PECONIC ESTUARY PROGRAM
Long Term Eelgrass Monitoring Program

Eelgrass Trends Analysis Report: 1997-2002
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THE PECONIC ESTUARY PROGRAM OFFICE
SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES
OFFICE OF ECOLOGY

SUBMITTED BY:

CHRIS PICKERELL
AND
STEPHEN SCHOTT

MARINE PROGRAM
CORNELL COOPERATIVE EXTENSION
SUFFOLK COUNTY

Summary

This report represents six seasons of eelgrass (*Zostera marina* L.) monitoring in the Peconic Estuary and includes trends analysis for nitrogen-based water quality parameters, eelgrass shoot densities, and macroalgae percent cover. The program monitors six eelgrass beds in the Peconic Estuary and they include: Bullhead Bay (Southampton), Gardiners Bay (Shelter Island), Northwest Harbor (East Hampton), Orient Harbor (Southold), Southold Bay (Southold), and Three Mile Harbor (East Hampton). The program has continued to evolve since 1997, with several changes having been implemented regarding sampling protocol. Most notably, the program has increased the number of replicate sample per site and has discontinued destructive sampling techniques. Water quality, based on the Suffolk County Department of Health Services data, has steadily improved at the 6 eelgrass monitoring sites. Organic nitrogen levels (TKN and TDKN) have decrease significantly since 1997, while total nitrogen (TN and TDN) have remain stable. Nitrate and nitrite levels (NO_x) were relatively low. The health of the eelgrass in the estuary is generally good. The major trend evident in the eelgrass data is the almost constant decline of eelgrass shoot densities in the six monitoring beds. Although this trend is alarming, it may be that this is a natural response to increasingly better water quality (*e.g.*, clarity) as the eelgrass plants become less stressed. Most of the eelgrass beds have remained relatively stable in their areal cover with the exception of Southold Bay and Three Mile Harbor. There has been noticeable loss to sections of these two beds since 1997. The losses have generally occurred in sections along the edges and may have been influenced by human activities (*e.g.*, prop wash, mooring anchor scouring). Continued monitoring of the beds will provide more data to better identify the nature of this trend. Macroalgae percent cover trends in the monitoring beds have been variable. The majority of the beds have seen a net decrease in percent cover since 2000 with Northwest Harbor and Bullhead Bay experiencing increases of over 30% in 2002. Macroalgae do represent a competitive threat to eelgrass, especially under eutrophic conditions where they can quickly overgrow an eelgrass meadow and shade out or smother the *Zostera*. Although macroalgae are not currently a threat to any of the eelgrass beds, the potential for macroalgal blooms is still present and should be monitored.

Introduction

Eelgrass(*Zostera marina* L.) is an important resource in coastal ecosystems. Eelgrass beds provide nursery habitat for a variety of commercially and recreationally important species. Juvenile bay scallops (*Argopecten irradians irradians)*, experience enhanced survival from predation in the presence of eelgrass (Pohle et al., 1991) and therefore could be impacted by declining eelgrass populations. Eelgrass meadows also act to stabilize sediment and contribute significantly to the primary production in bays and estuaries (Phillips and McRoy, 1980).

The decline of eelgrass 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 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 this species, the better able the Peconic Estuary Program will be to implement policies to protect and enhance 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 necessary to assess 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 on the East Coast.

Methods

The initial methodology for the eelgrass monitoring program was developed, in consultation with eelgrass researchers from Chesapeake Bay and New Hampshire, as a very basic collection of data to be used in a qualitative evaluation of the health of the eelgrass beds in the Peconic Estuary. The methods adopted during the first years of the program were used for the 1997-1999 monitoring seasons. Following this early work the monitoring program has continued to evolve over the last 6 seasons. The program started with a limited, qualitative methodology that included three sites and few replicate samples, which technical consultants found to be adequate for a monitoring program. Currently, the monitoring protocols are more quantitative, with six eelgrass sites and significantly higher numbers of replicates, allowing for more appropriate statistical analysis of data. As the program has evolved, care has been taken to retain the continuity of sampling and ensure that newly collected data is comparable to older data sets. Additional protocols can and will be added, as needed, to address concerns as they arise (*e.g.*, detailed temperature monitoring and genetic screening of local meadows). The future of the program may include the development and use of models to calculate several physical parameters that currently require destructive sampling. This section will detail the changes in monitoring methodology from 1997 to the present and will include rationale for modification of methods and their subsequent benefits to the program.

1997-1998

For the 1997 and 1998 seasons, the program focused on three sites, Bullhead Bay, Northwest Harbor, and Orient Harbor. The protocol consisted of divers collecting above and below sediment biomass from anchored 0.25 m^2 quadrats, using a knife to sever below ground rhizome connections. Initially, 3-4 quadrats per bed (one quadrat per station) were collected in this manner, but replicates were added in 1998 increasing the number to 12 quadrats per bed. The whole plants were placed in plastic mesh baskets and transported to the boat, where the plants were placed in labeled plastic bags and then the bags were stored in a cooler for transport to the lab. The laboratory analysis was intensive, including individual shoot scrutiny, and examined a host of parameters including number of shoots per $meter^2$, perceived shoot age, presence/absence of flower shoots, number of leaves per shoot, presence of wasting disease and number of leaves/leaf area infected, presence of epiphytes and number of leaves/leaf area affected. The leaves were scraped to remove epiphytes which were saved and measured for dry weight biomass, then the whole plants were dried and biomass was determined for above ground parts, below ground parts and whole plant. Sediment analysis was also conducted on the three beds (and subsequently on the three additional beds) to provide a characterization of the sediments at each site. Analysis included particle/grain size and composition, as well as organic content. Sections of the deep edge of the beds were mapped using a differential global positioning system (DGPS) with sub-meter accuracy. The DGPS, set to log positions at 5-second intervals, was placed in a kayak and towed by a diver swimming the edge of the eelgrass bed. Light attenuation coefficient was calculated using light measurements taken with a Licor quantum sensor with data logger on the day of sampling at three depths.

1999

Three additional eelgrass beds were added in the 1999 season. Beds in Gardiners Bay (Hay Beach Point, Shelter Island), Southold Bay (near the mouth of Mill Creek, Southold), and Three Mile Harbor (East Hampton) were chosen. The inclusion of these beds provided data on eelgrass growing under different environmental conditions than the original three eelgrass beds. Their addition made the program more representative of eelgrass populations throughout the estuary. Other than the addition of several sites, the monitoring program remained unchanged during 1999.

2000

2000 represents the first year that the SAV monitoring program responsibilities were assumed by the authors. With this change there was a re-assessment of previous efforts with an eye towards increasing the statistical rigor of sampling while maintaining consistency in the sites monitored. In 2000, it was suggested that the sample size for the monitoring program was too small to properly analyze statistically. The response to this suggestion was to increase the sample size from 12 quadrats per bed to 60 quadrats per beds. Also, additional stations were established in the six monitoring beds raising the number of stations from 3 to 6 per bed, providing better overall coverage of each bed. At each station, divers randomly placed ten 0.10 m^2 quadrats within a 10 meter radius of the GPSed station point. In six of the quadrats, the divers estimated percent cover of macroalgae, noted genera (and species when possible) of the macroalgae, then carefully removed the macroalgae and counted the eelgrass shoots. The remaining four quadrats were used to destructively collect above ground biomass or the eelgrass and macroalgal biomass. The quadrats were randomly placed and the percent coverage of macroalgae was estimated, then the macroalgae was removed from the quadrat and placed into labeled ziplock bags. The eelgrass was clipped close to the sediment surface with EMT shears and placed into labeled bags. The bags were placed in a cooler and transported back to the laboratory where the macroalgae was identified, sorted by phyla into aluminum tins, weighed, then placed in a drying oven until constant mass was obtained. The eelgrass shoots were counted to determine shoot density, then the blades were scraped with the edge of a glass slide to remove epibionts (flora and fauna). The epibionts were placed in individually labeled aluminum trays, weighed, then paced in the drying oven until there was constant mass. The 'scraped' eelgrass from each quadrat was then bundled together in aluminum foil, weighed, then placed in the drying oven until constant mass was achieved. When all of the materials were sufficiently dried and weighed, biomass was calculated for the individual beds as grams per $meter^2$. The shoot density from the collected material was combined with the field data to produce a density measure of shoots per $meter^2$ for each bed.

The deep edge delineation methods was changed in 2000, from the towed kayak method to a more efficient method. The new methodology couples a transom-mounted depth finder with the DGPS unit used in the towed kayak method. The DGPS is set to take a "quick point" at the push of a button. As the boat is piloted in a zig-zag along the edge of a bed, the depth finder screen is monitored for a characteristic change in bottom profile indicating the edge of the bed. When this profile is observed, a "quick point" is taken. The resulting DGPS data is loaded to a geographic information system and a line of the deep edge is generated.

<u>2001- present</u>

Program ideology changed for the 2001 sampling season when the potential negative impacts of destructive sampling were considered. This type of sampling was not seen as an appropriate methodology to collect data on eelgrass for several reasons. Firstly, these beds deal with bioturbation, storms and anthropogenic impacts almost continuously. To add the destructive collection of eelgrass biomass, small though it may be, is still a negative impact on the target bed. Secondly, destructive sampling around set stations may influence a subsequent season's data. Any decline in shoot density at a station could be an artifact of the biomass harvesting from the previous year and may present false evidence of decline. Lastly, when compared with our peers in other monitoring programs for seagrasses worldwide, very few use destructive biomass as an integral part of their monitoring activities. Based on this reasoning, destructive sampling was eliminated from the program for the 2001 season and continues.

With the program moving away from destructive sampling for the 2001 and 2002 seasons, the sampling methods were modified to continue to collect a statistically relevant data set. The current sampling protocols includes the counting of eelgrass shoots and macroalgae percent cover estimation in ten 0.10 m^2 quadrats at each of the 6 stations in the monitoring beds for a total of sixty quadrat counts per bed. Macroalgae was identified to species when possible in the field and samples of unidentified macroalgae were returned to the laboratory for closer examination. The deepwater edge was mapped in 2001 using the depth finder/DGPS method detailed above. In 2002, however, the deep edge delineation was mapped using aerial photographs of the estuary taken in 2001, but ground-truthed in the summer of 2002. Ralph Tiner, from the USFWS, digitized the 2001 aerial photographs and delineated potential eelgrass beds throughout the estuary. CCE was responsible for ground truthing the delineations for the project. Tiner's report (Tiner et al., 2003), included delineation of eelgrass beds and was used to determine the deep edge of the six monitoring beds for the 2002 season.

<u>Future</u>

Future monitoring seasons will likely see modifications in the sampling protocol resulting from the need to adapt to new conditions or sample new parameters. A method for calculating eelgrass biomass based on non-destructive data collection will be tested in the 2004 season. The method will use field estimation techniques that have been used successfully with other species of seagrass. This new method should allow the program to develop a model to predict biomass based on shoot density, a parameter that has been sampled since 1997, and provide estimations of biomass from the seasons that did not include destructive biomass measures.

Deep edge delineation of the six monitoring sites will continue in future seasons. The methods of collecting this data will continue to evolve and incorporate new technologies when available. A change that is being considered for the 2004 season is the purchase of a submersible camera that can be integrated with the DGPS unit and lowered from a boat to identify and accurately position the eelgrass edge. This technology will be useful for ground-truthing future aerial surveys and cold water monitoring of restoration projects.

Water Quality Trends

Water quality data for the Peconic Estuary has been collected by the Suffolk County Department of Health Services in select areas since the 1970s and now consists of a well distributed collection of water sampling stations. The water quality data presented below is based on data from SCDHS stations that are in or adjacent to the six eelgrass beds in the monitoring program. In at least one case (Bullhead Bay, Southampton), the SCDHS has created a station to compliment the eelgrass monitoring program. Although the SCDHS collects a wide range of water quality data, only select parameters are included in this report as they are considered to have the most influence on the health of eelgrass. Specifically, the nitrogen-based parameters will be focused on as they influence macroalgae growth, which can lead to competition and shading/smothering. High water column nitrogen levels have also been reported to potentially cause metabolic imbalances in eelgrass (Burkholder et al., 1992).

The parameters that will be discussed will include NO_x (nitrate/nitrite), TKN (total Kjeldahl nitrogen), TDKN (total dissolved Kjeldahl nitrogen), TN (total nitrogen), and TDN (total dissolved nitrogen). NO_x includes the inorganic nitrogen compounds nitrate (NO_3) and nitrite (NO_2). Kjeldahl nitrogen is the sum of organic nitrogen and ammonia (NH_3) in seawater and can include those compounds that are dissolved in the seawater (TDKN) or a total of dissolved and particulate compounds (TKN). Total nitrogen is the sum of nitrate (NO_3), nitrite (NO_2), organic nitrogen and ammonia. Some of these nitrogen sources are dissolved and readily available for physiological processes (TDN), while others are suspended in the water column and less available for biological activities.

This section will present the water quality data collected for each of the six eelgrass beds in the monitoring program since their inclusion in the program. Each bed will be presented with the SCDHS water quality data and analyses and conclusions.
It should be noted that the included data represents an annual average for the parameters discussed. As eelgrass has a dormancy period in the cold, winter months and requires little nutrients, excluding the data for these months would be appropriate when considering their affects on eelgrass growth. However, due to the relatively small sample numbers for the water quality data, all months were included to increase the rigor of the statistical analysis.

Bullhead Bay

In 1998, Suffolk County Department of Health Services established a water quality monitoring station (Station 148) in the middle of Bullhead Bay in support of the Eelgrass Monitoring Program. The water quality data described below represent the measurements from 1998-2002.

The general water quality trend in Bullhead Bay indicates a minor, but significant decrease in total nutrient levels, but an increase in the concentrations on NO_x, over the target years (Graph 1a; Appendix 1a). The water quality data shows that the annual NO_x concentration in Bullhead Bay has increased by almost 10 times in the 4.5 years of data collection from 0.005 mg L^{-1} (the minimum reportable limit for NO_x) in 1998 to a high of 0.037 mg L^{-1} in 2001 (Appendix 1a). The 2002 NO_x concentrations dropped to 0.027 mg L^{-1} and may signify a leveling off or decrease in the NO_x in Bullhead Bay in the following years. Of concern, however is the fact that nitrates/nitrites are components of chemical fertilizers, seepage from septic systems, and atmospheric deposition among other sources and an increase in their concentrations may be linked to changes in human activities in the surrounding uplands. It should be noted that in the Fall of 2000, the Suffolk County Public and Environmental Health Laboratory (SCPEHL) replaced the Traacs analyzer (used to measure NO_x) with a Lachat unit. The calibration of the new unit was improperly set and the NO_x values between October 17, 2000 and June 5, 2001 were suspect. Chemists caught the error and the data set has been rectified.

Graph 1 also shows the general trends of the other four parameters analyzed. For TKN and TDKN, there was a statistically significant reduction from 1998 to 2000 in both measurements (Appendix 1a). Similarly, TN and TDN showed a significant decreasing trend from 2000 to 2002, although the concentrations stabilized between 2001 and 2002, exhibiting no significant change between the 2 years

(Graph 1a; Appendix 1a).

The water quality in Bullhead Bay continues to require monitoring. The increase in NO_x in the system may suggest that anthropogenic activities around the system are having an effect. The general decrease in TN and TDN in recent years, even in the face of increased NO_x suggests that there may be a significant reduction in the sources of organic nitrogen for this system. This raises the question of why are the organic sources declining. All four of these measures either consist of or include an organic nitrogen component in their measure and an overall decrease in the nitrogen levels when the NO_x has been increasing suggests a reduction or loss of the sources organic of nitrogen.

