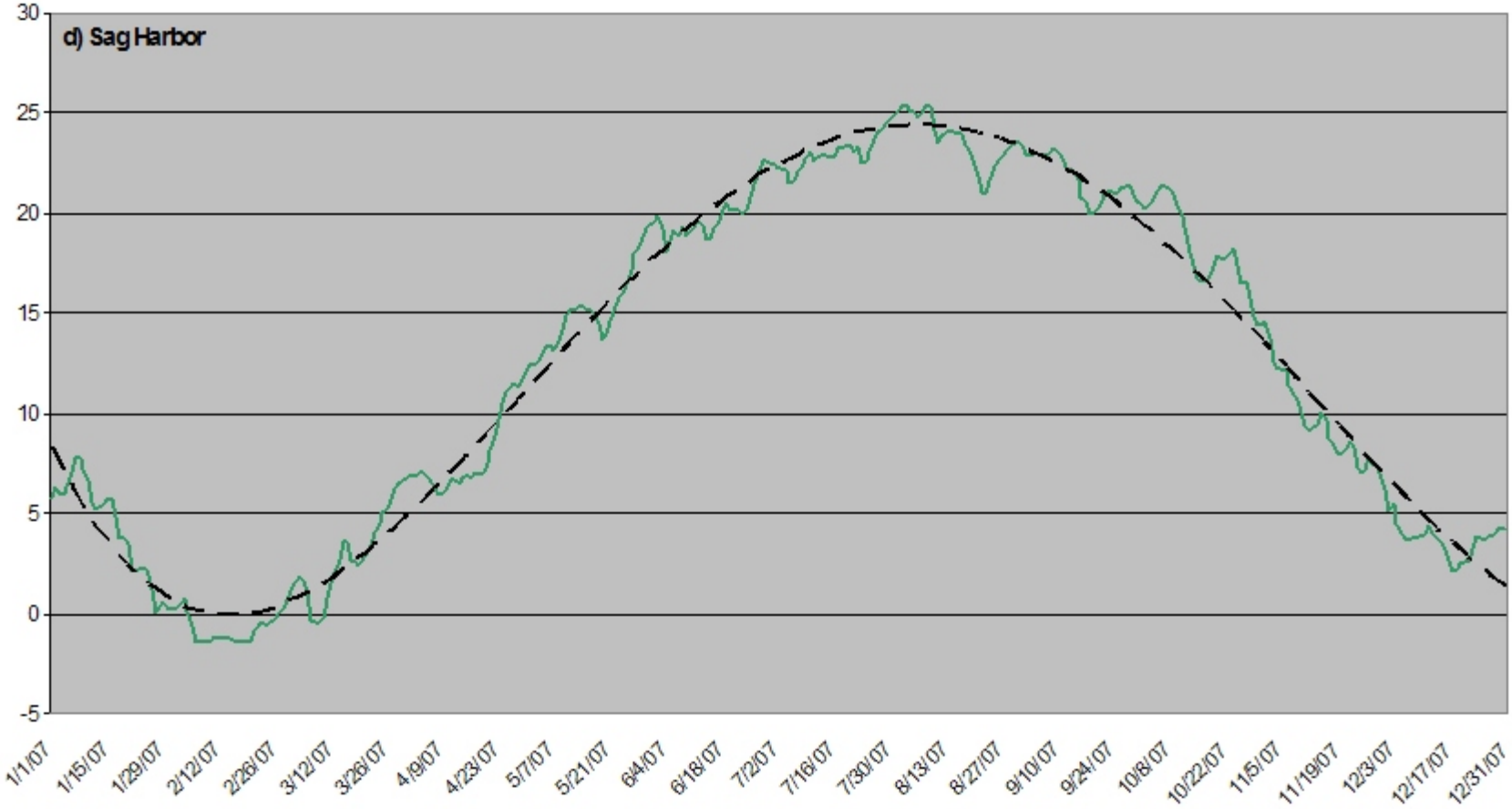
9/20/2007
9/27/2007
10/4/2007
10/11/2007


