Peconic Estuary Program 2002 Eelgrass (*Zostera marina*) Long-Term Monitoring Program

Progress Report 5

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Submitted To:

The Peconic Estuary Program Office
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Office of Ecology

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Summary

The Peconic Estuary Program's Long Term Eelgrass Monitoring Program continued in 2002. The six monitoring beds were sampled from mid August to late September, 2002. Divers conducted 60 quadrat counts of eelgrass shoot density and macroalgae percent cover at each monitoring site. Overall, eelgrass shoot densities and macroalgae percent cover had decreased from 2001. However, macroalgae percent cover showed an almost 30% increase in Northwest Harbor and Bullhead Bays. The eelgrass bed delineations from aerial photographs, completed for the PEP, show little significant variation from deep edge delineations conducted using the depthfinder-DGPS method from previous monitoring seasons.

The significant decrease in eelgrass shoot densities, while an alarming event, may be a response to the increasingly cleaner waters in the Peconic Estuary. With lower nitrogen levels estuary-wide, there is a reduction in phytoplankton and macroalgae that would otherwise compete with and shade eelgrass. In the absence of this competition or stress, the eelgrass may reduce its shoot densities to allocate energy to other processes. Continued monitoring will aid in determining the cause(s) of this trend.

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, providing an important habitat in our shallow estuary waters for shellfish and finfish and 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 and plan for future work. 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 scheduled basis in order to develop a basic understanding of the ecology of the target entity. 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 an adaptation to the unique ecology and demography of the eelgrass in the Peconic estuary and varies significantly from other monitoring programs in the Chesapeake and other areas on the east coast.

Methods

The PEP SAV Monitoring Program includes six eelgrass beds located throughout the estuary and representing a range of environmental factors. The name and township location of each of the reference beds are listed in Table 1 and an aerial perspective of each site can be 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.

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 Harbor (SH)	Southold
Three Mile Harbor (TMH)	East Hampton

The monitoring program has evolved its methodologies from its inception in 1997. In the beginning, sampling consisted of the destructive collection of three (four in Bullhead Bay) 0.25 m^2 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 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, the number of replicate samples per station 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

Table 2. Descriptive statistics for eelgrass stem density.

Location	Sample Size (n)	Mean Stem Density (shoots/m^2)	Standard Error
Bullhead Bay (BH)	60	201	±14.1
Gardiners Bay (GB)	60	306	±24.6
Northwest Harbor (NWH)	60	350	±18.9
Orient Harbor (OH)	60	230	±13.4
Southold Harbor (SH)	60	384	±15.6
Three Mile Harbor (TMH)	60	135	±9.6

destructive sampling aspect of the program. The specific monitoring protocol for 2002 is outlined below.

Eelgrass Monitoring

The monitor, for the 2002 season, was initiated on 26 August, 2002 and completed on 30 September, 2002. Due to mechanical difficulty with the vessel used for the program, there was a gap of approximately one month between the start and completion of the survey for 2002.

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 algal percent cover in 0.10 m^2 quadrats. Divers also make observations on blade lengths and overall health of plants that they observe. 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 whether it is non-epiphytic or epiphytic on the eelgrass. Divers were careful not to disturb the eelgrass causing plants to be uprooted or otherwise damaged.

Data was incorporated into a spreadsheet and statistically analyzed using SigmaStat software (SPSS Inc. 1997).

Bed Delineation

For the 2002 season, the delineation for the deep edge was taken from the Tiner et al. report (2003). These delineations are considered accurate for this report as they were ground-truthed by CCE several months prior to the 2002 monitoring effort, and significant change was not expected in this short interval. Refer to the report by Tiner et al. (2003) for photographs of the sites with delineation.

Results

Eelgrass Stem Density

The basic descriptive statistics for the eelgrass stem densities are represented in Table 2. Included in the table are the sample sizes (replicates), mean stem density, and standard error of the means.