Gardiners Bay

The Gardiners Bay eelgrass bed uses the water quality data from SCDHS Water Quality Station 144, Cornelius Point, Shelter Island. The general water quality for Gardiners Bay has been fairly stable over the course of the eelgrass monitoring program. Nitrogen levels represented by TKN, TDKN, TN, and TDN have remained relatively constant or have slightly decreased over the six seasons (Appendix 1b; Graph 1b). There were significant overall reductions in TKN and TDKN from 1997 until the discontinuation of the data set in the summer of 2000, culminating in concentrations half of those in 1997. There were no significant changes in the TN and TDN, but their data set is still fairly small and trends may be more evident over time. NO_x was relatively stable from 1997 to 1999, with concentrations at or near detection limits for the laboratory tests (Appendix 1b). By 2001, there was a significant increase in the NO_x at the station, but this increase in NO_x was reduced by approximately 1/3 in 2002, bringing NO_x concentrations into a more reasonable range (Appendix 1b). As mentioned previously, the increase in NO_x at this station may be a remnant from equipment changes and subsequent calibration errors, which were then rectified at SCPEHL in 2001.

Looking at the data in Appendix 1b and Graph 1b, there is an obvious increase in NO_x starting in 2000. One would expect that nitrogen loading for this bed would be minimal due to its location in the estuary and the high currents that flush the area, for the most part, is as expected. Excluding the increase in NO_x concentrations in 2000, the nitrogen levels have remained relatively stable, and it is unlikely that poor water quality will have a major impact on this bed in the future. More likely, damage/loss in the bed will come from mechanical disturbance (*i.e.*, erosion and boating damage).

Northwest Harbor

The water quality of Northwest Harbor has seen an overall decrease in nitrogen enrichment since 1997. TKN and TDKN concentrations steadily decreased from 1997 to 2002, starting at a mean concentration of 0.46 mg L^{-1} (TKN) and 0.41 mg L^{-1} (TDKN) and ending at 0.15 mg L^{-1} and 0.12 mg L^{-1}, respectively (Appendix 1c; Graph 1c). TN and TDN showed no significant changes in the 2.5 years of data collection and have ranged from approximately 0.20 mg L^{-1} to 0.24 mg L^{-1} for both parameters (Appendix 1c). Northwest was found to have a trend toward increasing concentrations of NO_x, similar to those observed in the data for both Bullhead Bay and Gardiners Bay. Mean concentrations for the period of 1997-1999 were identified to be at or near 0.005 mg L^{-1} NO_x (the minimum reportable limit), but in 2000, levels doubled and continued to rise in

2001, when the mean concentration reached 0.33 mg L^{-1} NO_x (Appendix 1c). There was not a significant change in the 2002 levels of NO_x for this system, and this may indicate a stabilization of this nutrient in the coming years.

Northwest Harbor is a well flushed system with input from Gardiners Bay. The shoreline for much of this system is undeveloped. The increase in NO_x, which could be associated with chemical fertilizers or other sources, has been on the rise despite the lack of development of the land adjacent to the harbor.

Orient Harbor

Orient Harbor is one of the original three eelgrass beds in the monitoring program and has an extensive water quality data set. The mean annual concentrations (1997-2002) of the five water quality parameters to be discussed are included in Appendix 1d. The mean annual concentrations for this data is presented in Graph 1d.

The re-occurring trend that was seen in the previous beds repeats itself in the Orient Harbor data. TKN and TDKN steadily decreased from 1997 to 2000 starting at 0.44 mg L^{-1} and 0.38 mg L^{-1} and ending at 0.13 mg L^{-1} and 0.10 mg L^{-1}, respectively with the concentrations leveling off a bit between 1999 and 2000 (Appendix 1d). The levels of TN and TDN remained relatively constant with no significant changes between years. NO_x showed a marked increase in 2000, though it was not significantly higher than 1999, from an annual average of 0.0069 mg L^{-1} to 0.012 mg L^{-1} (Appendix 1d). The following year, 2001, the concentrations of NO_x increased to a mean of 0.038 mg L^{-1} and remained relatively high, 0.021 mg L^{-1}, in 2003.

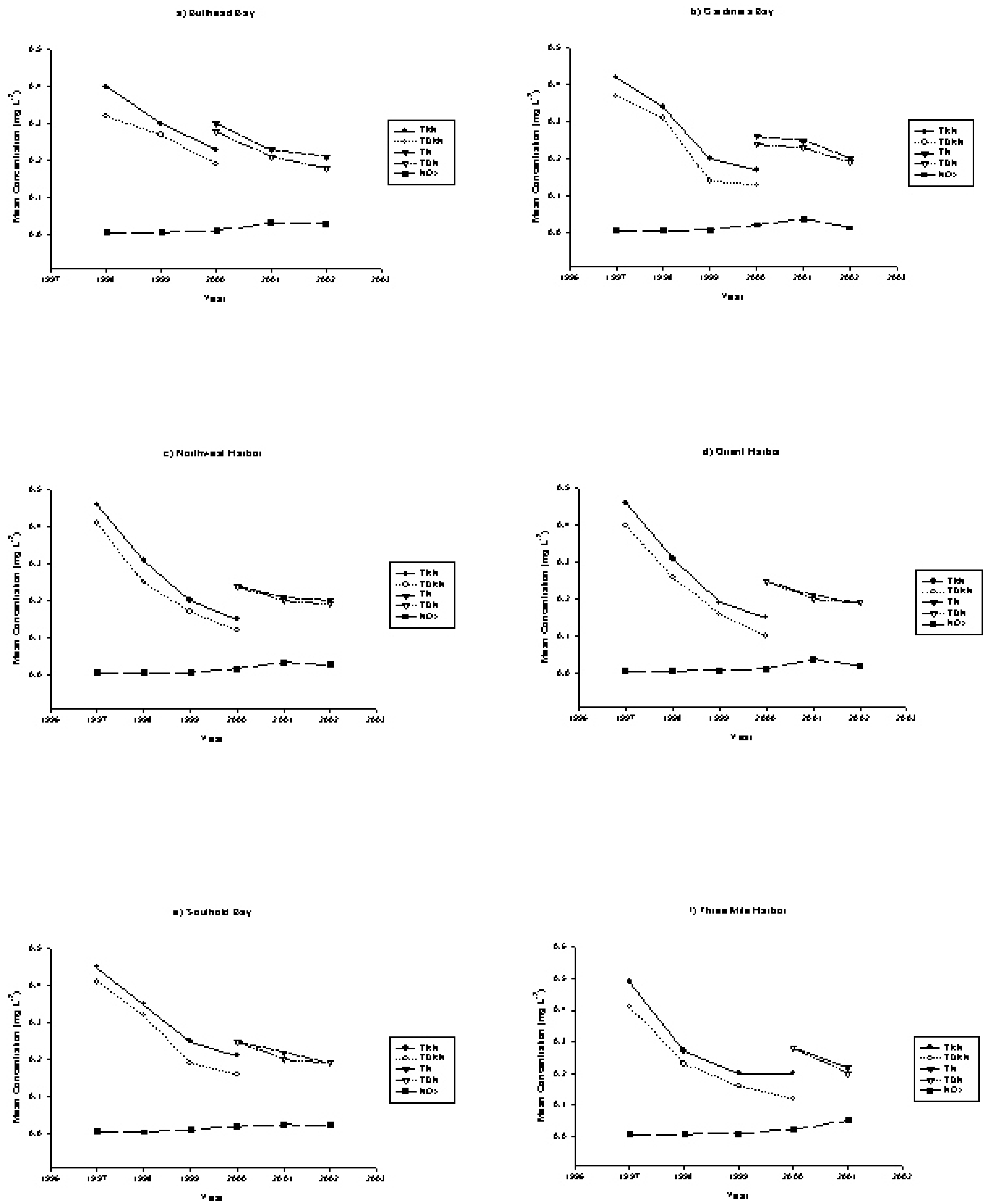
Again, we see that the organic nitrogen constituents have decreased over the period of 1997-2002 while the inorganic (NO_x) has increased, effectively canceling the effects of one another on TN and TDN. Still, there is no clear indication of where the decrease in organic nitrogen is originating or why NO_x started to increase in 2000. It may be that more data (continued SCDHS sampling) will aid in understanding the dynamics of the data.

Southold Bay

The eelgrass bed outside of the mouth to Mill Creek, Southold, is the most stressed bed in the program. The bed has two boat channels cut through it that sees an large rate of boat traffic during the summer season. The bed is habitually choked by macroalgal growth likely influenced by the nutrients from Mill Creek and Hashamomack Pond. The SCDHS maintains a water quality station in Mill Creek and that data was used for the eelgrass bed in adjacent Southold Bay.

The trend of decreasing organic nitrogen, TKN and TDKN, continued with Southold Bay. Both of these parameters were found to be less than one half the 1997 concentrations by 2002 (Appendix 1e; Graph 1e). The TKN and TDKN leveled out more quickly than the previous sites, showing no significant annual change after the 1998 season (Appendix 1e). TN and TDN showed no significant change from 2000 to 2002, following the general trend that has been seen in the other beds so far. The concentrations of NO_x increased from 1997 to 1999 (mean annual concentration of 0.0059 mg L^{-1} to 0.0094 mg L^{-1}), but plateau-ed from 1999 to 2002 with no significant change in concentrations between years. This differs from the other beds in that NO_x leveled off in some cases two years before the other beds considered. Also, one would expect that this bed would have

Graphs 1a-f. Mean annual concentrations of nitrogen-based water quality parameters for the eelgrass monitoring sites. (See Appendix 15 for enlarged versions of graphs).



higher concentrations of TN and TDN than other beds due to the influence of Mill Creek and Hashamomack Pond, bodies of water that have historically been closed to shellfishing due to fecal coliform contaminations likely from wildlife and domestic animals.

Three Mile Harbor

Three Mile Harbor was added to the eelgrass monitoring program in 1999, however, SCDHS had been testing the water in the harbor prior to its inclusion. The station that was established in Three Mile Harbor, Station 115, was discontinued after 2001, so the data will include analysis from 1997 to 2001. The 1997 and 1998 water quality data is included, even though this system was not among the three original beds in the eelgrass monitoring program, for continuity in the analysis between all of the beds.

Three Mile Harbor followed the same trends that were common to all of the eelgrass beds in the program during this period. The mean annual concentrations of TKN and TDKN decreased significantly from 1997 to 2000 for both parameters (Appendix 1f; Graph 1f) and were statistically stable from 1998 to 2000. TN and TDN were represented by only 1.5 years worth of data, but Student t-test found that there was no significant change in the TN over this period, but there was a significant decrease in TDN (Appendix 1e). Further analysis and conclusions are not possible with a data set of less than two years, and any conclusions drawn from the TN and TDN data should be considered inaccurate. Three Mile Harbor did follow the expected trend that was found in the other beds where NO_x concentration has significantly increased since 1997, rising from a mean annual concentration of 0.0057 mg L^{-1} to a level of 0.052 mg L^{-1} in 2001 (Appendix 1e). A ten-fold increase over such a short period of time indicates a major change in the system or a significant change in the processing/testing of the water samples.

Overview

Overall, the water quality has continued to improve or at least maintain levels with regard to total nitrogen in the Estuary. Of special note is the concentrations of TN and TDN for all of the sites. The measurement of these parameters began in summer of 2000, and although there has been little significant change in their levels from that time, if one compares the concentrations of TKN and TDKN taken prior to the institution of TN/TDN measurements, there has been some significant improvement in the organic nitrogen component estuary-wide. For example, the TKN mean annual concentrations for Orient Harbor (Appendix 1d) ranged from a high of 0.46 mg L^{-1} in 1997 and decreased to 0.15 mg L^{-1} by 2000. Keeping in mind that TKN is composed of organic nitrogen and ammonia (NH_3), these concentration are purely the organic nitrogen constituent in the system. A rough estimation of TN for this period could be calculated by adding the TKN with the NO_x. When this is done for the 1997 season, the resulting estimate of TN would be 0.465 mg L^{-1}, which compared to a measured TN (NOx, organic nitrogen and ammonia) in 2000 of 0.25 mg L^{-1} (Appendix 1d) shows a considerable decrease in organic nitrogen levels.

There is also the unexplained increase in NOx to consider. The fact this increase occurred in the same year (2000) for all six eelgrass beds suggests that this may be a result of more than just natural processes. The increase in NO_x measurements since 200 may be attributed to SCPEHL's change in instrumentation used to measure NO_x.

Eelgrass Trends

It was recognized early in the development of the Peconic Estuary Program that eelgrass was one of the estuary's most important natural resources. The impetus to protect and manage this resource required information on the general health and distribution of the eelgrass population with in the Peconic Estuary. This void in basic knowledge lead to the creation of the eelgrass monitoring program. The goals of the program are to collect and provide a long-term data set of parameters of eelgrass health and dynamics that could be used to gauge the effectiveness of PEP activities. The evolution of sampling methodologies was discussed previously and will not be considered in detail in this section. This section will instead focus on the one eelgrass parameter that has remained constant over the inception of the eelgrass monitoring program in 1997, eelgrass shoot density. This parameter is a widely used and accepted parameter for seagrass monitoring in general and is used almost exclusively to monitor eelgrass in the Chesapeake Estuary. Whereas, the Chesapeake program utilizes computer analysis of aerial photographs of eelgrass beds to estimate density, similar to the method used by Tiner et al. (2003) for his analysis of Peconic Estuary eelgrass, the PEP eelgrass monitoring program relies on in-situ collection of shoot densities from the six monitoring beds.

<u>Bullhead Bay</u>

Shoot Density

Collection of eelgrass data in Bullhead Bay began in 1997. Graph 2a represents the mean eelgrass shoot density for Bullhead Bay for the six seasons of monitoring. In 1997, only four 0.25 m^2 quadrats were sampled, not providing a statistically relevant sample size, so the data was not included in the statistical analysis, however, the 1997 data was included in the descriptive statics for Bullhead Bay (Appendix 9). For the remaining years, 1998-2002, the data was analyzed using an ANOVA on Ranks test and found to have a significant difference between years (Table 1). Multiple pairwise comparisons found that the more recent years (2000-2002) had significantly lower shoot densities than the 1998 and 1999 seasons, with 2001 having the lowest shoot density of all of the monitoring years (Table 1; Appendix 9).

Areal Extent

Overall, the extent of the eelgrass in Bullhead Bay has remained, remarkably, good. Over the course of the monitoring program, there has only been one dramatic change in the distribution of the beds. This change occurred in 2001, when two stations within the bed were completely defoliated. The cause of this loss is not certain, however, it is believed that the cold winter of 2001, and the ice that resulted, may have been responsible for the loss. Ice scour is a known physical disturbance of eelgrass, especially in the shallower areas of the beds. Ice can lock around the eelgrass shoots and when it breaks free, it can uproot large sections of a bed. This is the most likely cause due to the lack of overall damage to the bed that would occur from a non-localized event (*e.g.*, disease or degraded water quality).

<u>Gardiners Bay</u>

Shoot Density

Gardiners Bay was added to the program in 1999, resulting in 4 years of data on eelgrass. The mean shoot density for each year is plotted in Graph 2b. The basic

Table 1. Eelgrass shoot densities for the six Peconic Estuary monitoring sites. The data represents the annual average (± standard error of the mean) for each bed. Significant differences between pairs of means within sites , determined by multiple pairwise comparison procedure, are indicated by matching superscript letters.

	Eelgrass Bed					
Year	BB	GB	NWH	OH	SB	TMH
1997	710 ±196		209 ±24	573 ±68		
1998	620 ±112[a]		311 ±21[a]	696 ±82[a]		
1999	548 ±79[b]	499 ±37[a]	507 ±57[a,b,c]	587 ±50[b]	805 ±69[a,b,c]	361 ±49[a,b]
2000	301 ±26[b,c]	470 ±23[b]	330 ±21[b]	488 ±52[c]	471 ±31[a]	193 ±17[a]
2001	150 ±18[a,b,c]	373 ±16	409 ±20	452 ±16[d]	467 ±32[b]	209 ±13[c]
2002	201 ±14[a,b]	305 ±25[a,b]	350 ±19[c]	230 ±13[a,b,c,d]	384 ±16[c]	135 ±10[b,c]

descriptive statistics for Gardiners Bay are found in the report in Appendix 10. Analysis of the shoot densities for this bed since 1999 found few significant changes in shoot density until 2002 (Table 1). The 2002 shoot density was the only year that differed from another year, with both 1999 and 2000 having been found to have significantly higher shoot densities. It is difficult to determine if the decline in shoot density in 2002 is the start of a trend for this bed.