d) Sag Harbor
30
25
20
15
10
5
0
-5
1/1/07
1/15/07
1/29/07
2/12/07
2/26/07
3/12/07
3/26/07
4/9/07
4/23/07
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5/21/07
6/4/07
6/18/07
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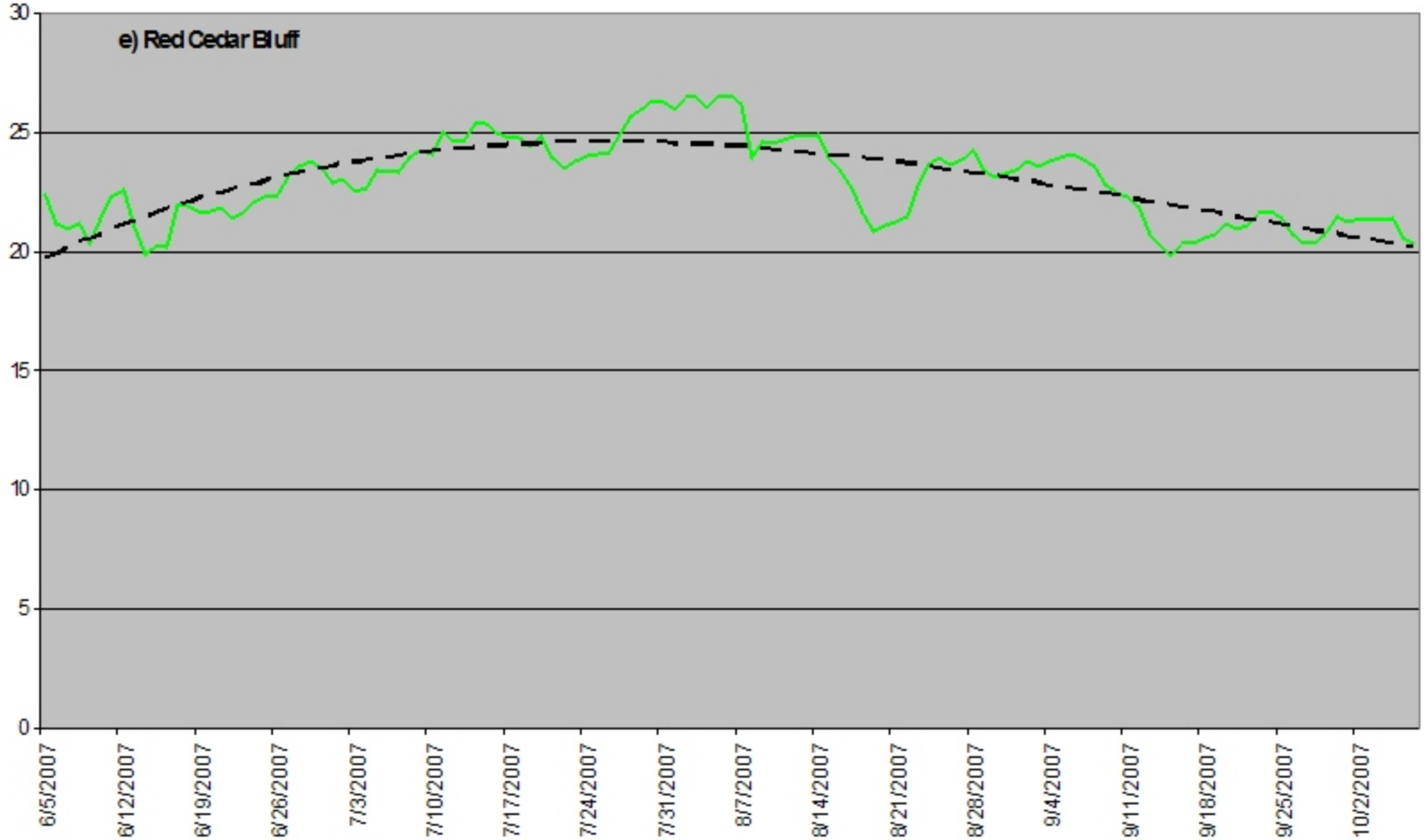
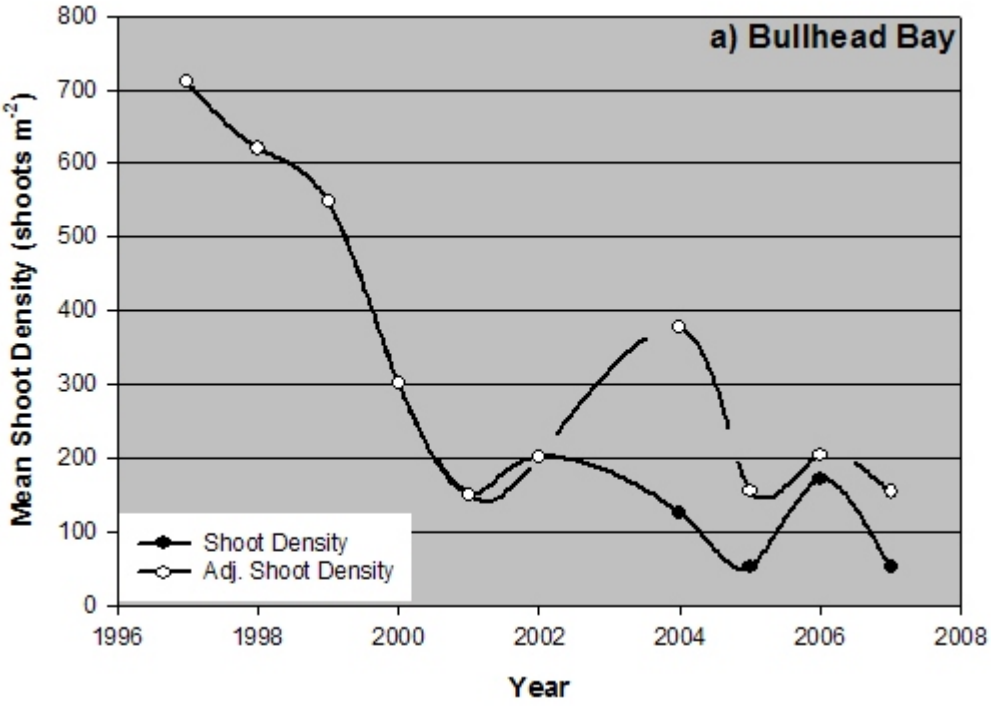
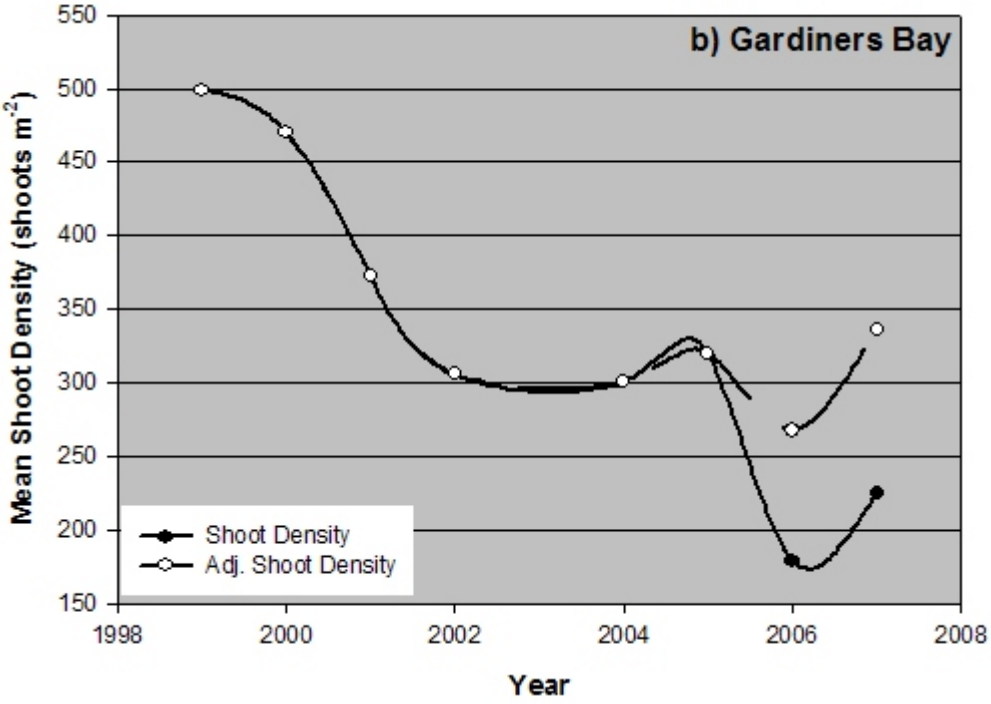
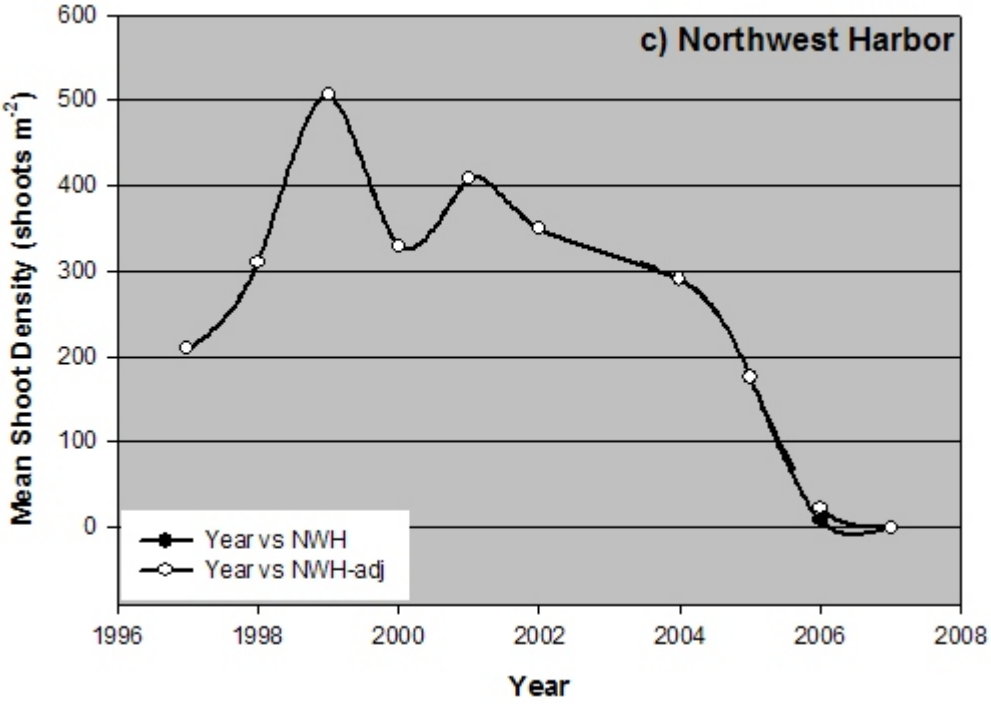
12/31/07