The stem density data was further analyzed using Kruskal-Wallis One way Analysis of Variance on Ranks (ANOVA) to determine differences between beds (Appendix 1). This test analyzes the distance between median values among the different beds. The test found a significant difference ($H=124.247$; $p= <0.001$) in the median eelgrass stem densities. The test was able to further analyze the data by completing a Pairwise Multiple Comparison Procedure (Dunn's Method) to elucidate differences

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

Eelgrass Bed	Percent Macroalgae Coverage
Bullhead Bay	56.4
Gardiners Bay	23.4
Northwest Harbor	64.3
Orient Harbor	12.7
Southold Harbor	32.6
Three Mile Harbor	22.8

between individual beds. The test found that Southold Harbor (SH), Gardiners Bay (GB), and Northwest Harbor (NWH) were not significantly different in stem densities ($p = >0.05$), with these three beds represented the highest stem densities of the six eelgrass beds. Bullhead Bay (BH) and Three Mile Harbor (TMH) contained the lowest stem densities ($p = >0.05$). Orient Harbor (OH) was left in the middle between Gardiners Bay and Bullhead Bay displaying no significant difference from either of the two beds. The complete statistical results are found in Appendix 1.

Algal Percent Cover

Algal percent cover was quantified for each quadrat within the six beds. Table 3 contains the mean percent coverage of macroalgae for each bed. The data was analyzed using Kruskal-Wallis One Way Analysis ANOVA on Ranks and the percent algal cover in the six beds was found to be significantly different based on the median percent cover per bed ($H = 93.18$; $p = < 0.001$) (Appendix 2). The pairwise comparisons found that Bullhead Bay and Northwest Harbor did not significantly differ in terms of algae cover, but they had considerably higher algal percent cover than all of the other beds ($p = <0.05$). There was no significant difference in algae cover between the remaining beds ($p = >0.05$). The complete results of the test can be found in Appendix 2.

Table 4 represents a taxa list for the macroalgae observed in the six monitoring sites for 2002. Presence and status as an epiphyte or nonepiphyte are indicated by (E) or (N), respectively.

Deep Edge Delineation

The delineations from the Tiner (2003) based on aerial photographs from 2001 and ground-truthing from summer/fall 2002 allowed for the accurate identification of the complete deep edge of the six eelgrass beds.

The delineations of the deep water edge from the Tiner report (2003) showed minor changes from the 2001 season. The exceptions to this trend would be the Gardiners Bay site in which observable changes in the "finger-like" projections of the bed are obvious and Northwest Harbor, where the true extent of the bed was not accurately delineated in the report. The Northwest Harbor bed is much more extensive than the delineation suggests and this fact should be noted.

Discussion

The 2002 season proved to be a unique year due to unusual environmental conditions and an unexpected deviation from the normal monitoring schedule. Both factors could have influenced the results of the data collected for eelgrass stem density and algal percent cover for the season.

In 2002, the region was faced with a prolonged drought which may have influenced the growing conditions in the estuary. The normal spring/fall phytoplankton blooms were severely inhibited, in both concentration and duration, leaving the estuary waters extremely clear. Suffolk County Water Quality measures of secchi depth found

Table 4. Macroalgal species observed in monitored beds in 2002. Indication of species status as an epiphyte(E) on eelgrass or a nonepiphyte(N) in the six beds is included.

Species	BB	GB	NWH	OH	SB	TMH
Green						
Chaetomorpha linum	N					
Cladophora spp.	N					
Codium fragile		N	N		N	N
*Ulva flexuosa**	E+N					
*Ulva intestinalis**	N	N				
Ulva spp.					N	
(*Formerly Enteromorpha species)						
Brown						
Fucus distichus					N	
Fucus spp.		N				
Sargassum filipendula		N	N		N	
Red						
Agardhiella subulata	N		N		N	
Audouinellia spp.		E				
Ceramium rubrum	N		N			
Ceramium spp.	N	E	N			E+N
Champia parvula	E			E		
Chondrus crispus		N				
Cystoclonium purpureum					N	
Grinnellia americana		N	N	N	N	
Lomentaria bailyana		N			N	
Polysiphonia denudata	N			E		
Polysiphonia elongata						
Polysiphonia harveyi	E+N					
Polysiphonia spp.	E+N	N	N	N		
Spermothamnion repens			E+N	N	E+N	
Spyridia filamentosa	E+N	N	E+N	N	E+N	E+N

that the estuary waters were unusually clear (>13 feet in some areas) (Appendix 3). The clear water would allow more light to penetrate the water column to greater depths, benefitting eelgrass.