Areal Extent

The decrease in the areal extent of the Gardiners Bay eelgrass bed could be attributed to the loss of eelgrass around one or two of the sampling stations caused by burial or erosion of sediment. This loss is likely a natural result of the dynamic nature of this bed caused by the high currents and wave action. Due to the strong currents that the site experiences, there is an annual translocation of sand that alters the bed by burying or eroding the eelgrass. Although the shifting sands may destroy sections of the bed, they may also provide new areas for eelgrass seeds to settle and establish by providing depressions or a boundary layer of low current flow that would retain seeds that would otherwise be swept away.

Northwest Harbor

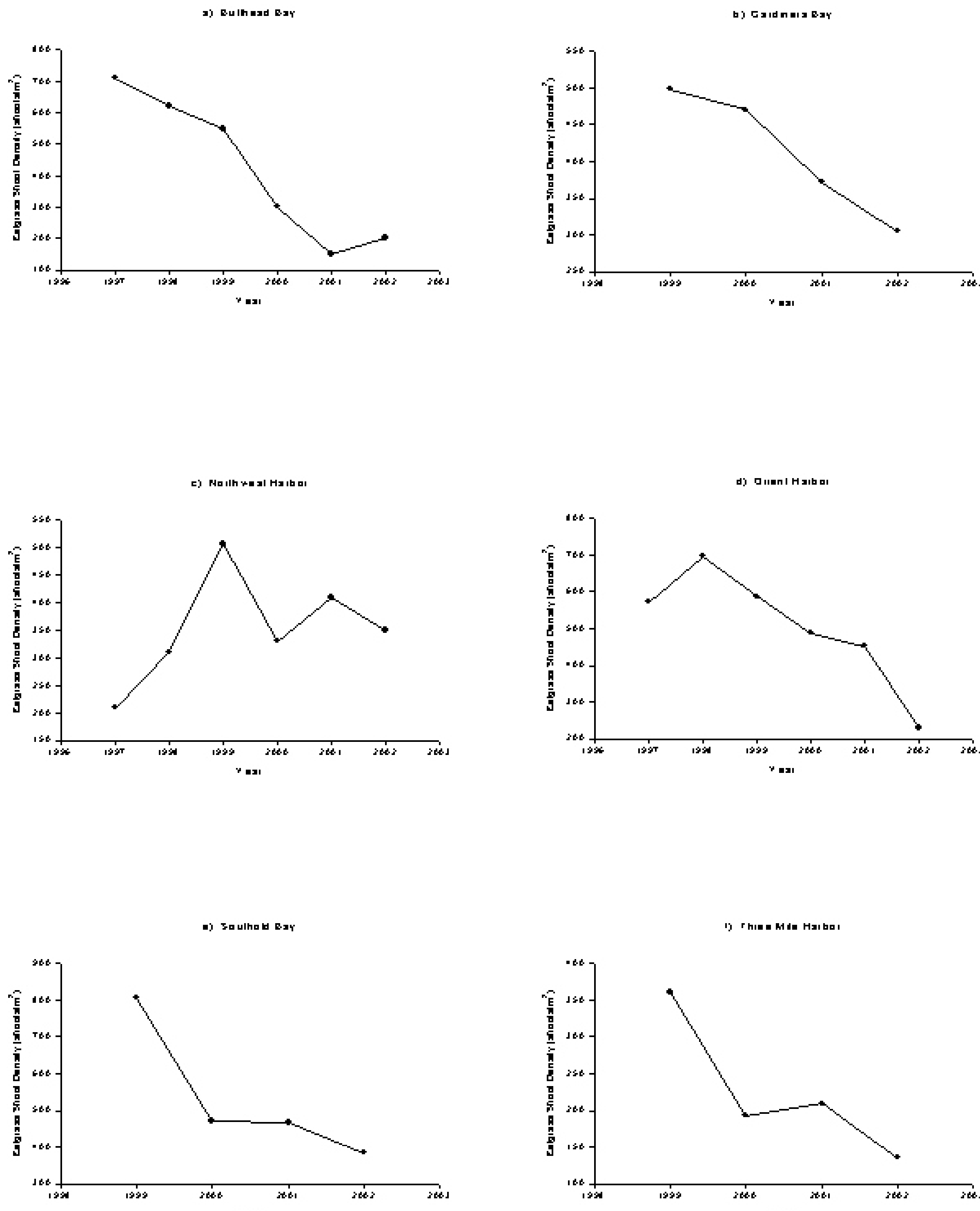
Shoot Density

As with Bullhead Bay, Northwest Harbor was one of the three original beds in 1997, and similarly, only a few quadrats (n=3) were sampled from the bed for that year making it unsuitable for statistical analysis, so the 1997 data has not been included with the other seasons. The complete data set of mean annual shoot densities is presented in Graph 2c and the complete descriptive statistical report is found in Appendix 11. Northwest Harbor has shown significant fluctuation shoot density from 1997 to 2002 (Graph 2c; Table 1). The “up and down” dynamic in shoot density may be the beds natural trend with the bed displaying significant decreases in shoot densities some years followed by recovery the next year. This bed will require further monitoring to accurately characterize the eelgrass population dynamics of this bed as the current data set displays no conclusive trend.

Areal Extent

The areal extent of the Northwest Harbor

Graphs 2a-f. Mean eelgrass Shoot density for the six monitoring sites. (Shoot density is calculated as shoots m^2). (See Appendix 16 for enlarged versions of the graphs).



bed has not shown a significant change over since 1997. Although some areas of the bed have displayed some "thinning" in terms of shoot density, there has been no significant loss to the areal extent of the bed.

Orient Harbor

Shoot Density

The data set for Orient Harbor includes data from 1997 which, can not be used in the statistical analysis of eelgrass shoot density over the course of the monitoring program, but will be included in the descriptive statistics report (Appendix 12) and in Graph 2d. Orient Harbor has maintained a relatively stable shoot density for 1997-2001 with no statistically significant changes until the 2002 season which had a significantly lower, almost 50% of other seasons, shoot density than the previous years (Graph 2d; Table 1). Although the 2002 decrease is an event to continue to monitor, due to the uncharacteristic change in shoot density for this bed based on previous years, it may not herald a continued decline and may well be the population's response to the increased clarity that was observed while conducting the 2002 monitoring survey. Continued monitoring of this bed will determine if this event is an ongoing trend or a short-term event.

Areal Extent

Orient Harbor has been a relatively stable bed in terms of areal extent. There has been some loss in the northern extent of the bed, where the shoreline is more heavily populated and developed, and will require continued observation to determine if this loss will continue or if it has stabilized.

Southold Bay

Shoot Density

Southold Bay has been an interesting bed since it was introduced to the monitoring program in 1999. One of the reasons that it was chosen for the program was its perceived status as an eelgrass bed in decline. The bed is impacted heavily by human activities from boat traffic (the bed is bisected by two boating channels) and by nutrient inputs from Hashamomack Pond via Mill Creek. The mean annual shoot densities for Southold Bay's bed are presented in Graph 2e and the descriptive statistics are reported in Appendix 13. Southold Bay has consistently maintained one of the highest mean shoot densities of the six eelgrass beds in the monitoring program (Table 1). It is not uncommon in this bed to have areas where the shoot density exceeds 1000 shoots m^2 (Descriptive Statistics Report, Appendix 13). The 1999 season was the highest shoot density year and was significantly greater than all of the following years (Table 1). After the decrease from the 805 shoots m^2 to 471 shoots m^2 from 1999 to 2000, the shoot densities in the bed have remained stable with only insignificant changes in shoot density being observed.

Areal Extent

Southold Bay remains an eelgrass bed in trouble, as its areal coverage continues to decrease and lost areas become overgrown with macroalgae (*e.g. Codium fragile* and *Spyridia filamentosa*), possibly preventing the re-colonization of lost sections even with an alleviation of stressors.

Three Mile Harbor

Shoot Density

Three Mile Harbor is one of the "new" beds in the monitoring program, having been introduced in 1999. The bed is unique in its range of sediment type and the amount of human activity that takes place in and around the entire harbor. Currently, the eelgrass bed is located in the western section of the harbor near the mouth of Steven Hand's Creek. On its deep edge, the bed is in approximately 9 feet of water and the sediment is a very loose muck that affords the plants little anchorage. Plants are very sparse in this area and in general the bed has the lowest mean shoot density of any of the other beds (Table 1; Graph 2f). The mean shoot density for 1999 represented the highest shoot density and was significantly higher than the 2000 and 2002 seasons. Although there has been significant fluctuations in shoot density, the eelgrass population in Three Mile Harbor has maintained a predictable, low shoot density from 1999-2002.

Areal Extent

It does appear that the overall size of the bed is shrinking back from the deep edge and possibly along the northern edge, adjacent to the waterskiing area. Direct impacts may include a decrease in water quality/clarity due to the high boat traffic and propellor damage in the areas of the bed that are in or adjacent to the designated water skiing area. Even with the shrinkage of the bed, it has maintained a consistent shoot density and this will make detection of future bed degradation more obvious.

<u>Overview</u>

In general, a majority of the beds appear healthy and have maintained relatively stable shoot densities over the course of this program. The overall trends in beds has been a decline in shoot density from 1997-2002, however these apparent trends should be considered with some caution due to artifacts of small sample size in the 1997-1999 data. The low number of replicate quadrats for these years could have influenced the mean shoot densities causing artificially inflated or deflated densities resulting in false trend. This shortcoming can be rectified with continued monitoring of these sites and re-evaluation of the shoot density data after additional seasons.

"Wasting disease", omnipresent in most eelgrass populations, has not been observed to be a significant problem in the Peconic Estuary eelgrass beds. Inspection of plants in an eelgrass meadow will encounter blades that demonstrate the symptomatic, necrotic lesions of the disease, but infection is generally isolated and not epidemic and at this time does not pose a significant threat to the eelgrass populations in the estuary. There are still conflicting views in the literature regarding the trigger for a large-scale infection of "wasting disease", but it is likely that chronic stress would make eelgrass more susceptible to this problem.

Physical damage has been observed in all beds and has resulted from several sources, both anthropogenic and natural. Prop scars and groundings by boats have been observed in several of the beds including Bullhead Bay, Gardiners Bay, and Southold Bay. It is common to see boats cutting across the Gardiners Bay eelgrass site as they cut the channel marker departing from Greenport. Boats have been observed run aground on the shoal that borders the northern edge of the bed and it is likely that many more boats have traversed the shoal with a higher tide and run across the eelgrass bed. The Southold eelgrass bed has a boat channel that bisects the site and services several marinas, resulting in a high amount of prop wash at the site, especially in sections of the bed directly adjacent to the channel.

Another physical disturbance that has been encountered in the monitoring site damage from anchors or moorings. This is prevalent in Three Mile Harbor where small boats are moored off of Hand’s Creek in the eelgrass bed. Eelgrass around the mooring anchors has been cleared by the mooring chain dragging along the bottom. Orient Harbor has some moored sailboats, but most of the boats are located outside of the beds, though abandoned mooring anchors have been observed within the bed.

Some natural causes of physical damage include erosion due to hydrodynamic forces (*i.e.*, currents and waves). The Gardiners Bay has the highest hydrodynamic activity of the six monitoring program beds. A constant shifting of sand and erosion of section of the eelgrass bed due to high current make this bed highly dynamic in regards to its edge boundaries and making it difficult to assess loss/gain on an annual basis.

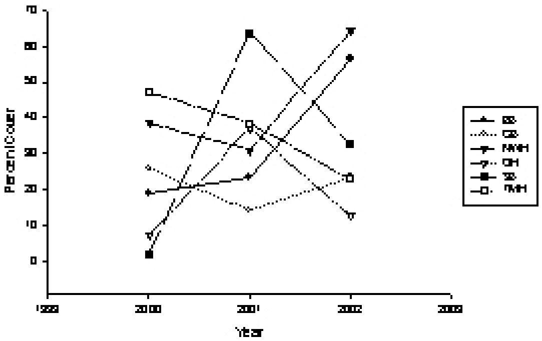
Macroalgal Trends

The observation of macroalgae in the eelgrass beds is an important component of the monitoring program due to the competitive interaction between eelgrass and macroalgae. Macroalgae are by far the better competitor in terms of growth rate and response to increased nutrient, however they tend to be ephemeral and do not compete well with eelgrass under “clean” water conditions. Macroalgae (and phytoplankton) are one of the reasons that an emphasis has been placed world-wide on the reduction of nitrogen discharge into coastal waters. If enough nitrogen is released into an estuary, the resulting bloom(s), both macroalgal and phytoplankton, can shade eelgrass and cause mortality in the eelgrass population. Relatedly, Brown Tide (*Aureococcus anophageffrens*) bloom onset conditions may be optimized by elevated ratios of available dissolved organic nitrogen (high DON) in surface waters, with respect to the supply of dissolved inorganic nitrogen (low DIN). During the Brown Tide events in the mid 1980's and again in the mid 1990's, several eelgrass populations where reported by baymen to have died off completely.

Brown Tide is a phytoplankton event and has not returned to the greater portion of the Estuary since its subsidence in 1995, however, smaller scale losses of eelgrass beds have continued, in part, due to the overgrowth of macroalgae like *Ulva lactuca, Codium fragile*, and *Spyridia filamentosa*. To better monitor the potential impact of macroalgae, the eelgrass monitoring program has adopted the use of percent cover estimation of macroalgae in the 60 quadrats surveyed in each of the beds. Previously, macroalgae, epiphytic and non-epiphytic, were collected and returned to the laboratory for biomass determination. Although, biomass gives an accurate view of how productive the macroalgae is in the eelgrass bed per unit area, it is not a good indicator of the potential impact that the algae presents to the eelgrass. To clarify this, consider the biomass of a large, fleshy macroalga (*e.g.*, a kelp or rockweed). A single individual may constitute a fairly large biomass, especially when compared to a less substantial alga, like an *Ulva* or a filamentous species. It would take a considerable amount of the “smaller” macroalgae to equal the biomass of the one large, fleshy species. This biomass of “smaller” algae would also take up more space than the single large plant. While biomass is a good indicator of how much algae is in a given area, it does not provide a quantitative measure of how much space the algae takes up and in an eelgrass bed, the area covered by macroalgae is related to the total amount of competition between eelgrass and macroalgae for the most important resource, light.

The data presented below represents the

Graph 3. Mean percent macroalgae cover of the six eelgrass monitoring sites for 2000-2002.



macroalgal percent cover estimations for the six monitoring beds from 2000 to 2002. Also, to provide an overview of the complexity and variety of the macroalgal assemblages found in the Peconic Estuary's eelgrass beds, a table has been synthesized listing all of the marine macroalgae that have been observed in eelgrass beds throughout the estuary (Appendix 2).

Bullhead Bay

Bullhead Bay supports a large population of macroalgae, primarily *Spyridia filamentosa*. Fortunately, the bulk of this population seems to contain itself to the southeastern portion of the bay, close to the culvert that runs from the golf course, and has not encroached on the eelgrass bed to a significant extent since 1997. From 1997 through 1999, the only macroalgal parameter that was analyzed was algal biomass. As was mentioned above, algal biomass is not an accurate measure of the potential competition for light and space with eelgrass. In 2000, the percent estimated coverage of macroalgae was added to the monitoring program as a means of determining the total percentage of an eelgrass bed that was covered in macroalgae. The mean percent cover from 2000 to 2002 is represented in Graph 3. From 2000 to 2002, there was an increasing trend in the percent coverage (Graph 3). The percent cover of macroalgae increased from less than 25% in 2000 and 2001 to over 50% mean percent cover (Graph 3). The composition of the macroalgal community has remained fairly constant from 1997 to 2002, with red algal species representing the majority of the total species and specifically, *Spyridia filamentosa* (Appendix 3).