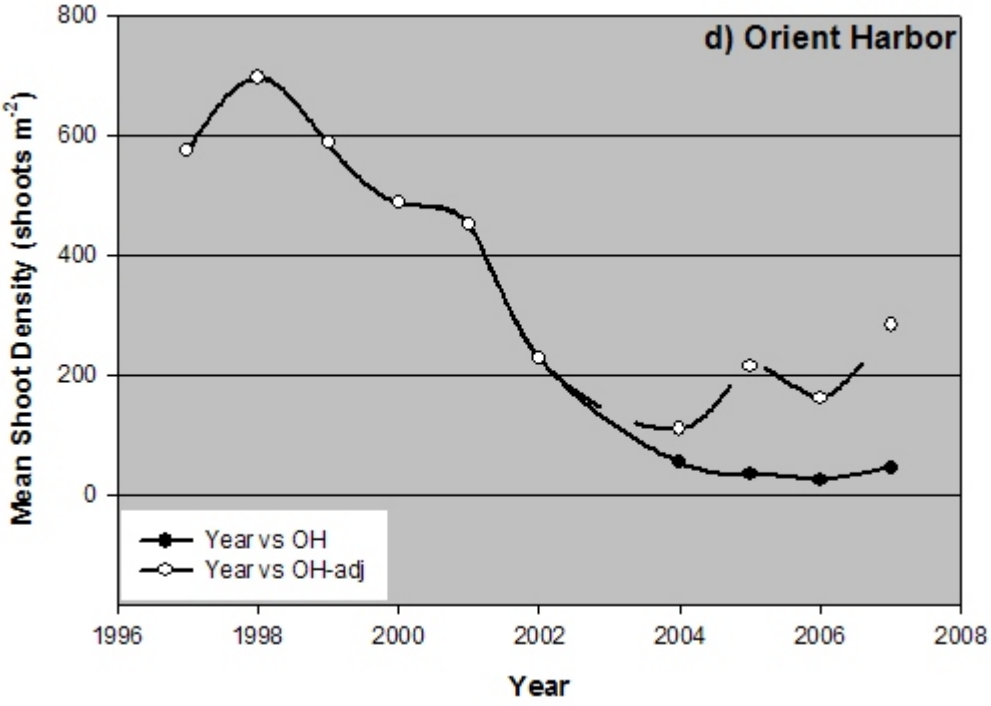

e) Red Cedar Bluff
30
25
20
15
10
5
0
6/5/2007
6/12/2007
6/19/2007
6/26/2007
7/3/2007
7/10/2007
7/17/2007
7/24/2007
7/31/2007
8/7/2007
8/14/2007
8/21/2007
8/28/2007
9/4/2007
9/11/2007
9/18/2007
9/25/2007
10/2/2007

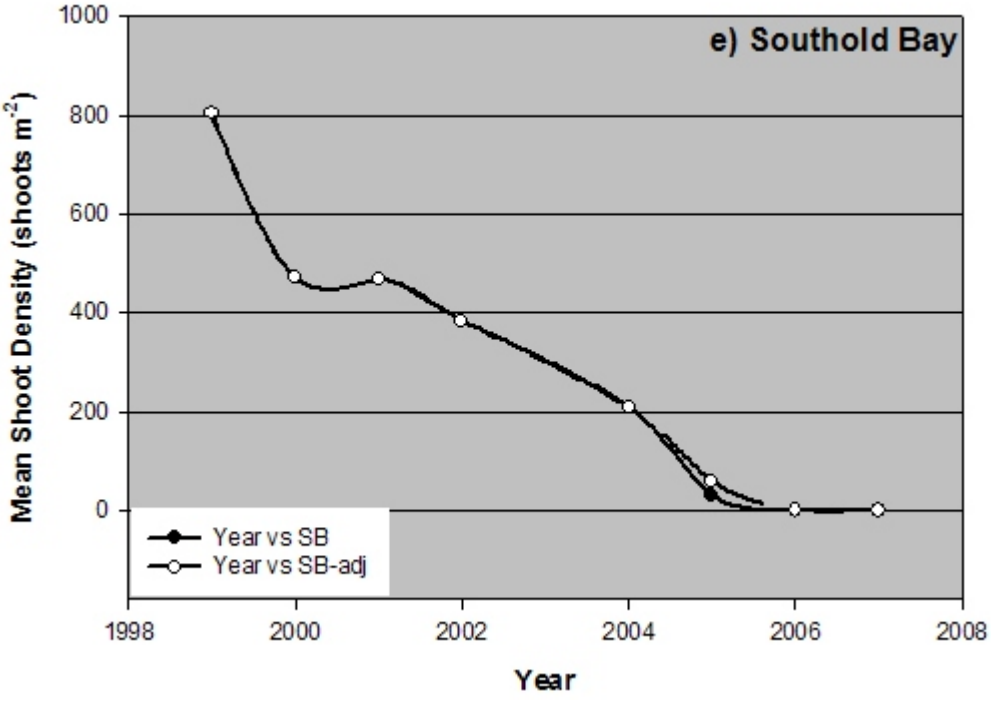
Appendix 2. Graphs of the mean eelgrass shoot densities for the six long-term monitoring sites. (Shoot density is expressed as shoots $^{-2}$). The dashed line represents the mean eelgrass shoot density for each of the beds with unvegetated stations removed.