Even with the increased water clarity, all six eelgrass monitoring sites showed a decrease in the average stem density in 2002, but the changes in eelgrass shoot density could be attributed to changes in water clarity. Turbid waters result in decrease light penetration and place a stress on eelgrass plants and can elicit an increase in shoot density or shoot length to acquire more light for the plants. Conversely, if the waters are very clear, as the Peconic Estuary was during the growing season in 2002, the plants would not need the greater surface area provided by more shoots, but instead could conserve resources for use in rhizome elongation and reproduction, resulting in decreased stem density.

Macroalgal percent coverage in the six beds also deviated noticeably from previous years. Three of the beds with perennially high macroalgal cover (Bullhead Bay, Northwest Harbor, and Southold Bay), showed a decrease in percent cover of seaweeds. Whereas in past years all three of these beds have had high percent coverage of macroalgae (>75%), these beds were below their norms in 2002. The decrease in macroalgae in the eelgrass beds may be linked to the drought conditions of the region. With reduced rain, and subsequent reduced runoff and groundwater seepage, there may have been a limitation in one or more micro-nutrients that algae needs to bloom. Nitrogen did not seem to be limited in the estuary as concentrations of Total Nitrogen (TN), Total Dissolved Nitrogen (TDN) and Nitrate/Nitrite (NOx) were above the limits set in the PEP CCMP(Appendix 4). A nutrient limitation of some kind is supported by the occurrence of a "weak" spring phytoplankton bloom and the continually clear waters throughout the summer.

For two of the beds, Orient Harbor and Southold Harbor, shoot density and macroalgal cover data may have been influenced by being surveyed one month later than norm. Due to mechanical difficulties, these two sites were monitored in the end of September 2002, one month after the seasons survey is usually completed. Time of year can affect plant growth habits due to water temperature changes and day length. It is unlikely that water temperature change influenced the measured parameters as water temperatures change little from the end of August to the end of September. Day length may have had some influence on shoot densities, but there is no data to support this hypothesis. It should be noted, however, that there are many plant species that use day length as a cue for senescence of leaves and this mechanism may be present in eelgrass. Even though Orient Harbor and Southold Harbor both displayed an unusual decrease in shoot density from previous years, the decrease seems to be in order with the decreases observed in all of the beds for 2002. The one month lapse in the survey most likely did not influence the data significantly.

It is difficult to determine whether or not the observed decreases in shoot density in all of the beds from previous years indicates a health concern for the Peconic eelgrass or if it is just a natural response of the plants when stresses, such as light attenuation and macroalgal competition, are relieved. Based on field observations, it seems the latter case is more likely as the plants appeared to be healthy. This is especially evident in the Southold Harbor bed where, in the past shoot densities were near 1000 shoots/m^2 and the plants were small (<0.5 m in length), and now plants are larger, though in a lower density. The situation does bear watching and if this is the beginning of a negative trend, it will become evident in the subsequent surveys.

In regards to the deep edge delineation of the six beds, there were only minor deviations from 2001 in most of the beds. However, the eelgrass bed in Northwest Harbor is grossly underestimated in its extent. The beds is almost continuous from Cedar Point around and down to the mouth of Northwest Creek. It is possible that the contrast in the aerial photograph was such that the deeper sections of the bed were missed. This error should be noted and a correction should be made in the next aerial survey. The other minor changes in the delineations are likely artifacts of differences in methodology and resolution between the 2001 delineation, conducted via depth finder and GPS, and the aerial delineations completed by Tiner and used for this report. The exception to this however, would be the Gardiners Bay eelgrass bed. This bed has a number of "finger-like" projections of eelgrass along its deep edge that run parallel to the main navigational channel that runs into Greenport harbor. These projections of eelgrass are dynamic due to the influence of current and wave action in this area of the bed causing sediment (primarily sand) to bury or erode fro this area, thus exerting an annual change of appearance.

Overall, despite the reduced stem density, the eelgrass appears to be healthy in all beds. The increased water clarity and decline of macroalgae within the beds was certainly a benefit to the conditions of the plants for 2002 and it is hoped that this trend will continue throughout the estuary, allowing all of the eelgrass beds to continue to recover from the Brown Tide event of a decade ago.