Gardiners Bay

The Gardiners Bay eelgrass bed is not a prime habitat for macroalgal growth. The combination of high current flow and wave action and small sediment size make it difficult for macroalgae to attach and grow, therefore most of the species encountered in this bed are drift macroalgae, likely dislodged from one of the large boulders that are common around Cornelius Point, south of the eelgrass bed. Due to the proximity of the harden substrate, a surface that is uncommon in any of the other beds, Gardiners Bay enjoys a high diversity of macroalgae (Appendices 2 and 4). Even though this site maintains a high diversity, percent cover of macroalgae in the eelgrass bed is low (< 30%) and has remained relatively stable from 2000-2002 (Graph 3).

Northwest Harbor

Northwest Harbor has supported a moderate population of macroalgae and with less diversity than Gardiners Bay (Graph 3; Appendix 2). In 2000 and 2001, the mean percent cover of macroalgae for Northwest Harbor was less than 40% (Graph 3). The mean percent cover in 2002 rose to over 60% and predominately consisted of red algal species (Graph 3; Appendix 5). The majority of macroalgae in the Northwest

Harbor bed are of a filamentous morphology, allowing individuals to become easily entangled in the eelgrass canopy when the current carries them in from outlying areas. Once an individual is entangled, it grows and spreads through the canopy, insinuating itself into large areas of eelgrass.

Orient Harbor

Orient Harbor has generally been one of the beds that is least impacted by macroalgae. There was a significant increase in mean percent cover from 2000 to 2001, but decreased again in 2002 to near 10% cover (Graph 3). The macroalgal community in this bed is dominated by red algal species with very few brown or green algae having been observed since 1997 (Appendix 6). Algal species composition is seasonally based in this bed, as winter and early spring observations have found that brown algae tends to dominate the bed at these times. Red algae starts to appear in May and persists through mid autumn.

Southold Bay

Southold Bay has consistently supported a significant population of macroalgae in its bed. Areas of the bed that have been lost over the course of the monitoring program have seen the eelgrass replaced by macroalgae (*e.g. Codium fragile*). Considering the mean macroalgal percent cover for Southold Bay (Graph 3), there was a significant increase in percent cover from 2000 to 2001 of over 60%. The macroalgal cover then dropped in 2002 to half of the 2001 total, but was still 30% higher than the 2001 totals. The percent cover for 2000 seems too low based on observations of the bed for 4 seasons. This bed usually hosts a large macroalgal population and this almost lack of algae cover is a rare occurrence. Even though the 2000 survey shows a small percent cover of the site, the diversity of the algae population was relatively high with 11 total species, mostly composed of red algae (Appendix 7).

Three Mile Harbor

Three Mile Harbor has maintained the lowest macroalgal diversity of all of the beds, though the algal community has persisted at mean percent coverage that are relatively high when compared to the rest of the monitoring sites (Graph 3). When the percent cover data from 2000 to 2002 was analyzed, there was a significant difference between the years, but a pairwise comparison test could not identify between which years the difference occurred (Appendix 14). The difference is likely to have occurred between the 2000 and 2002 data, as the percent cover decreased by more than half between these years (Graph 3). The fact that Three Mile Harbor supports a significant population of macroalgae is not surprising, considering the amount of human activities (*i.e.*, mooring fields and shore-front development) and its location at the mouth of Hand's Creek, that this bed would be able to support a considerable amount of plant life based on nutrient inputs. Also the relative protected nature of the harbor would favor the growth of algae species that do not require a hardened substrate to attach and grow (*e.g. Spyridia filamentosa*). In fact, there is little algal species diversity within the bed, with the peak year of coverage consisting of only 7 species of macroalgae and most recently, only 3 species were noted (Appendix 8).

Overview

The percent cover of macroalgae in the eelgrass beds has, generally, seen an increasing trend since 2000. Four of the monitoring beds, Bullhead Bay, Northwest

Harbor, Orient Harbor and Southold Bay, showed overall increases in percent cover (Graph 3) from 2000-2002. Gardiners By and Three Mile Harbor remained relatively stable during this period, maintaining low percent coverage of macroalgae at each site. The main "problematic" macroalga in all of the monitoring sites appears to the red, filamentous alga *Spyridia filamentosa*. This species is ubiquitous in the Peconic Estuary and is commonly found in quiet, low energy areas where it can form large tangled mats. When *Spyridia* is encountered in eelgrass beds, it is entangled in the eelgrass canopy and can cover a significant area, potentially shading the eelgrass it is growing in. In Bullhead Bay, *Spyridia* has grown in large patches in the southern end of the embayment. The eelgrass in this section of the bed has been retreating from this area as *Spyridia* has become more extensive. It is unclear whether the alga is the cause of the eelgrass loss or if it is just opportunistic in colonizing the vacant space, but the literature has reported that macroalgal mats can smother/shade seagrass in areas of degraded water quality (*i.e.*, nitrogen enrichment).

Another impact of macroalgae on eelgrass may extend from the competition for space. In areas where eelgrass has been lost due to an acute disturbance event or chronic recession of the bed, sediment composition tends to shift toward larger particle size. In some beds, these larger particles are able to supply an attachment point for macroalgae, like *Codium fragile*, which quickly grow and occupy the space. In Orient Harbor, this tends to occur in patches that have opened up in the bed and these patches may persist due to macroalgae colonization. On a larger scale, in Southold Bay, a significant area of the eelgrass bed has receded along the eastern edge and *Codium fragile* became established and currently dominates the area with 100% cover. In the future, if the factors that caused the initial retreat of the eelgrass are alleviated, re-colonization of eelgrass to this area may be problematic due to competition with the macroalgae.

Discussion

Water Quality

The long-term monitoring program has provided the Peconic Estuary Program with an important baseline of data regarding the general health of eelgrass in the estuary. This report has found that the overall water quality in the estuary is improving, with organic nitrogen levels showing a decline from 1997-2002. Inorganic nitrogen levels increased significantly in 2000, but have since stabilized and should be monitored in the future. The total nitrogen at all of the eelgrass monitoring sites has changed little since 2000, when the parameter was included in the SCDHS water quality monitoring, suggesting that even as inorganic nitrogen has increased in the estuary, organic nitrogen has conversely decreased to a similar degree. The increase in inorganic nitrogen, specifically nitrate, could be due to pulses of high, nitrate-laden groundwater that have seeped into the bays.

Whatever may be the cause, the levels are likely not high enough to be a detriment to eelgrass health in the Peconics. In fact, the overall low total nitrogen concentrations in the estuary favor eelgrass over macroalgae and phytoplankton, resulting in less shading and competition and reduced stress for the eelgrass. While the Peconic's waters are largely considered mesotrophic, Pedersen and Borum (1992) reported that eelgrass is suited to oligotrophic waters due to its ability to assimilate nitrogen from the sediment and water column, as well as recycle nitrogen internally from older parts of the blades to the new growth areas. Phytoplankton require 6 times the amount of dissolved nitrogen that eelgrass needs (Pedersen and Borum, 1992), so in clean, clear waters eelgrass is a better competitor for nitrogen and can fully take advantage of increased light due to the lack of phytoplankton.

Shoot Density

The health of the eelgrass based on *in situ* observation since 1997 is relatively good. However, Graphs 2a-f suggest that the eelgrass at most of the monitoring sites may be in decline based on mean shoot densities. Eelgrass has been found to respond to light limitations in two ways: 1) the blades elongate in an attempt to reach a level in the water column where light levels are more conducive to growth, or 2) in shallower waters, the plants may increase the number of shoots to maximize surface area for photosynthesis. The decrease in eelgrass shoot densities therefore, may be the response of the eelgrass plants to an alleviation of low light-induced stress. The decreased shoot density from the early years of the program to the present may also reflect the changes in monitoring protocols from few replicate samples per bed in 1997 to the more significant 60 replicate samples in the current methodology.

Regarding the notable decline in eelgrass shoot densities in all of the eelgrass monitoring program beds in 2002, this event may be explained by increased water clarity, as the visibility in all of the beds for that season was at least 10 feet, resulting in increased light levels for photosynthesis. Macroalgae abundance in the beds was generally lower than previous years, with exceptions of Bullhead Bay and Northwest Harbor. So, the 2002 decline in shoot densities could have been the response of the plants adapting to "higher light" conditions where energy can be directed to storage or reproduction instead of unnecessary shoot production.

Areal Extent

The majority of the eelgrass beds, including Bullhead Bay, Gardiners Bay, Northwest Harbor, and Orient Harbor, continue to experience relatively minor changes in their areal extents. The majority of the changes in areal extent that have been observed are likely resulted from the natural dynamics of the eelgrass beds and their interactions with natural phenomenon (*i.e.*, erosion deposition, bioturbation) with relatively small impact from human activities in and around these beds. Although there has been little change to these beds during the years of the monitoring program, the areal extents of these beds warrant continued observation to detect significant changes and work toward preventing large scale loss to any of these beds.

Two beds are still of concern to the monitoring program. The areal extents of Southold Bay and Three Mile Harbor continue to shrink at a slow but constant rate. In the case of Southold Bay, the areas of bed that have been lost have become overgrown with *Codium fragile*, which may make re-colonization of these lost areas difficult, even with favorable growth conditions for the eelgrass. Three Mile Harbor has not suffered any major losses during the course of this program, but the plants inhabiting the deep edge are rooted in soupy, mud and provide little anchorage. Increased boat traffic could cause fluidization of the sediment causing the plants to become unanchored and drift away. Moorings in the eelgrass bed, especially near the mouth of Hands Creek, have caused sections of eelgrass to be scoured by dragging mooring chains. The long-term impact of these moorings is not clear, but future increases in the number of moorings at this site could impact the bed significantly.

Macroalgal Cover

Macroalgae continue to be a problem in some beds, where it overgrows eelgrass or colonizes lost areas preventing eelgrass from re-establishing itself. The red alga, *Spyridia filamentosa*, is comon in Peconic Estuary eelgrass beds. In most of these beds its presence could be considered insignificant, but for Bullhead Bay and Northwest Harbor, this macroalga has the potential to overgrow and shade sections of these beds. In Bullhead Bay, it is unclear if the retreat of the eelgrass in southern sections of the beds are the result of competitive pressure from the alga, or if *S. filamentosa* has colonized this area opportunistically.

Another macroalga of concern is *Codium fragile*. Since its introduction to the Northwest Atlantic Ocean in 1956, it has quickly spread north and south of Long Island. In the Peconic Estuary, this green alga hasn't been the nuisance that it has become in New England. It doesn't seem to directly threaten eelgrass, as the alga needs hard substrate to attach and most eelgrass beds contain fine sediments. Where *Codium* may come into conflict with eelgrass is in areas where eelgrass once grew but has subsequently died off. Without the eelgrass to trap finer sediments, these areas have become coarser grained, providing *Codium* with appropriate substrate to attach and spread. These former eelgrass areas have now become monocultures of *Codium* and such is the case in a portion of Southold Bay. The settlement of *Codium* in these areas may effectively prevent eelgrass from recolonizing these lost areas, however, the competition between *Codium* and eelgrass has not been studied.

Conclusions

Overall, the extant beds in the Peconic Estuary appear to be fairly stable, with a few exceptions. There has been no large-scale loss to any of the monitoring beds over the duration of the program and the few significant eelgrass losses (*e.g.* in Bullhead Bay) appear to have been natural, localized events and not a systemic problem. There are eelgrass beds in the Estuary that are of concern and bear continued monitoring. For Southold Bay and Three Mile Harbor, impacts from human usage will continue to affect the beds, unless some effort to minimize these impacts is initiated. For Bullhead Bay, water quality may be an issue, though nitrogen loading from surrounding land-use activities is not evident in the SCDHS data. The Bullhead Bay bed is prone to episodes of high diatom epiphytization of the eelgrass, which is likely triggered by some nitrogen input. Macroalgae, like *Spyridia filamentosa*, will continue to be a presence in eelgrass beds, especially those in or around quiet waters. Whether this, or other species of macroalgae in the Peconic Estuary are truly a competitive threat to eelgrass in our area is unclear, but seagrass loss due to macroalgal competition has been documented in other areas around the world and, therefore, may be cause for concern.

The PEP long-term monitoring program has contributed much to the understanding of eelgrass in the Peconic Estuary. The quantitative data collected by this program is valuable to current management and restoration efforts in the Estuary. It is imperative that this significant effort be continued into the future so that the health and well being of the resource can be properly assessed and managed

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Appendix 1a-f. The average annual concentrations of nitrogen-based water quality parameters for the six eelgrass monitoring sites. The parameters are nitrate/nitrite (NOx), total Kjeldahl nitrogen (TKN), total dissolved Kjeldahl nitrogen (TDKN), total nitrogen (TN), and total dissolved nitrogen (TDN).

1a) Bullhead Bay

	Water Quality Parameters				
Year	NOx	TKN	TDKN	TN	TDN
1998	0.0051	0.40	0.32		
1999	0.0057	0.30	0.27		
2000	0.011	0.23	0.19	0.30	0.28
2001	0.037			0.23	0.21
2002	0.027			0.21	0.18

1b) Gardiners Bay

	Water Quality Parameters				
Year	NOx	TKN	TDKN	TN	TDN
1997	0.0054	0.42	0.37		
1998	0.0050	0.34	0.31		
1999	0.0072	0.20	0.14		
2000	0.022	0.17	0.13	0.26	0.24
2001	0.038			0.25	0.23
2002	0.013			0.20	0.19

1c) Northwest Harbor

	Water Quality Parameters				
Year	NOx	TKN	TDKN	TN	TDN
1997	0.0053	0.46	0.41		
1998	0.0050	0.31	0.25		
1999	0.0057	0.20	0.17		
2000	0.016	0.15	0.12	0.24	0.24
2001	0.033			0.21	0.20
2002	0.027			0.20	0.19

Appendix 1 continued.

1d) Orient Harbor

	Water Quality Parameters				
Year	NOx	TKN	TDKN	TN	TDN
1997	0.0054	0.46	0.40		
1998	0.0061	0.31	0.26		
1999	0.0069	0.19	0.16		
2000	0.012	0.15	0.10	0.25	0.25
2001	0.038			0.21	0.20
2002	0.021			0.19	0.19

1e)Southold Bay

	Water Quality Parameters				
Year	NOx	TKN	TDKN	TN	TDN
1997	0.0059	0.45	0.41		
1998	0.0047	0.35	0.32		
1999	0.0094	0.25	0.19		
2000	0.019	0.21	0.16	0.25	0.25
2001	0.024			0.22	0.20
2002	0.023			0.19	0.19

1f) Three Mile Harbor

	Water Quality Parameters				
Year	NOx	TKN	TDKN	TN	TDN
1997	0.0057	0.49	0.41		
1998	0.0072	0.27	0.23		
1999	0.0081	0.20	0.16		
2000	0.021	0.20	0.12	0.28	0.28
2001	0.052			0.22	0.20

Appendix 2. List of macroalgae taxa identified in the six eelgrass monitoring sites and other Peconic Estuary eelgrass beds. Epiphyte (E) and Nonepiphyte/Drift (N) status is indicated for each species based on observations.

	Location						
Macroalgal Species	BB	GB	NWH	OH	SB	TMH	Other
Green (Chlorophyta)							
Chaetomorpha linum	E+N						N
Cladophora spp.	E+N	N			N		N
Codium fragile		N	N		N	N	N
*Ulva clathrata**							N
*Ulva flexuosa**	E+N						N
*Ulva intestinalis**	N	N		E+N			E+N
Ulva lactuca	N	N	N	N	N	N	N
*Ulva linza**							N
*Ulva spp.**						N	
(*Formerly *Enteromorpha* species)							
Brown (Phaeophyta)							
Acrothrix gracilis			N				
Ascophyllum nodosum		N					N
Chorda tomentosa							N
Chordaria flagelliformis							N
Desmarestia aculeata							N
Desmarestia viridis							N
Ectocarpus siliculosus	E						E+N
Eudesme virescens				E+N			E+N
Fucus distichus		N		N	N		N
Fucus vesiculosus							N
Petalonia fascia		E+N	E+N	E+N	E+N		E+N
Petalonia zosterifolia		E+N	E+N	E+N	E+N		E+N
Punctaria latifolia				N			N
Punctaria tenuissima				N			N
Sargassum filipendula		N	N		N		N
Scytosiphon lomentaria		N	N	N			N
Sphaerotrichia divaricata				N			
Stilophora rhizoides	N						
Red (Rhodophyta)							

Appendix 2 continued.