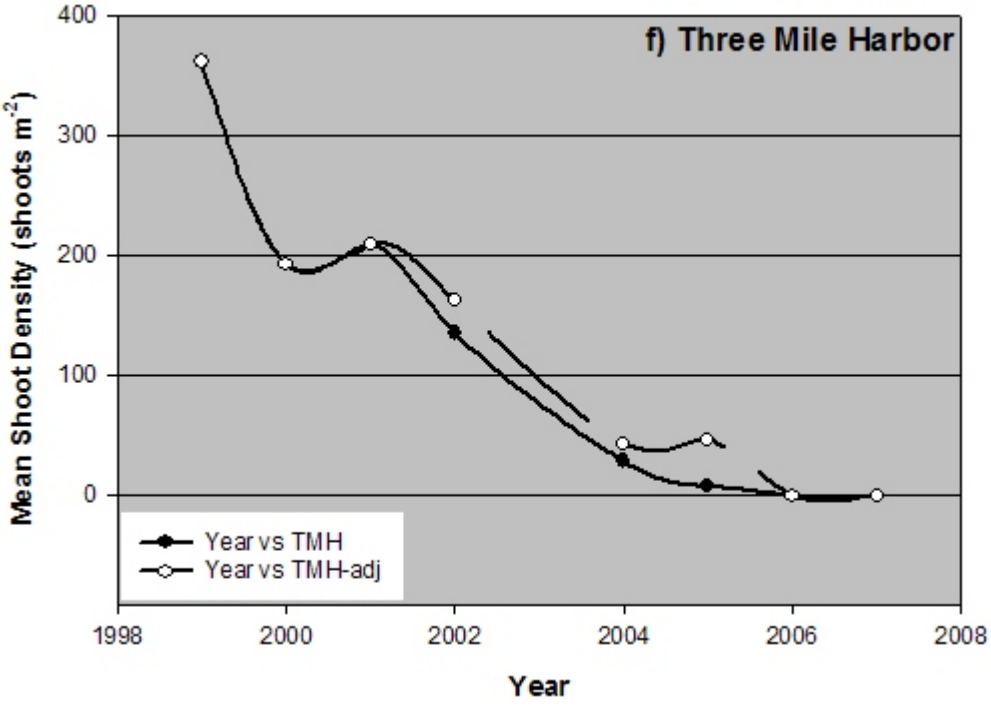



b) Gardiners Bay
Mean Shoot Density (shoots m-2)
550
500
450
400
350
300
250
200
150
1998
2000
2002
2004
2006
2008
Year
Shoot Density
Adj. Shoot Density

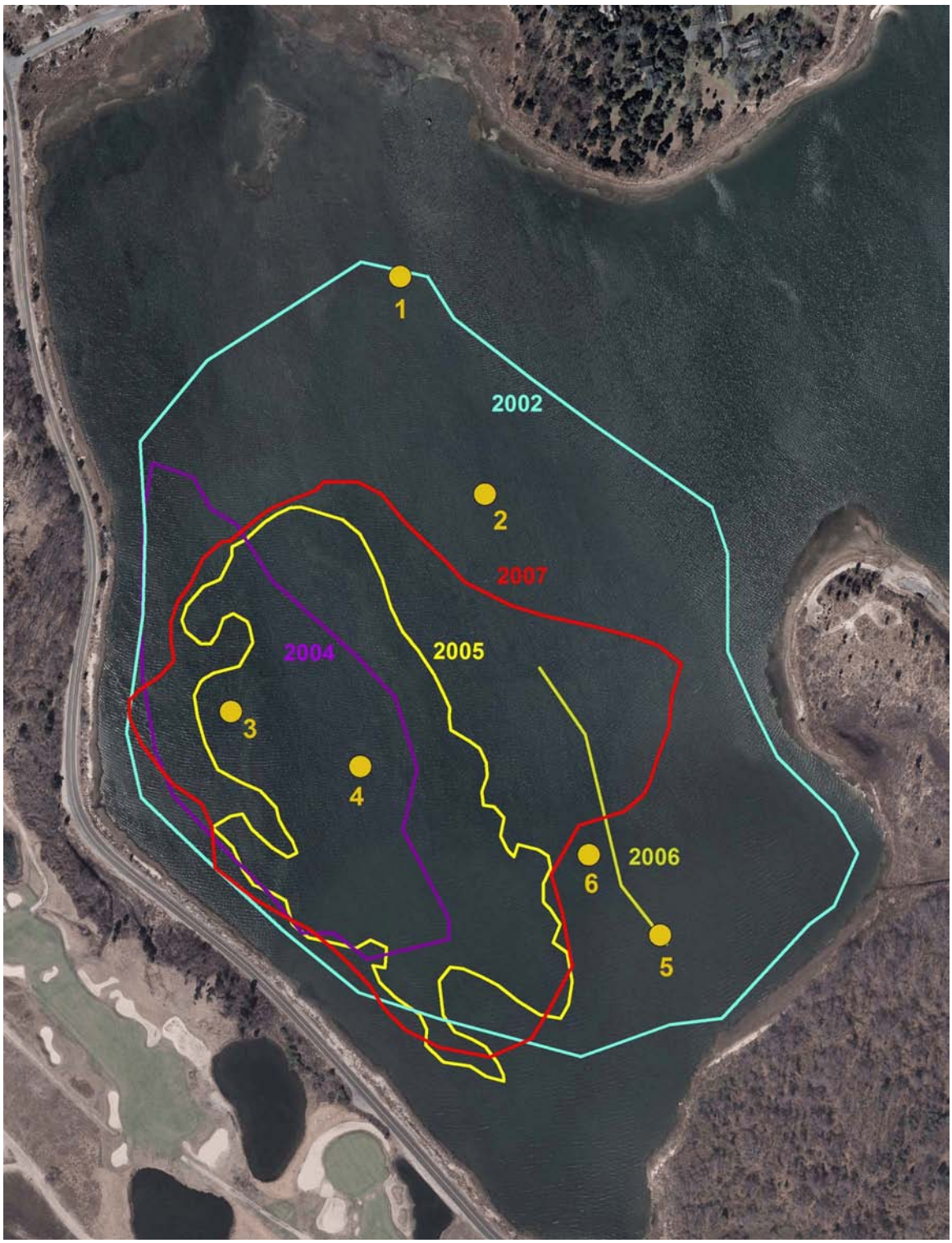

c) Northwest Harbor
Mean Shoot Density (shoots m-2)
600
500
400
300
200
100
0
1996
1998
2000
2002
2004
2006
2008
Year
Year vs NWH
Year vs NWH-adj


d) Orient Harbor
Mean Shoot Density (shoots m-2)
800
600
400
200
0
1996
1998
2000
2002
2004
2006
2008
Year
Year vs OH
Year vs OH-adj