References

Tiner, R.W., H.C. Bergquist, D. Siraco, and B.J. McClain, 2003. An Inventory of Submerged Aquatic Vegetation and Hardened Shorelines for the Peconic Estuary, New York. U.S. Fish and Wildlife Service, Northeast Region, Hadley, MA. Prepared for the Peconic Estuary Program of the Suffolk County Department of Health Services, Office of Ecology, Riverhead, NY. 47 pp.

Appendix 1-Statistical Analysis of Stem Density

One Way Analysis of Variance

Data source: Stem Densities (shoots/m2) in SAV Monitoring-2002

Normality Test: Passed (P > 0.200)

Equal Variance Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks Sunday, September 29, 2002, 07:46:47

Data source: Stem Densities (shoots/m2) in SAV Monitoring-2002

Group	N	Missing	Median	25%	75%
BH	60	0	180.000	120.000	270.000
GB	60	0	340.000	160.000	410.000
NWH	60	0	330.000	245.000	445.000
OH	60	0	235.000	150.000	305.000
SH	60	0	370.000	285.000	455.000
TMH	60	0	150.000	110.000	190.000

H = 124.247 with 5 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Dunn's Method) :

Comparison	Diff of Ranks	Q	P<0.05
SH vs TMH	177.625	9.349	Yes
SH vs BH	126.908	6.679	Yes
SH vs OH	104.983	5.525	Yes
SH vs GB	51.608	2.716	No
SH vs NWH	26.525	1.396	No
NWH vs TMH	151.100	7.953	Yes
NWH vs BH	100.383	5.283	Yes
NWH vs OH	78.458	4.129	Yes
NWH vs GB	25.083	1.320	No
GB vs TMH	126.017	6.632	Yes
GB vs BH	75.300	3.963	Yes
GB vs OH	53.375	2.809	No
OH vs TMH	72.642	3.823	Yes
OH vs BH	21.925	1.154	No
BH vs TMH	50.717	2.669	No

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Appendix 2-Statistical Analysis of Algal Coverage

One Way Analysis of Variance
Data source: Percent Algae Cover in SAV Monitoring-2002

Normality Test: Failed (P = <0.001)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks Saturday, December 06, 2003, 17:19:39

Data source: Percent Algae Cover in SAV Monitoring-2002

Group	N	Missing	Median	25%	75%
BH	60	0	50.00	10.00	100.00
GB	60	0	10.00	5.00	45.00
NWH	60	0	75.00	40.00	90.00
OH	60	0	7.50	5.00	10.00
SH	60	0	10.00	0.00	50.00
TMH	60	0	5.00	0.00	50.00

H = 93.18 with 5 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

To isolate the group or groups that differ from the others use a multiple comparison procedure.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparison	Diff of Ranks	q	P<0.05
NWH vs OH	8273.00	10.26	Yes
NWH vs TMH	8098.00	10.05	Yes
NWH vs GB	6433.50	7.98	Yes
NWH vs SH	6392.50	7.93	Yes
NWH vs BH	1751.00	2.17	No
BH vs OH	6522.00	8.09	Yes
BH vs TMH	6347.00	7.87	Yes
BH vs GB	4682.50	5.81	Yes
BH vs SH	4641.50	5.76	Yes
SH vs OH	1880.50	2.33	No
SH vs TMH	1705.50	2.12	No
SH vs GB	41.00	0.051	No
GB vs OH	1839.50	2.28	No
GB vs TMH	1664.50	2.06	No
TMH vs OH	175.00	0.22	No

Note: The multiple comparisons on ranks do not include an adjustment for ties.

Appendix 3. Suffolk County Department of Health Services water quality data for nitrate (NOx), total nitrogen (TN), and total dissolved nitrogen (TDN)for 2002. Data represents annual mean concentrations in mg L^{-1}. (N.D. = No Data)

	Water Quality Parameters			
Site	Secchi Depth (ft)	NOx	TN	TDN
Bullhead Bay	>6	0.027	0.21	0.18
Gardiners Bay	>10	0.013	0.2	0.19
Northwest Harbor	>8	0.027	0.20	0.19
Orient Harbor	>9	0.021	0.19	0.19
Southold Bay	>7	0.023	0.19	0.19
Three Mile Harbor	N.D.	N.D.	N.D.	N.D.