Macroalgal Species	BB	GB	NWH	OH	SB	TMH	Other
Agardhiella subulata	N		N		N	N	N
Agloathamnion westbrookiae				E			
Antithamnion cruciatum							E
Audouinellia spp.		E					E
Callithamnion corymbosum							E+N
Callithamnion tetragonium							E
Ceramium fastigiatum			N	N	E+N	E+N	
Ceramium rubrum	N	E	E+N	E+N	E+N	E+N	N
Champia parvula	E		E+N	E+N	E		E+N
Chondria bailyana			E+N			N	E+N
Chondrus crispus		N					N
Corallina officinalis		N					N
Cystoclonia purpureum					N		
Dasya baillouviana		N		N			N
Dumontia contorta							N
Gracilaria tikvahiae	N	N			N	N	N
Griffithsia globulifera		E					
Grinnellia americana		N	N	N	N	N	N
Lomentaria bailyana		N	E+N	E	E+N	N	N
Palmaria palmata		N					N
Phyllophora pseudoceranoides		N					
Pleonosporium borreri					E		
Plumaria plumosa		N					N
Polysiphonia denudata	N	N	N				N
Polysiphonia elongata		N	N				N
Polysiphonia harveyi	E+N		N				N
Polysiphonia nigra	E+N						
Polysiphonia spp.	N	N	N	N			N
Porphyra umbilicalis							N
Rhodomela conifervoides		N			N		N
Spermothamnion repens		E+N	E+N	E+N	E+N	E	E+N
Spyridia filamentosa	N	E+N	E+N	E+N	E+N	E+N	N
Titanoderma pustulatum		E		E			E

Appendix 3. Macroalgae species in the Bullhead Bay eelgrass bed from 1997-2002.

Year					
1997	1998	1999	2000	2001	2002
Ulva lactuca	*Ulva lactuca*	*Chaetomorpha* spp.	*Ulva flexuosa**	*Cladophora* spp.	*Cladophora* spp.
Ulva spp.*	*Ulva* spp.	*Cladophora sericea*	*Ulva intestinalis**	*Ulva lactuca*	*Ulva flexuosa**
Agardhiella subulata	*Stilophora rhizoides*	*Ulva* spp.*	*Ulva* spp.*	*Agardhiella subulata*	*Chaetomorpha linum*
Ceramium spp.	*Gracilaria tikvahiae*	*Ectocarpus* spp.	*Agardhiella subulata*	*Ceramium* spp.	*Agardhiella subulata*
	Polysiphonia spp.	*Ceramium* spp.	*Gracilaria tikvahiae*	*Champia parvula*	*Ceramium* spp.
		Gracilaria tikvahiae	*Polysiphonia* spp.	*Spyridia filamentosa*	*Champia parvula*
		Polysiphonia spp.	*Spyridia filamentosa*	*Ruppia maritima***	*Polysiphonia* spp.
		Spyridia filamentosa	Cyanobacterial mat		*Spyridia filamentosa*

* Formerly the genus *Enteromorpha*.
** *Ruppia maritima* is a submerged , euryhaline angiosperm, but it is included in this list as a marine macrophyte.

Appendix 4. Macroalgae species in the Gardiners Bay eelgrass bed from 1999-2002.

Year			
1999	2000	2001	2002
Codium fragile	*Codium fragile*	*Cladophora* spp.	*Codium fragile*
Ulva spp.*	*Fucus distichus*	*Codium fragile*	*Ulva intestinalis**
Ascophyllum nodosum	*Callithamnion* spp.	*Ectocarpus* spp.	*Fucus* spp.
Sargassum filipendula	*Ceramium* spp.	*Agardhiella subulata*	*Sargassum filipendula*
Agardhiella subulata	*Champia parvula*	*Ceramium* spp.	*Audouinella* spp.
Ceramium spp.	*Chondria* spp.	*Champia parvula*	*Ceramium* spp.
Champia parvula	*Chondrus crispus*	*Chondrus crispus*	*Chondrus crispus*
Griffithsia globulifera	*Dasya baillouviana*	*Grinnellia americana*	*Polysiphonia* spp.
Grinnellia americana	*Gracilaria tikvahiae*	*Lomentaria* spp.	*Spyridia filamentosa*
Lomentaria spp.	*Grinnellia americana*	*Phyllophora pseudoceranoides*	
Polysiphonia spp.	*Lomentaria* spp.	*Spyridia filamentosa*	
Rhodomela conifervoides	*Polysiphonia* spp.		
Spermothamnion repens	*Plumaria plumosa*		
Spyridia filamentosa	*Rhodomela* spp.		
	Spermothamnion repens		
	Spyridia filamentosa		

* Formerly the genus *Enteromorpha*.

Appendix 5. Macroalgae species in the Northwest Harbor eelgrass bed from 1997-2002.

Year					
1997	1998	1999	2000	2001	2002
Ceramium spp.	*Codium fragile*	*Acrothrix gracilis*	*Codium fragile*	*Codium fragile*	*Codium fragile*
Spyridia filamentosa	*Acrothrix gracilis*	*Ceramium* spp.	*Sargassum filipendula*	*Sargassum filipendula*	*Ceramium* spp
	Polysiphonia spp.	*Polysiphonia* spp.	*Agardhiella subulata*	*Agardhiella subulata*	*Grinnellia americana*
	Spyridia filamentosa	*Spyridia filamentosa*	*Ceramium* spp.	*Ceramium* spp.	*Polysiphonia* spp.
			Champia parvula	*Grinnellia americana*	*Spermothamnion repens*
			Chondria spp.	*Lomentaria* spp	*Spyridia filamentosa*
			Grinnellia americana	*Polysiphonia* spp.	
			Lomentaria spp.	*Spermothamnion repens*	
			Polysiphonia spp.	*Spyridia filamentosa*	
			Spermothamnion repens		
			Spyridia filamentosa		

Appendix 6. Macroalgae species in the Orient Harbor eelgrass bed from 1997-2002.

Year					
1997	1998	1999	2000	2001	2002
Codium fragile	Mixed Reds	*Ceramium* spp.	*Codium fragile*	*Codium fragile*	*Champia parvula*
Sphaerotrichia divaricata		*Champia parvula*	*Agardhiella subulata*	*Ceramium* spp.	*Grinnellia americana*
Stilophora rhizoides		*Polysiphonia* spp.	*Agloathamnion westbrookiae*	*Spyridia filamentosa*	*Polysiphonia* spp.
Ceramium spp.		*Spermothamnion repens*	*Ceramium* spp.		*Spermothamnion repens*
Dasya baillouviana			*Champia parvula*		*Spyridia filamentosa*
Lomentaria baileyana			*Chondria* spp.		
			Polysiphonia spp.		
			Spermothamnion repens		
			Spyridia filamentosa		
			Unidentified Red filament		

Appendix 7. Macroalgae species in the Southold Bay eelgrass bed from 1999-2002.

Year			
1999	2000	2001	2002
Codium fragile	*Codium fragile*	*Cladophora* spp.	*Codium fragile*
Ceramium spp.	*Ulva* spp.*	*Codium fragile*	*Ulva* spp.*
Champia parvula	*Agardhiella subulata*	*Ulva* spp.*	*Fucus distichus*
Gracilaria tikvahiae	*Ceramium* spp.	*Sargassum filipendula*	*Sargassum filipendula*
Pleonosporium borreri	*Champia parvula*	*Agardhiella subulata*	*Agardhiella subulata*
Polysiphonia spp.	*Lomentaria* spp.	*Ceramium* spp.	*Cystoclonium purpureum*
Spyridia filamentosa	*Plumaria plumosa*	*Champia parvula*	*Grinnellia americana*
	Polysiphonia spp.	*Lomentaria* spp.	*Lomentaria* spp
	Rhodomela conifervoides	*Polysiphonia* spp	*Spermothamnion repens*
	Spermothamnion repens	*Spermothamnion repens*	*Spyridia filamentosa*
	Spyridia filamentosa	*Spyridia filamentosa*	

* Formerly the genus *Enteromorpha*.

Appendix 8. Macroalgae species in the Thee Mile Harbor eelgrass bed from 1999-2002.

Year			
1999	2000	2001	2002
Ulva spp.*	*Codium fragile*	*Codium fragile*	*Codium fragile*
Polysiphonia spp.	*Ceramium* spp.	*Agardhiella subulata*	*Ceramium* spp.
Spyridia filamentosa	*Chondria* spp.	*Lomentaria* spp.	*Spyridia filamentosa*
	Gracilaria tikvahiae	*Polysiphonia* spp.	
	Lomentaria spp.	*Spermothamnion repens*	
	Polysiphonia spp.	*Spyridia filamentosa*	
	Spyridia filamentosa		

* Formerly the genus *Enteromorpha*.

Appendix 9. Statistical reports from SigmaStat software (SPSS, 1999) for the Bullhead Bay water quality parameters, eelgrass shoot density, and macroalgae percent cover.

Descriptive Statistics
Data source: BH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
BB 98 NOx	16	0	0.0051	0.00025	0.000063	0.00013
BB 99 NOx	17	0	0.0057	0.0022	0.00053	0.0011
BB 00 NOx	20	0	0.011	0.011	0.0025	0.0051
BB 01 NOx	22	0	0.037	0.032	0.0067	0.014
BB 02 NOx	26	0	0.027	0.030	0.0058	0.012

Column	Range	Max	Min	Median	25%	75%
BB 98 NOx	0.00100	0.0060	0.0050	0.0050	0.0050	0.0050
BB 99 NOx	0.0090	0.014	0.0050	0.0050	0.0050	0.0052
BB 00 NOx	0.037	0.042	0.0050	0.0055	0.0050	0.012
BB 01 NOx	0.10	0.11	0.0050	0.028	0.0090	0.056
BB 02 NOx	0.11	0.12	0.0050	0.014	0.0070	0.040

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
BB 98 NOx	4.00	16.00	0.54	<0.001	0.081	0.00041
BB 99 NOx	3.91	15.70	0.39	<0.001	0.097	0.00063
BB 00 NOx	2.14	3.79	0.31	<0.001	0.22	0.0048
BB 01 NOx	0.88	-0.10	0.18	0.052	0.82	0.051
BB 02 NOx	1.78	2.64	0.27	<0.001	0.70	0.041

One Way Analysis of Variance
Data source: BH in 5-Year Water Quality Trend Analysis

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

Data source: BH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
BB 98 NOx	16	0	0.0050	0.0050	0.0050
BB 99 NOx	17	0	0.0050	0.0050	0.0052
BB 00 NOx	20	0	0.0055	0.0050	0.012
BB 01 NOx	22	0	0.028	0.0090	0.056

BB 02 NOx	26	0	0.014	0.0070	0.040

H = 41.34 with 4 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
BB 01 NOx vs BB 98 NOx	46.39	4.82	Yes
BB 01 NOx vs BB 99 NOx	40.78	4.31	Yes
BB 01 NOx vs BB 00 NOx	26.65	2.94	Yes
BB 01 NOx vs BB 02 NOx	7.99	0.94	No
BB 02 NOx vs BB 98 NOx	38.40	4.12	Yes
BB 02 NOx vs BB 99 NOx	32.79	3.59	Yes
BB 02 NOx vs BB 00 NOx	18.66	2.14	No
BB 00 NOx vs BB 98 NOx	19.74	2.01	No
BB 00 NOx vs BB 99 NOx	14.14	1.46	No
BB 99 NOx vs BB 98 NOx	5.61	0.55	No

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

Descriptive Statistics

Data source: BH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
BB 98 TKN	16	0	0.40	0.13	0.034	0.072
BB 99 TKN	17	0	0.30	0.10	0.025	0.053
BB 00 TKN	10	0	0.23	0.13	0.041	0.092

Column	Range	Max	Min	Median	25%	75%
BB 98 TKN	0.48	0.57	0.087	0.42	0.33	0.51
BB 99 TKN	0.31	0.48	0.17	0.27	0.23	0.40
BB 00 TKN	0.35	0.41	0.060	0.24	0.12	0.31

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
BB 98 TKN	-0.82	0.59	0.13	0.588	6.41	2.84
BB 99 TKN	0.36	-1.34	0.18	0.165	5.15	1.73
BB 00 TKN	0.16	-1.37	0.16	0.615	2.29	0.67

One Way Analysis of Variance

Data source: BH in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 0.816)

Group Name	N	Missing	Mean	Std Dev	SEM
BB 98 TKN	16	0	0.40	0.13	0.034
BB 99 TKN	17	0	0.30	0.10	0.025
BB 00 TKN	10	0	0.23	0.13	0.041

Source of Variation	DF	SS	MS	F	P
Between Groups	2	0.19	0.096	6.53	0.004
Residual	40	0.59	0.015		
Total		42	0.78		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.004).

Power of performed test with alpha = 0.05: 0.835

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
BB 98 TKN vs. BB 00 TKN	0.17	3	4.97	0.003	Yes
BB 98 TKN vs. BB 99 TKN	0.098	3	3.28	0.065	No
BB 99 TKN vs. BB 00 TKN	0.074	3	2.17	0.287	No

Descriptive Statistics

Data source: BH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
BB 98 TDKN	16	0	0.32	0.14	0.035	0.075
BB 99 TDKN	17	0	0.27	0.082	0.020	0.042
BB 00 TDKN	10	0	0.19	0.12	0.038	0.086

Column	Range	Max	Min	Median	25%	75%
BB 98 TDKN	0.51	0.56	0.050	0.32	0.21	0.41
BB 99 TDKN	0.32	0.49	0.17	0.26	0.22	0.31

BB 00 TDKN	0.40	0.45	0.050	0.19	0.100	0.23

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
BB 98 TDKN	-0.064	-0.32	0.12	0.666	5.17	1.96
BB 99 TDKN	1.33	2.30	0.20	0.078	4.56	1.33
BB 00 TDKN	1.05	1.57	0.16	0.583	1.87	0.48

One Way Analysis of Variance
Data source: BH in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 0.201)

Group Name	N	Missing	Mean	Std Dev	SEM
BB 98 TDKN	16	0	0.32	0.14	0.035
BB 99 TDKN	17	0	0.27	0.082	0.020
BB 00 TDKN	10	0	0.19	0.12	0.038

Source of Variation	DF	SS	MS	F	P
Between Groups	2	0.11	0.057	4.27	0.021
Residual	40	0.53	0.013		
Total		42	0.65		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.021).