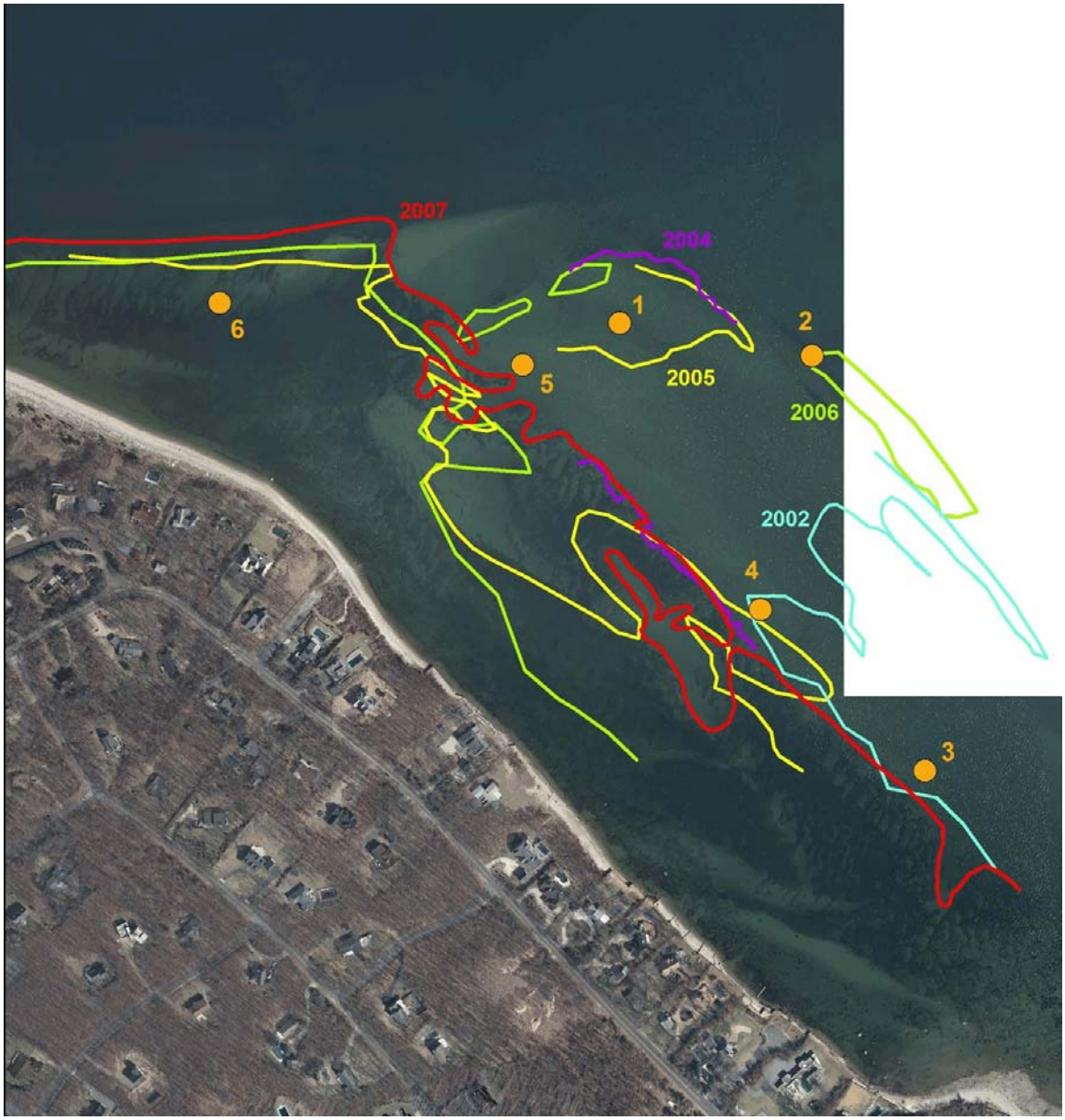

e) Southold Bay
Mean Shoot Density (shoots m-2)
1000
800
600
400
200
0
1998
2000
2002
2004
2006
2008
Year
Year vs SB
Year vs SB-adj


f) Three Mile Harbor
Mean Shoot Density (shoots m-2)
400
300
200
100
0
1998
2000
2002
2004
2006
2008
Year
Year vs TMH
Year vs TMH-adj

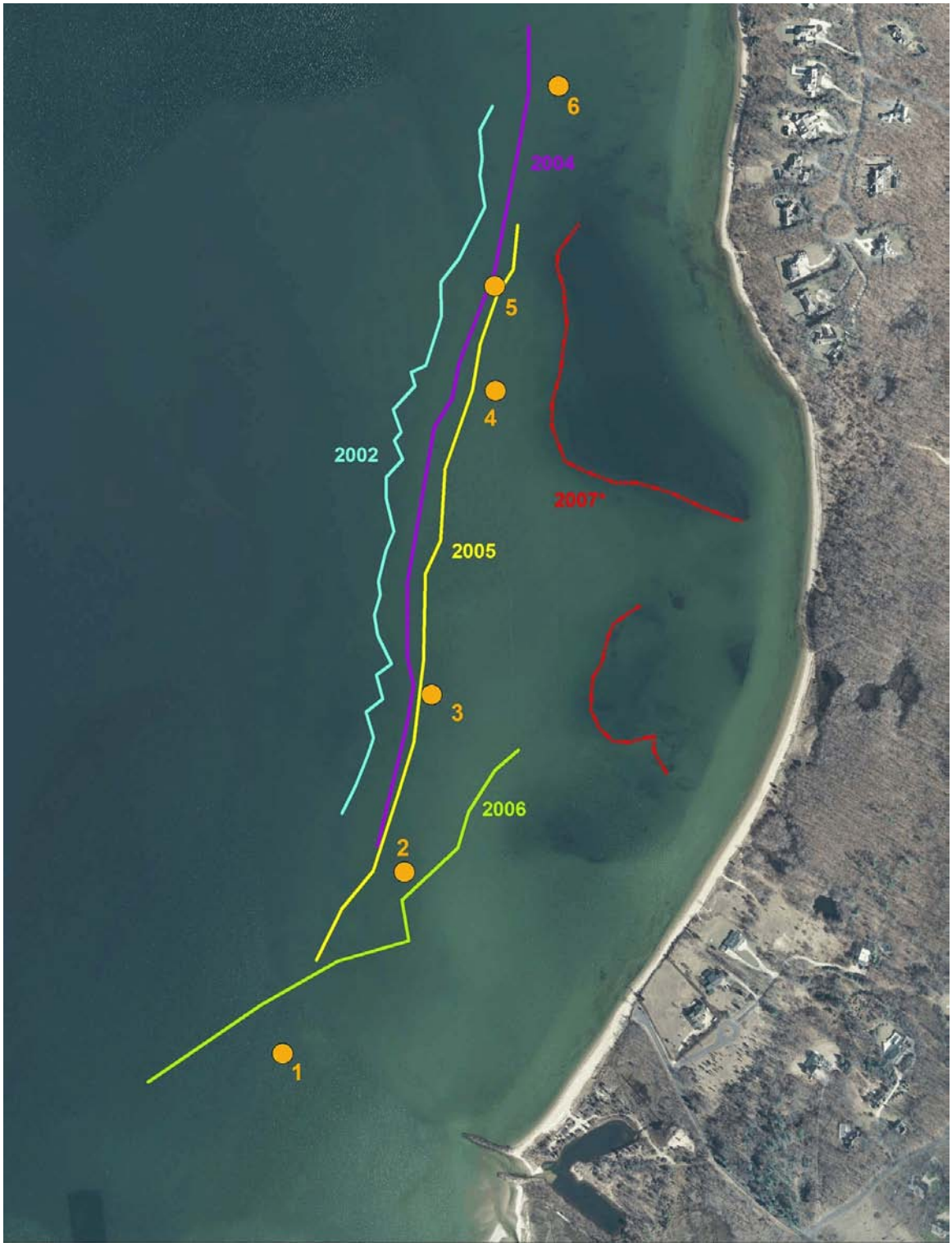
Appendix 3. Aerial photographs, with deep edge delineations, of the six monitoring sites for 2004. Monitoring stations are indicated by numbers (1-6) for each site.
a) **Bullhead Bay**



b) **Gardiner's Bay**

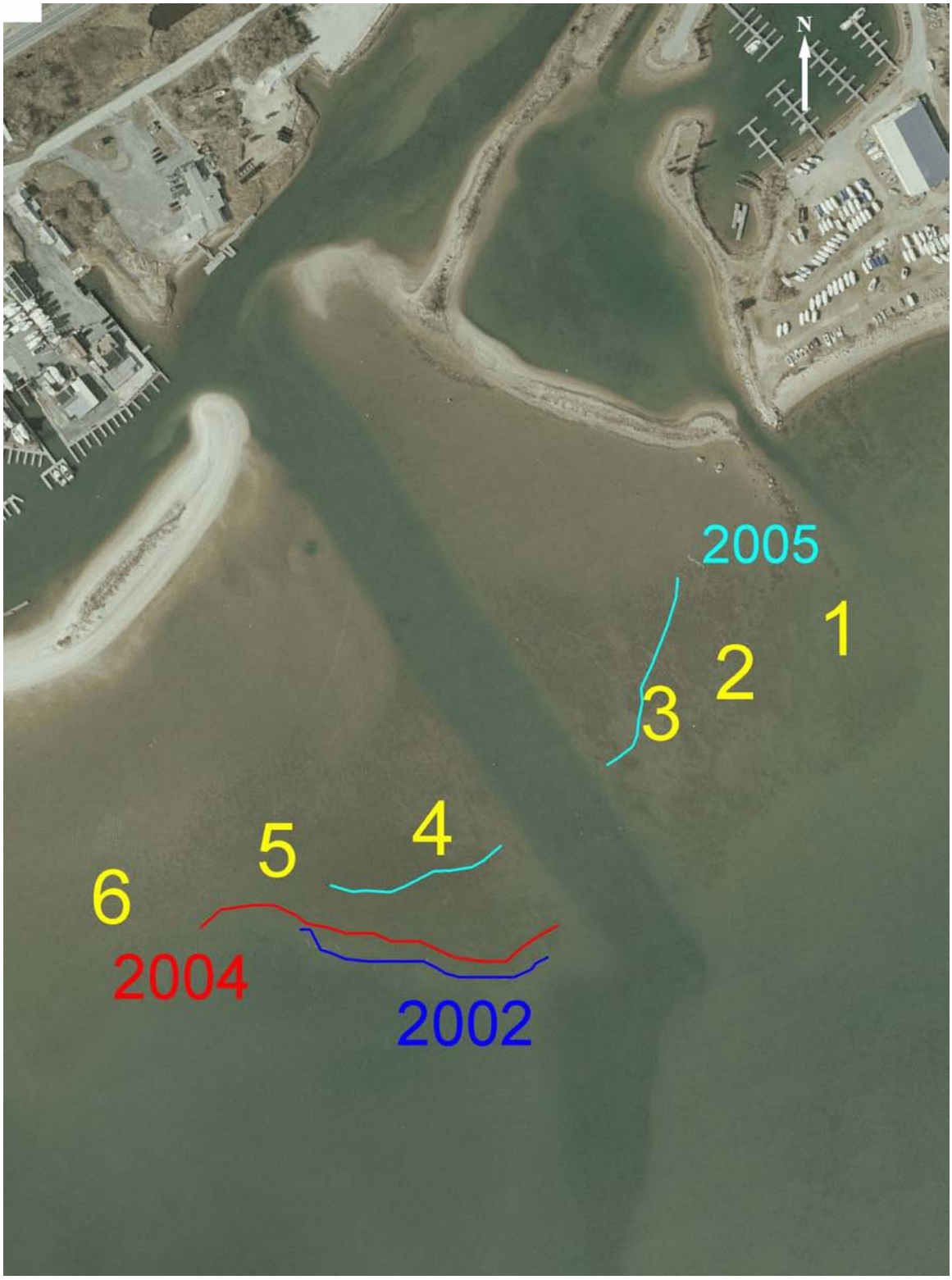


c) **Northwest Harbor**

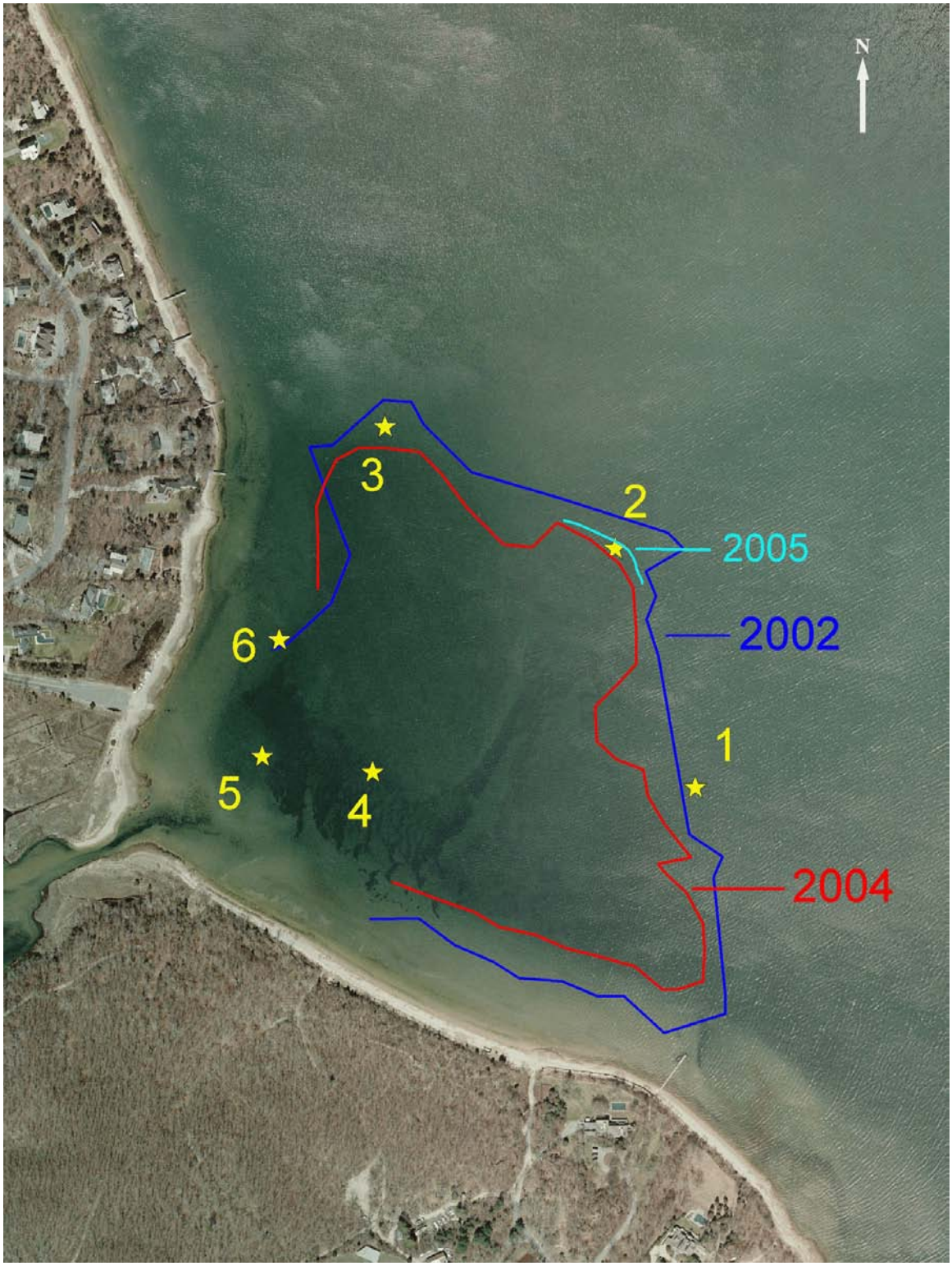


d) **Orient Harbor**

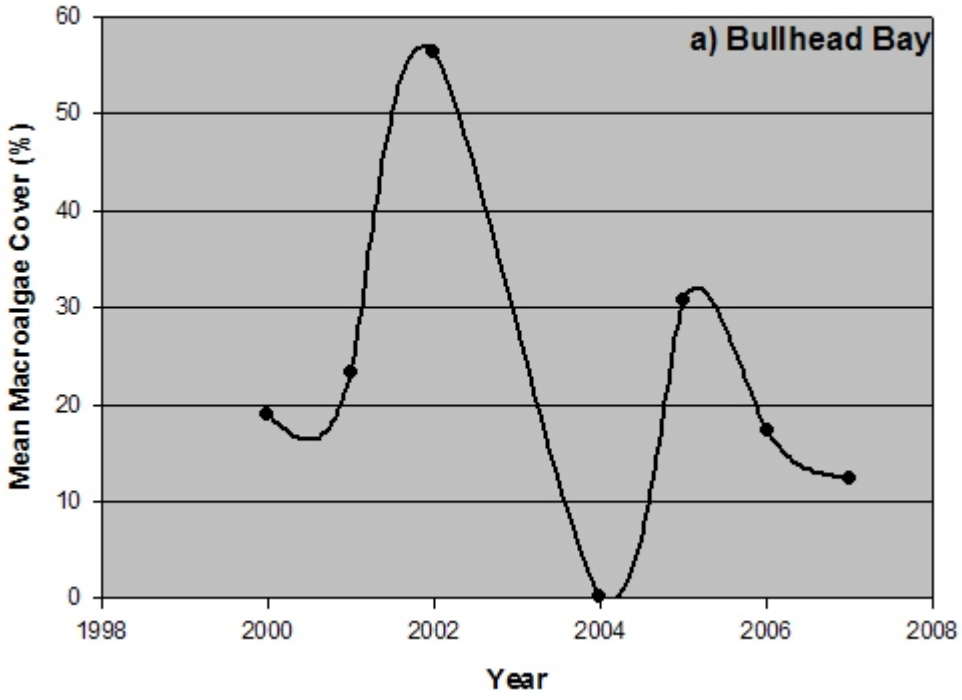
e) **Southold Bay** (note that there are no deep edges for 2006 