Power of performed test with alpha = 0.05: 0.584

The power of the performed test (0.584) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
BB 98 TDKN vs. BB 00 TDKN	0.14	3	4.13	0.015	Yes
BB 98 TDKN vs. BB 99 TDKN	0.055	3	1.92	0.371	No
BB 99 TDKN vs. BB 00 TDKN	0.081	3	2.50	0.194	No

Descriptive Statistics

Data source: BH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
BB 00 TN	20	10	0.30	0.061	0.019	0.044
BB 01 TN	22	0	0.23	0.078	0.017	0.035
BB 02 TN	26	0	0.21	0.074	0.015	0.030

Column	Range	Max	Min	Median	25%	75%
BB 00 TN	0.17	0.39	0.22	0.30	0.27	0.35
BB 01 TN	0.25	0.38	0.13	0.20	0.19	0.27
BB 02 TN	0.29	0.37	0.080	0.19	0.16	0.22

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
BB 00 TN	0.026	-1.26	0.15	0.676	3.03	0.95
BB 01 TN	0.97	-0.13	0.23	0.004	5.00	1.26
BB 02 TN	0.93	0.43	0.20	0.007	5.33	1.23

One Way Analysis of Variance

Data source: BH in 5-Year Water Quality Trend Analysis

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

Data source: BH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
BB 00 TN	10	0	0.30	0.27	0.35
BB 01 TN	22	0	0.20	0.19	0.27
BB 02 TN	26	0	0.19	0.16	0.22

H = 12.66 with 2 degrees of freedom. (P = 0.002)

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 = 0.002)

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
BB 00 TN vs BB 02 TN	22.28	3.55	Yes
BB 00 TN vs BB 01 TN	16.64	2.58	Yes
BB 01 TN vs BB 02 TN	5.64	1.15	No

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

Descriptive Statistics

Data source: BH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
BB 00 TDN	19	10	0.28	0.072	0.024	0.056
BB 01 TDN	22	0	0.21	0.082	0.018	0.037
BB 02 TDN	26	0	0.18	0.068	0.013	0.028

Column	Range	Max	Min	Median	25%	75%
BB 00 TDN	0.18	0.38	0.20	0.29	0.21	0.35
BB 01 TDN	0.27	0.39	0.12	0.18	0.16	0.24
BB 02 TDN	0.24	0.33	0.090	0.17	0.12	0.20

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
BB 00 TDN	0.23	-1.68	0.18	0.503	2.55	0.76
BB 01 TDN	1.10	-0.0034	0.24	0.002	4.64	1.12
BB 02 TDN	0.90	0.018	0.15	0.112	4.68	0.96

One Way Analysis of Variance

Data source: BH in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P = 0.015)

Equal Variance Test: Passed (P = 0.760)

Group Name	N	Missing	Mean	Std Dev	SEM
BB 00 TDN	9	0	0.28	0.072	0.024
BB 01 TDN	22	0	0.21	0.082	0.018
BB 02 TDN	26	0	0.18	0.068	0.013

Source of Variation	DF	SS	MS	F	P
Between Groups	2	0.072	0.036	6.43	0.003
Residual	54	0.30	0.0056		
Total		56	0.37		

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = 0.003).

Power of performed test with alpha = 0.05: 0.836

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
BB 00 TDN vs. BB 02 TDN	0.10	3	5.06	0.002	Yes
BB 00 TDN vs. BB 01 TDN	0.072	3	3.47	0.045	Yes
BB 01 TDN vs. BB 02 TDN	0.031	3	2.02	0.333	No

Descriptive Statistics

Data source: BB in 5-Year Eelgrass Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
BB 1997	4	0	710.00	392.32	196.16	624.27
BB 1998	12	0	620.00	387.15	111.76	245.98
BB 1999	12	0	548.00	271.97	78.51	172.80
BB 2000	60	0	301.17	200.09	25.83	51.69
BB 2001	60	0	150.17	138.66	17.90	35.82
BB 2002	60	0	201.17	109.19	14.10	28.21

Column	Range	Max	Min	Median	25%	75%
BB 1997	920.00	1264.00	344.00	616.00	460.00	960.00
BB 1998	1184.00	1296.00	112.00	424.00	368.00	976.00
BB 1999	944.00	1136.00	192.00	496.00	368.00	672.00
BB 2000	880.00	930.00	50.00	250.00	155.00	385.00
BB 2001	820.00	820.00	0.00	130.00	55.00	210.00
BB 2002	450.00	450.00	0.00	180.00	120.00	270.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
BB 1997	1.31	2.33	0.30	0.209	2840.00	2478144.00
BB 1998	0.42	-1.27	0.27	0.016	7440.00	6261504.00
BB 1999	0.92	0.69	0.21	0.155	6576.00	4417280.00
BB 2000	1.34	1.50	0.15	0.002	18070.00	7804300.00
BB 2001	2.21	8.59	0.14	0.005	9010.00	2487300.00
BB 2002	0.18	-0.63	0.094	0.210	12070.00	3131500.00

One Way Analysis of Variance
Data source: BB in 5-Year Eelgrass Shoot Density Analysis

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

Data source: BB in 5-Year Eelgrass Shoot Density Analysis

Group	N	Missing	Median	25%	75%
BB 1998	12	0	424.00	368.00	976.00
BB 1999	12	0	496.00	368.00	672.00
BB 2000	60	0	250.00	155.00	385.00
BB 2001	60	0	130.00	55.00	210.00
BB 2002	60	0	180.00	120.00	270.00

H = 57.20 with 4 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
BB 1999 vs BB 2001	103.83	5.56	Yes
BB 1999 vs BB 2002	77.53	4.15	Yes
BB 1999 vs BB 2000	52.62	2.82	Yes
BB 1999 vs BB 1998	5.25	0.22	No
BB 1998 vs BB 2001	98.58	5.28	Yes
BB 1998 vs BB 2002	72.28	3.87	Yes
BB 1998 vs BB 2000	47.37	2.54	No
BB 2000 vs BB 2001	51.21	4.75	Yes
BB 2000 vs BB 2002	24.92	2.31	No
BB 2002 vs BB 2001	26.29	2.44	No

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

Descriptive Statistics
Data source: BB in 5-Year Macroalgae Percent Cover Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
BB 2000	24	0	18.96	20.11	4.10	8.49
BB 2001	60	0	23.27	33.11	4.28	8.55
BB 2002	60	0	56.42	38.98	5.03	10.07

Column	Range	Max	Min	Median	25%	75%
BB 2000	75.00	75.00	0.00	15.00	2.50	25.00
BB 2001	100.00	100.00	0.00	5.00	0.00	50.00
BB 2002	100.00	100.00	0.00	50.00	10.00	100.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
BB 2000	1.50	2.15	0.26	<0.001	455.00	17925.00
BB 2001	1.25	0.14	0.29	<0.001	1396.00	97176.00
BB 2002	-0.14	-1.60	0.20	<0.001	3385.00	280625.00

One Way Analysis of Variance

Data source: BB in 5-Year Macroalgae Percent Cover

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
Data source: BB in 5-Year Macroalgae Percent Cover

Group	N	Missing	Median	25%	75%
BB 2000	24	0	15.00	2.50	25.00
BB 2001	60	0	5.00	0.00	50.00
BB 2002	60	0	50.00	10.00	100.00

H = 29.56 with 2 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
BB 2002 vs BB 2001	38.89	5.11	Yes
BB 2002 vs BB 2000	34.52	3.43	Yes
BB 2000 vs BB 2001	4.37	0.43	No

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

Appendix 10. Statistical reports from SigmaStat software (SPSS, 1999) for the Gardiners Bay water quality parameters, eelgrass shoot density, and macroalgae percent cover.

Descriptive Statistics
Data source: GB in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
GB 97 NOx	16	0	0.0054	0.0015	0.00037	0.00080
GB 98 NOx	15	0	0.0050	$8.8x10^{-11}$	$2.3x10^{-11}$	$4.9x10^{-11}$
GB 99 NOx	13	0	0.0072	0.0056	0.0016	0.0034
GB 00 NOx	18	0	0.022	0.022	0.0051	0.011
GB 01 NOx	7	0	0.038	0.022	0.0082	0.020
GB 02 NOx	16	0	0.013	0.011	0.0029	0.0061

Column	Range	Max	Min	Median	25%	75%
GB 97 NOx	0.0060	0.011	0.0050	0.0050	0.0050	0.0050
GB 98 NOx	0.00	0.0050	0.0050	0.0050	0.0050	0.0050
GB 99 NOx	0.018	0.023	0.0050	0.0050	0.0050	0.0050
GB 00 NOx	0.054	0.059	0.0050	0.0090	0.0050	0.045
GB 01 NOx	0.053	0.059	0.0060	0.045	0.017	0.057
GB 02 NOx	0.033	0.038	0.0050	0.0060	0.0050	0.018

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
GB 97 NOx	4.00	16.00	0.54	<0.001	0.086	0.00050
GB 98 NOx	0.00	-2.33	0.50	<0.001	0.075	0.00038
GB 99 NOx	2.47	5.41	0.50	<0.001	0.094	0.0011
GB 00 NOx	0.87	-1.11	0.27	0.001	0.39	0.016
GB 01 NOx	-0.70	-1.36	0.20	0.480	0.27	0.013
GB 02 NOx	1.42	0.65	0.31	<0.001	0.20	0.0045

One Way Analysis of Variance
Data source: GB in 5-Year Water Quality Trend Analysis

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

Data source: GB in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
GB 97 NOx	16	0	0.0050	0.0050	0.0050
GB 98 NOx	15	0	0.0050	0.0050	0.0050
GB 99 NOx	13	0	0.0050	0.0050	0.0050
GB 00 NOx	18	0	0.0090	0.0050	0.045
GB 01 NOx	7	0	0.045	0.017	0.057
GB 02 NOx	16	0	0.0060	0.0050	0.018

H = 38.43 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
GB 01 NOx vs GB 98 NOx	46.14	4.08	Yes
GB 01 NOx vs GB 97 NOx	43.89	3.92	Yes
GB 01 NOx vs GB 99 NOx	39.80	3.44	Yes
GB 01 NOx vs GB 02 NOx	24.49	2.19	No
GB 01 NOx vs GB 00 NOx	19.09	1.74	No
GB 00 NOx vs GB 98 NOx	27.06	3.14	Yes
GB 00 NOx vs GB 97 NOx	24.81	2.93	No
GB 00 NOx vs GB 99 NOx	20.71	2.31	No
GB 00 NOx vs GB 02 NOx	5.40	0.64	No
GB 02 NOx vs GB 98 NOx	21.66	2.44	No
GB 02 NOx vs GB 97 NOx	19.41	2.22	No
GB 02 NOx vs GB 99 NOx	15.31	1.66	No
GB 99 NOx vs GB 98 NOx	6.35	0.68	No
GB 99 NOx vs GB 97 NOx	4.10	0.44	No
GB 97 NOx vs GB 98 NOx	2.25	0.25	No

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

Descriptive Statistics

Data source: GB in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
GB 97 TKN	16	0	0.42	0.13	0.033	0.070
GB 98 TKN	15	0	0.34	0.16	0.042	0.090
GB 99 TKN	13	0	0.20	0.081	0.023	0.049
GB 00 TKN	6	0	0.17	0.045	0.019	0.048

Column	Range	Max	Min	Median	25%	75%
GB 97 TKN	0.55	0.70	0.15	0.41	0.38	0.48
GB 98 TKN	0.63	0.63	0.0050	0.31	0.25	0.43
GB 99 TKN	0.28	0.34	0.060	0.19	0.14	0.26
GB 00 TKN	0.13	0.23	0.100	0.17	0.14	0.19

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
GB 97 TKN	0.033	1.24	0.17	0.245	6.69	3.06
GB 98 TKN	0.050	0.25	0.12	0.686	5.10	2.10
GB 99 TKN	0.0070	-0.52	0.11	0.810	2.56	0.58
GB 00 TKN	-0.28	-0.068	0.18	0.628	1.01	0.18

One Way Analysis of Variance

Data source: GB in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P = 0.153)

Equal Variance Test: Passed (P = 0.146)

Group Name	N	Missing	Mean	Std Dev	SEM
GB 97 TKN	16	0	0.42	0.13	0.033
GB 98 TKN	15	0	0.34	0.16	0.042
GB 99 TKN	13	0	0.20	0.081	0.023
GB 00 TKN	6	0	0.17	0.045	0.019

Source of Variation	DF	SS	MS	F	P
Between Groups	3	0.49	0.16	10.35	<0.001
Residual	46	0.72	0.016		
Total		49	1.21		

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

Power of performed test with alpha = 0.05: 0.997

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
GB 97 TKN vs. GB 00 TKN	0.25	4	5.89	<0.001	Yes
GB 97 TKN vs. GB 99 TKN	0.22	4	6.69	<0.001	Yes
GB 97 TKN vs. GB 98 TKN	0.079	4	2.47	0.313	No
GB 98 TKN vs. GB 00 TKN	0.17	4	4.00	0.034	Yes
GB 98 TKN vs. GB 99 TKN	0.14	4	4.25	0.021	Yes
GB 99 TKN vs. GB 00 TKN	0.029	4	0.65	0.967	No

Descriptive Statistics
Data source: GB in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
GB 97 TDKN	16	0	0.37	0.14	0.036	0.076
GB 98 TDKN	15	0	0.31	0.19	0.049	0.11
GB 99 TDKN	13	0	0.14	0.058	0.016	0.035
GB 00 TDKN	6	0	0.13	0.044	0.018	0.046

Column	Range	Max	Min	Median	25%	75%
GB 97 TDKN	0.54	0.69	0.15	0.34	0.30	0.46
GB 98 TDKN	0.53	0.61	0.080	0.27	0.13	0.52
GB 99 TDKN	0.15	0.20	0.050	0.17	0.077	0.19
GB 00 TDKN	0.11	0.19	0.080	0.13	0.100	0.18

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
GB 97 TDKN	0.41	0.33	0.13	0.603	5.89	2.47
GB 98 TDKN	0.43	-1.26	0.17	0.271	4.67	1.96
GB 99 TDKN	-0.55	-1.51	0.25	0.032	1.80	0.29
GB 00 TDKN	0.33	-1.55	0.20	0.558	0.80	0.12

One Way Analysis of Variance
Data source: GB in 5-Year Water Quality Trend Analysis

Normality Test: Failed (P = 0.009)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks Saturday, January 31, 2004, 13:52:18

Data source: GB in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
GB 97 TDKN	16	0	0.34	0.30	0.46
GB 98 TDKN	15	0	0.27	0.13	0.52
GB 99 TDKN	13	0	0.17	0.077	0.19
GB 00 TDKN	6	0	0.13	0.100	0.18

H = 18.37 with 3 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
GB 97 TDKN vs GB 00 TDKN	21.27	3.05	Yes
GB 97 TDKN vs GB 99 TDKN	20.15	3.70	Yes
GB 97 TDKN vs GB 98 TDKN	6.32	1.21	No
GB 98 TDKN vs GB 00 TDKN	14.95	2.12	No
GB 98 TDKN vs GB 99 TDKN	13.83	2.50	No
GB 99 TDKN vs GB 00 TDKN	1.12	0.16	No

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

Descriptive Statistics

Data source: GB in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
GB 00 TN	12	0	0.26	0.081	0.023	0.051
GB 01 TN	7	0	0.25	0.097	0.037	0.090
GB 02 TN	16	0	0.20	0.084	0.021	0.045

Column	Range	Max	Min	Median	25%	75%
GB 00 TN	0.24	0.36	0.12	0.27	0.19	0.34
GB 01 TN	0.24	0.36	0.12	0.20	0.19	0.35
GB 02 TN	0.31	0.39	0.080	0.16	0.14	0.27

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
GB 00 TN	-0.21	-1.37	0.17	0.371	3.08	0.86

GB 01 TN	0.078	-2.12	0.27	0.136	1.75	0.49
GB 02 TN	0.85	0.061	0.23	0.021	3.15	0.73

One Way Analysis of Variance

Data source: GB in 5-Year Water Quality Trend Analysis

Normality Test: Failed (P = 0.002)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks Saturday, January 31, 2004, 13:52:28

Data source: GB in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
GB 00 TN	12	0	0.27	0.19	0.34
GB 01 TN	7	0	0.20	0.19	0.35
GB 02 TN	16	0	0.16	0.14	0.27

H = 4.45 with 2 degrees of freedom. (P = 0.108)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.108)

Descriptive Statistics

Data source: GB in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
GB 00 TDN	12	0	0.24	0.084	0.024	0.053
GB 01 TDN	7	0	0.23	0.10	0.039	0.094
GB 02 TDN	16	0	0.19	0.091	0.023	0.048

Column	Range	Max	Min	Median	25%	75%
GB 00 TDN	0.24	0.35	0.11	0.25	0.16	0.32
GB 01 TDN	0.24	0.35	0.11	0.19	0.16	0.34
GB 02 TDN	0.30	0.38	0.080	0.15	0.13	0.28

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
GB 00 TDN	-0.13	-1.54	0.14	0.642	2.88	0.77
GB 01 TDN	0.16	-2.39	0.25	0.184	1.64	0.45
GB 02 TDN	0.72	-0.66	0.24	0.016	3.06	0.71

One Way Analysis of Variance
Data source: GB in 5-Year Water Quality Trend Analysis

Normality Test: Failed (P = 0.003)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks Saturday, January 31, 2004, 13:52:41

Data source: GB in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
GB 00 TDN	12	0	0.25	0.16	0.32
GB 01 TDN	7	0	0.19	0.16	0.34
GB 02 TDN	16	0	0.15	0.13	0.28

H = 3.10 with 2 degrees of freedom. (P = 0.212)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.212)

Descriptive Statistics
Data source: GB in 5-Year Eelgrass Shoot Density Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
GB 1999	12	0	498.67	127.42	36.78	80.96
GB 2000	60	0	470.17	178.49	23.04	46.11
GB 2001	60	0	372.83	123.95	16.00	32.02
GB 2002	60	0	305.83	190.78	24.63	49.28

Column	Range	Max	Min	Median	25%	75%
GB 1999	464.00	720.00	256.00	504.00	424.00	584.00
GB 2000	820.00	950.00	130.00	465.00	340.00	580.00
GB 2001	700.00	760.00	60.00	365.00	280.00	455.00
GB 2002	670.00	670.00	0.00	340.00	160.00	410.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
GB 1999	-0.23	0.038	0.10	0.834	5984.00	3162624.00
GB 2000	0.20	-0.17	0.050	0.880	28210.00	15143100.00
GB 2001	0.40	0.89	0.065	0.698	22370.00	9246700.00
GB 2002	-0.27	-0.71	0.15	0.001	18350.00	7759500.00

One Way Analysis of Variance
Data source: GB in 5-Year Eelgrass Shoot Density Analysis
Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 0.025)

Group Name	N	Missing	Mean	Std Dev	SEM
GB 1999	12	0	498.67	127.42	36.78
GB 2000	60	0	470.17	178.49	23.04
GB 2001	60	0	372.83	123.95	16.00
GB 2002	60	0	305.83	190.78	24.63

Source of Variation	DF	SS	MS	F	P
Between Groups	3	970020.31	323340.10	11.89	<0.001
Residual	188	5112177.67	27192.43		
Total		191	6082197.98		

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

Power of performed test with alpha = 0.05: 1.000

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
GB 1999 vs. GB 2002	192.83	4	5.23	0.001	Yes
GB 1999 vs. GB 2001	125.83	4	3.41	0.075	No
GB 1999 vs. GB 2000	28.50	4	0.77	0.948	No
GB 2000 vs. GB 2002	164.33	4	7.72	<0.001	Yes
GB 2000 vs. GB 2001	97.33	4	4.57	0.007	No
GB 2001 vs. GB 2002	67.00	4	3.15	0.116	No

Descriptive Statistics
Data source: GB in 5-Year Macroalgae Percent Cover Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
GB 2000	24	0	25.83	21.40	4.37	9.04
GB 2001	60	0	14.18	15.53	2.01	4.01
GB 2002	60	0	23.37	25.29	3.26	6.53

Column	Range	Max	Min	Median	25%	75%
GB 2000	75.00	75.00	0.00	22.50	7.50	50.00

Column	Range	Max	Min	Median	25%	75%
GB 2001	100.00	100.00	0.00	10.00	5.00	20.00
GB 2002	90.00	90.00	0.00	10.00	5.00	45.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
GB 2000	0.70	-0.54	0.18	0.038	620.00	26550.00
GB 2001	3.27	15.35	0.29	<0.001	851.00	26301.00
GB 2002	1.15	0.087	0.27	<0.001	1402.00	70482.00

One Way Analysis of Variance
Data source: GB in 5-Year Macroalgae Percent Cover Analysis

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
Data source: GB in 5-Year Macroalgae Percent Cover Analysis

Group	N	Missing	Median	25%	75%
GB 2000	24	0	22.50	7.50	50.00
GB 2001	60	0	10.00	5.00	20.00
GB 2002	60	0	10.00	5.00	45.00

H = 4.78 with 2 degrees of freedom. (P = 0.092)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.092)

Appendix 11. Statistical reports from SigmaStat software (SPSS, 1999) for the Northwest Harbor water quality parameters, eelgrass shoot density, and macroalgae percent cover.

Descriptive Statistics
Data source: NWH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
NWH 97 NOx	47	0	0.0053	0.0020	0.00030	0.00060
NWH 98 NOx	42	0	0.0050	0.00015	0.000024	0.000048
NWH 99 NOx	36	0	0.0057	0.0021	0.00036	0.00073
NWH 00 NOx	21	0	0.016	0.024	0.0051	0.011
NWH 01 NOx	20	0	0.033	0.024	0.0054	0.011
NWH 02 NOx	18	0	0.027	0.036	0.0085	0.018

Column	Range	Max	Min	Median	25%	75%
NWH 97 NOx	0.014	0.019	0.0050	0.0050	0.0050	0.0050
NWH 98 NOx	0.00100	0.0060	0.0050	0.0050	0.0050	0.0050
NWH 99 NOx	0.0100	0.015	0.0050	0.0050	0.0050	0.0050
NWH 00 NOx	0.089	0.094	0.0050	0.0050	0.0050	0.011
NWH 01 NOx	0.075	0.080	0.0050	0.039	0.0075	0.051
NWH 02 NOx	0.10	0.11	0.0050	0.0075	0.0050	0.034

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
NWH 97 NOx	6.80	46.49	0.52	<0.001	0.25	0.0015
NWH 98 NOx	6.48	42.00	0.54	<0.001	0.21	0.0011
NWH 99 NOx	3.44	11.73	0.49	<0.001	0.21	0.0013
NWH 00 NOx	2.58	6.18	0.39	<0.001	0.33	0.016
NWH 01 NOx	0.20	-1.23	0.19	0.057	0.66	0.033
NWH 02 NOx	1.45	0.50	0.35	<0.001	0.49	0.035

One Way Analysis of Variance
Data source: NWH in 5-Year Water Quality Trend Analysis

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

Data source: NWH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
NWH 97 NOx	47	0	0.0050	0.0050	0.0050

NWH 98 NOx	42	0	0.0050	0.0050	0.0050
NWH 99 NOx	36	0	0.0050	0.0050	0.0050
NWH 00 NOx	21	0	0.0050	0.0050	0.011
NWH 01 NOx	20	0	0.039	0.0075	0.051
NWH 02 NOx	18	0	0.0075	0.0050	0.034

H = 78.58 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
NWH 01 NOx vs NWH 98 NOx	75.51	5.22	Yes
NWH 01 NOx vs NWH 97 NOx	73.70	5.18	Yes
NWH 01 NOx vs NWH 99 NOx	65.77	4.43	Yes
NWH 01 NOx vs NWH 00 NOx	34.34	2.06	No
NWH 01 NOx vs NWH 02 NOx	24.28	1.40	No
NWH 02 NOx vs NWH 98 NOx	51.23	3.41	Yes
NWH 02 NOx vs NWH 97 NOx	49.42	3.35	Yes
NWH 02 NOx vs NWH 99 NOx	41.49	2.70	No
NWH 02 NOx vs NWH 00 NOx	10.06	0.59	No
NWH 00 NOx vs NWH 98 NOx	41.17	2.89	No
NWH 00 NOx vs NWH 97 NOx	39.36	2.82	No
NWH 00 NOx vs NWH 99 NOx	31.42	2.15	No
NWH 99 NOx vs NWH 98 NOx	9.74	0.81	No
NWH 99 NOx vs NWH 97 NOx	7.94	0.67	No
NWH 97 NOx vs NWH 98 NOx	1.81	0.16	No

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

Descriptive Statistics
Data source: NWH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
NWH 97 TKN	47	1	0.46	0.20	0.030	0.060
NWH 98 TKN	42	0	0.31	0.15	0.024	0.048
NWH 99 TKN	36	0	0.20	0.079	0.013	0.027
NWH 00 TKN	13	0	0.15	0.069	0.019	0.042

Column	Range	Max	Min	Median	25%	75%
NWH 97 TKN	1.08	1.20	0.12	0.46	0.31	0.58
NWH 98 TKN	0.54	0.59	0.050	0.32	0.19	0.44
NWH 99 TKN	0.27	0.33	0.060	0.21	0.14	0.28
NWH 00 TKN	0.20	0.27	0.070	0.15	0.087	0.20

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
NWH 97 TKN	1.16	2.79	0.091	0.415	21.13	11.51
NWH 98 TKN	0.066	-1.01	0.067	0.820	13.02	5.02
NWH 99 TKN	-0.12	-1.28	0.16	0.026	7.23	1.67
NWH 00 TKN	0.43	-1.13	0.16	0.415	1.99	0.36

One Way Analysis of Variance

Data source: NWH in 5-Year Water Quality Trend Analysis

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
Data source: NWH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
NWH 97 TKN	47	1	0.46	0.31	0.58
NWH 98 TKN	42	0	0.32	0.19	0.44
NWH 99 TKN	36	0	0.21	0.14	0.28
NWH 00 TKN	13	0	0.15	0.087	0.20

H = 54.53 with 3 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
NWH 97 TKN vs NWH 00 TKN	70.10	5.62	Yes

NWH 97 TKN vs NWH 99 TKN	55.51	6.28	Yes
NWH 97 TKN vs NWH 98 TKN	28.16	3.32	Yes
NWH 98 TKN vs NWH 00 TKN	41.95	3.33	Yes
NWH 98 TKN vs NWH 99 TKN	27.35	3.03	Yes
NWH 99 TKN vs NWH 00 TKN	14.59	1.14	No

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

Descriptive Statistics
Data source: NWH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
NWH 97 TDKN	47	1	0.41	0.18	0.026	0.053
NWH 98 TDKN	42	0	0.25	0.14	0.022	0.044
NWH 99 TDKN	36	0	0.17	0.072	0.012	0.024
NWH 00 TDKN	13	0	0.12	0.065	0.018	0.039

Column	Range	Max	Min	Median	25%	75%
NWH 97 TDKN	0.77	0.88	0.11	0.43	0.25	0.52
NWH 98 TDKN	0.53	0.58	0.050	0.26	0.11	0.36
NWH 99 TDKN	0.26	0.31	0.050	0.17	0.11	0.22
NWH 00 TDKN	0.20	0.25	0.050	0.100	0.077	0.17

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
NWH 97 TDKN	0.43	0.026	0.078	0.628	18.78	9.08
NWH 98 TDKN	0.32	-0.7	0.098	0.381	10.41	3.40
NWH 99 TDKN	-0.065	-1.2	0.15	0.047	5.97	1.17
NWH 00 TDKN	0.87	-041	0.21	0.134	1.59	0.25

One Way Analysis of Variance
Data source: NWH in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P = 0.092)

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
Data source: NWH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
NWH 97 TDKN	47	1	0.43	0.25	0.52

NWH 98 TDKN	42	0	0.26	0.11	0.36
NWH 99 TDKN	36	0	0.17	0.11	0.22
NWH 00 TDKN	13	0	0.100	0.077	0.17

H = 52.28 with 3 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
NWH 97 TDKN vs NWH 00 TDKN	69.12	5.54	Yes
NWH 97 TDKN vs NWH 99 TDKN	54.00	6.11	Yes
NWH 97 TDKN vs NWH 98 TDKN	32.94	3.89	Yes
NWH 98 TDKN vs NWH 00 TDKN	36.17	2.87	Yes
NWH 98 TDKN vs NWH 99 TDKN	21.06	2.34	No
NWH 99 TDKN vs NWH 00 TDKN	15.12	1.18	No

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

Descriptive Statistics
Data source: NWH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
NWH 00 TN	8	0	0.24	0.055	0.020	0.046
NWH 01 TN	20	0	0.21	0.084	0.019	0.039
NWH 02 TN	18	0	0.20	0.089	0.021	0.044

Column	Range	Max	Min	Median	25%	75%
NWH 00 TN	0.18	0.32	0.14	0.23	0.22	0.28
NWH 01 TN	0.25	0.36	0.11	0.17	0.16	0.26
NWH 02 TN	0.32	0.40	0.080	0.19	0.13	0.28

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
NWH 00 TN	-0.16	0.62	0.19	0.513	1.90	0.47
NWH 01 TN	0.93	-0.53	0.25	0.002	4.19	1.01
NWH 02 TN	0.65	-0.35	0.14	0.386	3.63	0.87

One Way Analysis of Variance

Data source: NWH in 5-Year Water Quality Trend Analysis

Normality Test: Failed (P = 0.002)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks
Data source: NWH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
NWH 00 TN	8	0	0.23	0.22	0.28
NWH 01 TN	20	0	0.17	0.16	0.26
NWH 02 TN	18	0	0.19	0.13	0.28

H = 2.58 with 2 degrees of freedom. (P = 0.275)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.275)

Descriptive Statistics

Data source: NWH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
NWH 00 TDN	8	0	0.24	0.050	0.018	0.042
NWH 01 TDN	20	0	0.20	0.080	0.018	0.038
NWH 02 TDN	18	0	0.19	0.083	0.019	0.041

Column	Range	Max	Min	Median	25%	75%
NWH 00 TDN	0.15	0.31	0.16	0.23	0.21	0.29
NWH 01 TDN	0.25	0.36	0.11	0.17	0.14	0.24
NWH 02 TDN	0.29	0.37	0.080	0.16	0.12	0.27

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
NWH 00 TDN	-0.14	-0.57	0.17	0.603	1.94	0.49
NWH 01 TDN	1.12	-0.20	0.31	<0.001	4.03	0.94
NWH 02 TDN	0.66	-0.46	0.17	0.187	3.35	0.74

One Way Analysis of Variance

Data source: NWH in 5-Year Water Quality Trend Analysis

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

Data source: NWH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
NWH 00 TDN	8	0	0.23	0.21	0.29
NWH 01 TDN	20	0	0.17	0.14	0.24
NWH 02 TDN	18	0	0.16	0.12	0.27

H = 4.64 with 2 degrees of freedom. (P = 0.098)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.098)

Descriptive Statistics
Data source: NWH in 5-Year Eelgrass Shoot Density Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
NWH 1997	3	0	209.33	41.05	23.70	101.98
NWH 1998	12	0	310.67	72.67	20.98	46.17
NWH 1999	12	0	506.67	196.71	56.79	124.98
NWH 2000	60	0	329.83	166.03	21.43	42.89
NWH 2001	60	0	408.83	155.71	20.10	40.22
NWH 2002	60	0	349.83	146.15	18.87	37.76

Column	Range	Max	Min	Median	25%	75%
NWH 1997	80.00	244.00	164.00	220.00	178.00	238.00
NWH 1998	240.00	400.00	160.00	336.00	272.00	360.00
NWH 1999	704.00	864.00	160.00	520.00	368.00	616.00
NWH 2000	640.00	720.00	80.00	320.00	185.00	475.00
NWH 2001	700.00	820.00	120.00	400.00	280.00	520.00
NWH 2002	730.00	800.00	70.00	330.00	245.00	445.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
NWH 1997	-1.09	--	0.27	0.429	628.00	134832.00
NWH 1998	-1.01	0.18	0.22	0.128	3728.00	1216256.00
NWH 1999	-0.060	-0.024	0.15	0.613	6080.00	3506176.00
NWH 2000	0.38	-0.77	0.13	0.010	19790.00	8153700.00
NWH 2001	0.31	0.041	0.067	0.664	24530.00	11459100.00
NWH 2002	0.71	0.86	0.087	0.297	20990.00	8603300.00

One Way Analysis of Variance
Data source: NWH in 5-Year Eelgrass Shoot Density Analysis

Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 0.052)

Group Name	N	Missing	Mean	Std Dev	SEM
NWH 1998	12	0	310.67	72.67	20.98
NWH 1999	12	0	506.67	196.71	56.79
NWH 2000	60	0	329.83	166.03	21.43
NWH 2001	60	0	408.83	155.71	20.10
NWH 2002	60	0	349.83	146.15	18.87

Source of Variation	DF	SS	MS	F	P
Between Groups	4	477421.29	119355.32	4.95	<0.001
Residual	199	4800748.33	24124.36		
Total	203	5278169.63			