or 2007 due to complete loss of eelgrass).

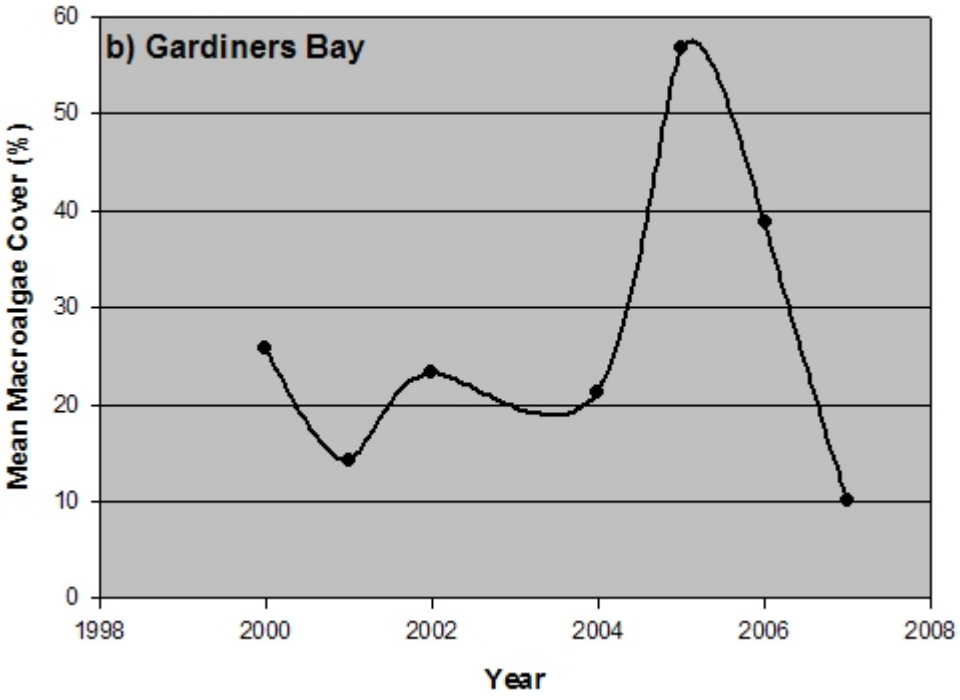


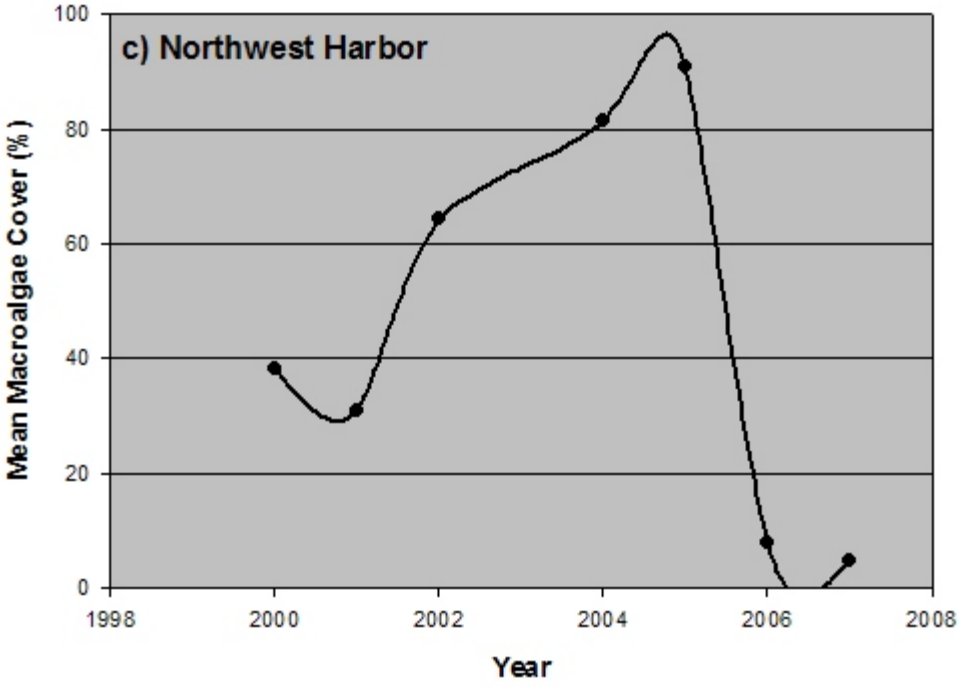
f) **Three Mile Harbor** (note that there are no 2006 or 2007 delineations due to complete loss of eelgrass within monitoring area).

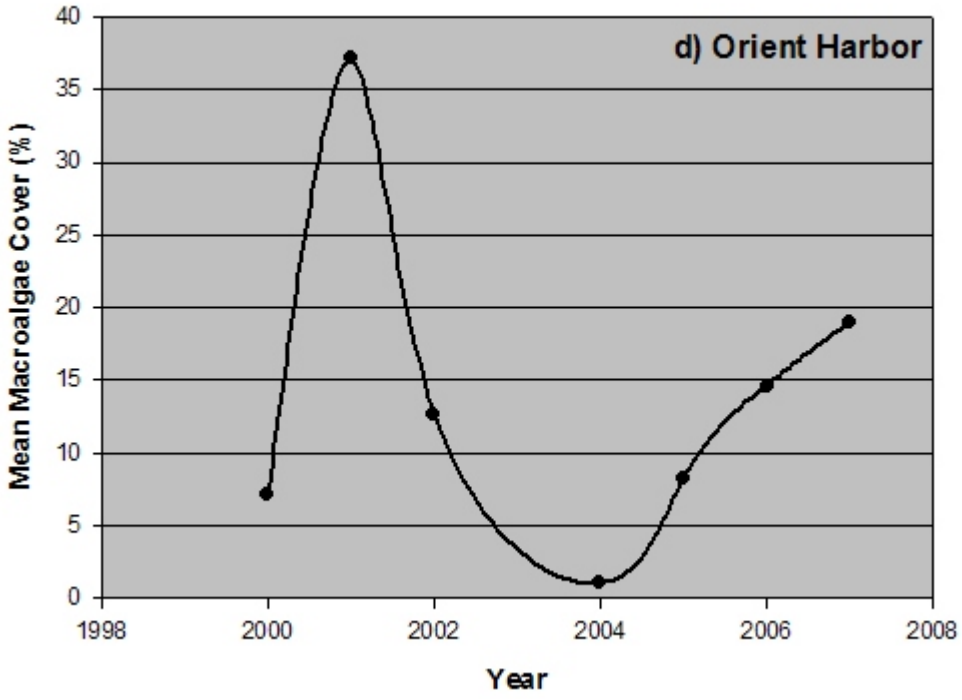


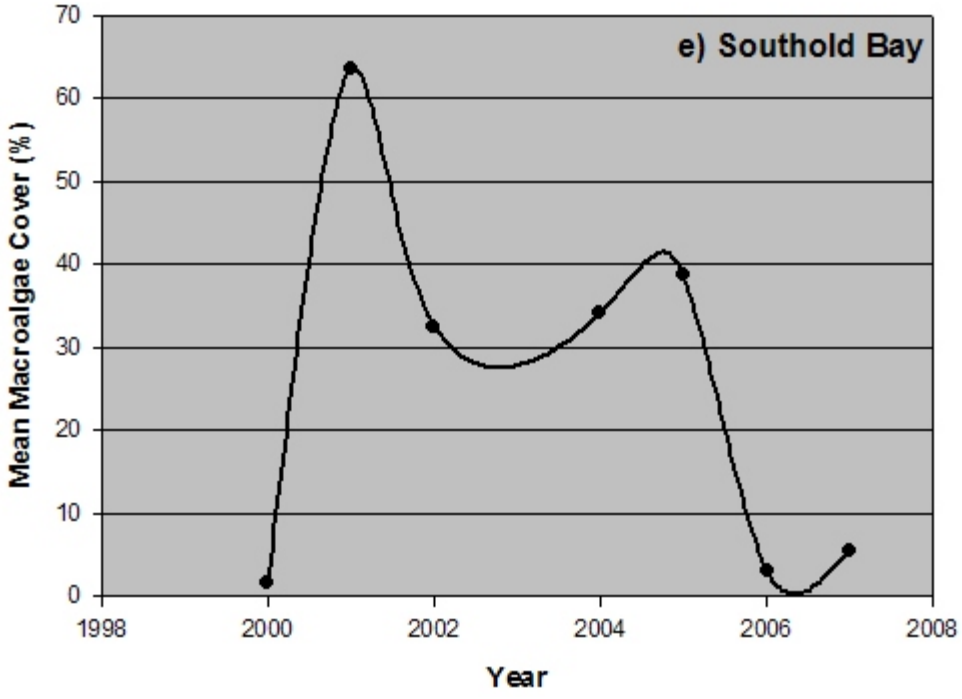
Appendix 4. Graphs representing the mean percent macroalgal cover at the six sites from 2000 to 2007.

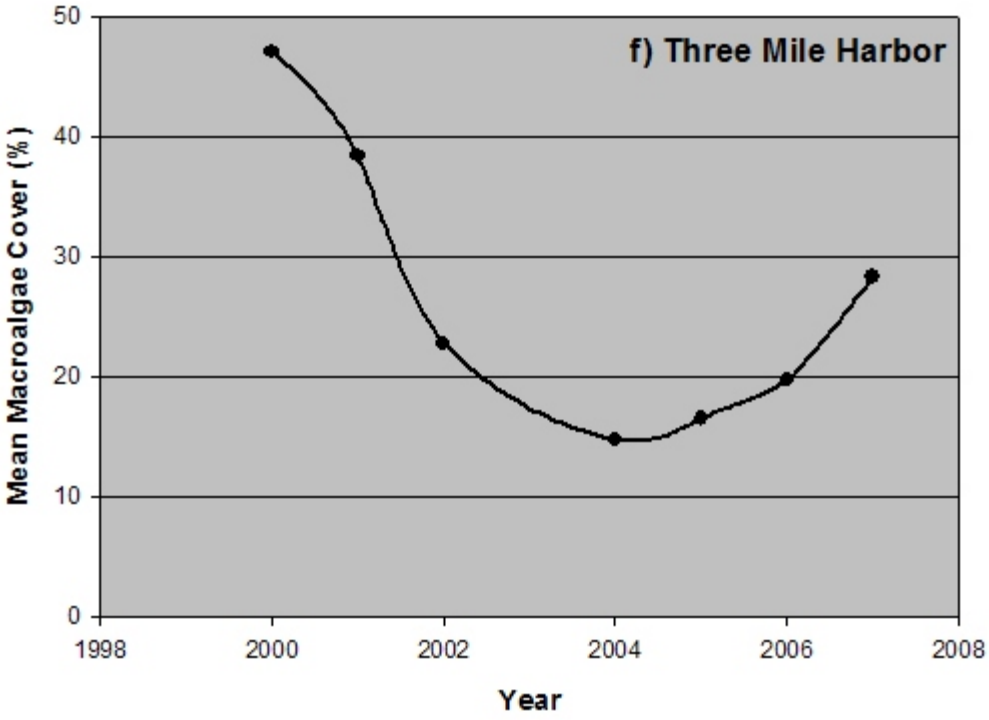



b) Gardiners Bay
Mean Macroalgae Cover (%)
0
10
20
30
40
50
60
1998
2000
2002
2004
2006
2008
Year


c) Northwest Harbor
Mean Macroalgae Cover (%)
0
20
40
60
80
100
1998
2000
2002
2004
2006
2008
Year


d) Orient Harbor
Mean Macroalgae Cover (%)
40
35
30
25
20
15
10
5
0
1998
2000
2002
2004
2006
2008
Year


e) Southold Bay
Mean Macroalgae Cover (%)
70
60
50
40
30
20
10
0
1998
2000
2002
2004
2006
2008
Year


f) Three Mile Harbor
Mean Macroalgae Cover (%)
50
40
30
20
10
0
1998
2000
2002
2004
2006
2008
Year