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

Power of performed test with alpha = 0.05: 0.909

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
NWH 1999 vs. NWH 1998	196.00	5	4.37	0.017	Yes
NWH 1999 vs. NWH 2000	176.83	5	5.09	0.003	Yes
NWH 1999 vs. NWH 2002	156.83	5	4.52	0.012	Yes
NWH 1999 vs. NWH 2001	97.83	5	2.82	0.270	No
NWH 2001 vs. NWH 1998	98.17	5	2.83	0.267	No
NWH 2001 vs. NWH 2000	79.00	5	3.94	0.043	No
NWH 2001 vs. NWH 2002	59.00	5	2.94	0.228	No

NWH 2002 vs. NWH 1998	39.17	5	1.13	0.931	No
NWH 2002 vs. NWH 2000	20.00	5	1.00	0.955	No
NWH 2000 vs. NWH 1998	19.17	5	0.55	0.995	No

Descriptive Statistics
Data source: NWH in 5-Year Macroalgae Percent Cover Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
NWH 2000	24	0	38.29	28.73	5.87	12.13
NWH 2001	60	0	30.92	23.91	3.09	6.18
NWH 2002	60	0	64.25	29.38	3.79	7.59

Column	Range	Max	Min	Median	25%	75%
NWH 2000	89.00	90.00	1.00	40.00	10.00	60.00
NWH 2001	100.00	100.00	0.00	30.00	10.00	37.50
NWH 2002	90.00	100.00	10.00	75.00	40.00	90.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
NWH 2000	0.23	-1.03	0.14	0.284	919.00	54179.00
NWH 2001	1.33	1.51	0.25	<0.001	1855.00	91075.00
NWH 2002	-0.44	-1.11	0.24	<0.001	3855.00	298625.00

One Way Analysis of Variance

Data source: NWH in 5-Year Macroalgae Percent Cover Analysis

Normality Test: Passed (P = 0.125)

Equal Variance Test: Passed (P = 0.062)

Group Name	N	Missing	Mean	Std Dev	SEM
NWH 2000	24	0	38.29	28.73	5.87
NWH 2001	60	0	30.92	23.91	3.09
NWH 2002	60	0	64.25	29.38	3.79

Source of Variation	DF	SS	MS	F	P
Between Groups	2	35060.03	17530.02	23.85	<0.001
Residual	141	103654.79	735.14		
Total		143	138714.83		

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

Power of performed test with alpha = 0.05: 1.000

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
NWH 2002 vs. NWH 2001	33.33	3	9.52	<0.001	Yes
NWH 2002 vs. NWH 2000	25.96	3	5.61	<0.001	Yes
NWH 2000 vs. NWH 2001	7.37	3	1.59	0.498	No

Appendix 12. Statistical reports from SigmaStat software (SPSS, 1999) for the Orient Harbor water quality parameters, eelgrass shoot density, and macroalgae percent cover.

Descriptive Statistics
Data source: OH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
OH 97 NOX	46	0	0.0054	0.0020	0.00030	0.00060
OH 98 NOx	70	0	0.0061	0.0045	0.00054	0.0011
OH 99 NOx	25	0	0.0069	0.0039	0.00077	0.0016
OH 00 NOx	21	0	0.012	0.012	0.0027	0.0055
OH 01 NOx	20	0	0.038	0.030	0.0068	0.014
OH 02 NOx	17	0	0.021	0.022	0.0053	0.011

Column	Range	Max	Min	Median	25%	75%
OH 97 NOx	0.013	0.018	0.0050	0.0050	0.0050	0.0050
OH 98 NOx	0.029	0.034	0.0050	0.0050	0.0050	0.0050
OH 99 NOx	0.013	0.018	0.0050	0.0050	0.0050	0.0073
OH 00 NOx	0.050	0.055	0.0050	0.0050	0.0050	0.014
OH 01 NOx	0.097	0.10	0.0050	0.029	0.013	0.057
OH 02 NOx	0.081	0.086	0.0050	0.011	0.0050	0.028

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
OH 97 NOx	5.87	36.39	0.52	<0.001	0.25	0.0015
OH 98 NOx	4.98	26.24	0.48	<0.001	0.43	0.0040
OH 99 NOx	2.26	4.32	0.41	<0.001	0.17	0.0015
OH 00 NOx	2.58	7.52	0.28	<0.001	0.26	0.0061
OH 01 NOx	0.81	-0.51	0.17	0.111	0.76	0.046
OH 02 NOx	1.97	4.03	0.27	0.002	0.35	0.015

One Way Analysis of Variance
Data source: OH in 5-Year Water Quality Trend Analysis

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
Data source: OH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
OH 97 NOX	46	0	0.0050	0.0050	0.0050
OH 98 NOx	70	0	0.0050	0.0050	0.0050
OH 99 NOx	25	0	0.0050	0.0050	0.0073
OH 00 NOx	21	0	0.0050	0.0050	0.014
OH 01 NOx	20	0	0.029	0.013	0.057
OH 02 NOx	17	0	0.011	0.0050	0.028

H = 86.55 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
OH 01 NOx vs OH 97 NOX	92.98	6.03	Yes
OH 01 NOx vs OH 98 NOx	88.38	6.05	Yes
OH 01 NOx vs OH 99 NOx	74.00	4.28	Yes
OH 01 NOx vs OH 00 NOx	51.55	2.87	No
OH 01 NOx vs OH 02 NOx	26.98	1.42	No
OH 02 NOx vs OH 97 NOX	66.01	4.04	Yes
OH 02 NOx vs OH 98 NOx	61.40	3.94	Yes
OH 02 NOx vs OH 99 NOx	47.03	2.60	No
OH 02 NOx vs OH 00 NOx	24.58	1.31	No
OH 00 NOx vs OH 97 NOX	41.43	2.73	No
OH 00 NOx vs OH 98 NOx	36.83	2.57	No
OH 00 NOx vs OH 99 NOx	22.45	1.32	No
OH 99 NOx vs OH 97 NOX	18.98	1.33	No
OH 99 NOx vs OH 98 NOx	14.38	1.07	No
OH 98 NOx vs OH 97 NOX	4.60	0.42	No

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

Descriptive Statistics
Data source: OH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
OH 97 TKN	46	2	0.46	0.16	0.023	0.047
OH 98 TKN	69	27	0.31	0.14	0.021	0.043
OH 99 TKN	25	0	0.19	0.067	0.013	0.028
OH 00 TKN	13	0	0.15	0.094	0.026	0.057

Column	Range	Max	Min	Median	25%	75%
OH 97 TKN	0.75	0.90	0.15	0.44	0.36	0.51
OH 98 TKN	0.54	0.56	0.025	0.29	0.21	0.41
OH 99 TKN	0.27	0.33	0.060	0.19	0.14	0.24
OH 00 TKN	0.34	0.37	0.030	0.13	0.098	0.20

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
OH 97 TKN	0.71	0.86	0.16	0.007	20.05	10.18
OH 98 TKN	0.17	-0.70	0.075	0.733	12.92	4.75
OH 99 TKN	0.0030	-0.33	0.11	0.536	4.79	1.03
OH 00 TKN	0.91	1.19	0.13	0.676	1.98	0.41

One Way Analysis of Variance
Data source: OH in 5-Year Water Quality Trend Analysis

Normality Test: Failed (P = 0.002)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks
Data source: OH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
OH 97 TKN	46	2	0.44	0.36	0.51
OH 98 TKN	69	27	0.29	0.21	0.41
OH 99 TKN	25	0	0.19	0.14	0.24
OH 00 TKN	13	0	0.13	0.098	0.20

H = 57.97 with 3 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
OH 97 TKN vs OH 00 TKN	66.15	5.83	Yes
OH 97 TKN vs OH 99 TKN	57.25	6.36	Yes
OH 97 TKN vs OH 98 TKN	28.79	3.71	Yes
OH 98 TKN vs OH 00 TKN	37.36	3.28	Yes
OH 98 TKN vs OH 99 TKN	28.46	3.13	Yes
OH 99 TKN vs OH 00 TKN	8.90	0.72	No

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

Descriptive Statistics
Data source: OH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
OH 97 TDKN	46	2	0.40	0.14	0.021	0.043
OH 98 TDKN	70	0	0.26	0.14	0.017	0.034
OH 99 TDKN	25	0	0.16	0.068	0.014	0.028
OH 00 TDKN	13	0	0.100	0.079	0.022	0.048

Column	Range	Max	Min	Median	25%	75%
OH 97 TDKN	0.76	0.81	0.050	0.38	0.32	0.48
OH 98 TDKN	0.53	0.55	0.025	0.23	0.16	0.40
OH 99 TDKN	0.28	0.31	0.030	0.15	0.100	0.20
OH 00 TDKN	0.20	0.23	0.030	0.100	0.030	0.16

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
OH 97 TDKN	0.42	1.07	0.096	0.376	17.51	7.82
OH 98 TDKN	0.28	-0.88	0.091	0.152	18.40	6.28
OH 99 TDKN	0.17	-0.34	0.12	0.412	3.94	0.73
OH 00 TDKN	0.65	-1.14	0.27	0.009	1.30	0.20

One Way Analysis of Variance
Data source: OH in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P = 0.089)

Equal Variance Test: Failed (P = 0.006)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: OH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
OH 97 TDKN	46	2	0.38	0.32	0.48
OH 98 TDKN	70	0	0.23	0.16	0.40
OH 99 TDKN	25	0	0.15	0.100	0.20
OH 00 TDKN	13	0	0.100	0.030	0.16

H = 57.25 with 3 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
OH 97 TDKN vs OH 00 TDKN	83.43	6.00	Yes
OH 97 TDKN vs OH 99 TDKN	67.50	6.12	Yes
OH 97 TDKN vs OH 98 TDKN	36.00	4.25	Yes
OH 98 TDKN vs OH 00 TDKN	47.43	3.57	Yes
OH 98 TDKN vs OH 99 TDKN	31.49	3.07	Yes
OH 99 TDKN vs OH 00 TDKN	15.94	1.06	No

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

Descriptive Statistics
Data source: OH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
OH 00 TN	8	0	0.25	0.062	0.022	0.052
OH 01 TN	20	0	0.21	0.085	0.019	0.040
OH 02 TN	17	0	0.19	0.090	0.022	0.046

Column	Range	Max	Min	Median	25%	75%
OH 00 TN	0.18	0.33	0.15	0.26	0.21	0.31
OH 01 TN	0.26	0.37	0.11	0.19	0.14	0.27
OH 02 TN	0.31	0.39	0.080	0.19	0.12	0.25

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
OH 00 TN	-0.27	-0.55	0.14	0.757	2.03	0.54
OH 01 TN	0.85	-0.62	0.16	0.178	4.24	1.03

OH 02 TN	0.67	-0.25	0.18	0.176	3.31	0.77

One Way Analysis of Variance
Data source: OH in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P = 0.175)

Equal Variance Test: Passed (P = 0.448)

Group Name	N	Missing	Mean	Std Dev	SEM
OH 00 TN	8	0	0.25	0.062	0.022
OH 01 TN	20	0	0.21	0.085	0.019
OH 02 TN	17	0	0.19	0.090	0.022

Source of Variation	DF	SS	MS	F	P
Between Groups	2	0.019	0.0093	1.33	0.275
Residual	42	0.29	0.0070		
Total		44	0.31		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.275).

Power of performed test with alpha = 0.05: 0.096

The power of the performed test (0.096) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

Descriptive Statistics

Data source: OH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
OH 00 TDN	8	0	0.25	0.059	0.021	0.050
OH 01 TDN	20	0	0.20	0.079	0.018	0.037
OH 02 TDN	17	0	0.19	0.082	0.020	0.042

Column	Range	Max	Min	Median	25%	75%
OH 00 TDN	0.16	0.33	0.17	0.24	0.21	0.30
OH 01 TDN	0.24	0.35	0.11	0.17	0.14	0.26
OH 02 TDN	0.29	0.38	0.090	0.17	0.11	0.24

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
OH 00 TDN	0.29	-0.78	0.18	0.561	1.98	0.52
OH 01 TDN	0.87	-0.70	0.19	0.070	3.94	0.89
OH 02 TDN	0.87	0.25	0.16	0.266	3.15	0.69

One Way Analysis of Variance
Data source: OH in 5-Year Water Quality Trend Analysis

Normality Test: Failed (P = 0.006)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks
Data source: OH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
OH 00 TDN	8	0	0.24	0.21	0.30
OH 01 TDN	20	0	0.17	0.14	0.26
OH 02 TDN	17	0	0.17	0.11	0.24

H = 4.78 with 2 degrees of freedom. (P = 0.091)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.091)

Descriptive Statistics
Data source: OH in 5-Year Eelgrass Shoot Density Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
OH 1997	3	0	573.33	118.28	68.29	293.82
OH 1998	10	0	696.00	260.00	82.22	185.99
OH 1999	12	0	586.67	171.29	49.45	108.83
OH 2000	60	0	487.83	200.57	25.89	51.81
OH 2001	60	0	451.50	127.24	16.43	32.87
OH 2002	60	0	229.50	103.77	13.40	26.81

Column	Range	Max	Min	Median	25%	75%
OH 1997	236.00	696.00	460.00	564.00	486.00	663.00
OH 1998	880.00	1088.00	208.00	712.00	576.00	832.00
OH 1999	496.00	832.00	336.00	600.00	456.00	720.00

OH 2000	950.00	990.00	40.00	460.00	350.00	610.00
OH 2001	720.00	780.00	60.00	460.00	360.00	540.00
OH 2002	430.00	440.00	10.00	235.00	150.00	305.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
OH 1997	0.35	--	0.20	0.633	1720.00	1014112.00
OH 1998	-0.52	0.22	0.16	0.560	6960.00	5452544.00
OH 1999	-0.12	-1.26	0.16	0.514	7040.00	4452864.00
OH 2000	0.34	-0.074	0.089	0.278	29270.00	16652300.00
OH 2001	-0.100	0.72	0.064	0.708	27090.00	13186300.00
OH 2002	-0.065	-0.75	0.100	0.139	13770.00	3795500.00

One Way Analysis of Variance
Data source: OH in 5-Year Eelgrass Shoot Density Analysis

Normality Test: Passed (P = 0.159)

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

Data source: OH in 5-Year Eelgrass Shoot Density Analysis

Group	N	Missing	Median	25%	75%
OH 1998	10	0	712.00	576.00	832.00
OH 1999	12	0	600.00	456.00	720.00
OH 2000	60	0	460.00	350.00	610.00
OH 2001	60	0	460.00	360.00	540.00
OH 2002	60	0	235.00	150.00	305.00

H = 91.64 with 4 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

OH 1998 vs OH 2002	119.52	5.99	Yes
OH 1998 vs OH 2001	44.43	2.23	No
OH 1998 vs OH 2000	40.49	2.03	No
OH 1998 vs OH 1999	12.16	0.49	No
OH 1999 vs OH 2002	107.37	5.81	Yes
OH 1999 vs OH 2001	32.27	1.75	No
OH 1999 vs OH 2000	28.33	1.53	No
OH 2000 vs OH 2002	79.03	7.41	Yes
OH 2000 vs OH 2001	3.94	0.37	No
OH 2001 vs OH 2002	75.09	7.04	Yes

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

Descriptive Statistics
Data source: OH in 5-Year Macroalgae Percent Cover Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
OH 2000	24	0	7.13	11.95	2.44	5.04
OH 2001	60	0	37.08	23.80	3.07	6.15
OH 2002	60	0	12.70	16.46	2.12	4.25

Column	Range	Max	Min	Median	25%	75%
OH 2000	50.00	50.00	0.00	3.00	0.00	7.50
OH 2001	95.00	100.00	5.00	30.00	20.00	50.00
OH 2002	90.00	90.00	0.00	7.50	5.00	10.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
OH 2000	2.45	6.66	0.32	<0.001	171.00	4501.00
OH 2001	0.82	0.098	0.15	0.002	2225.00	115925.00
OH 2002	2.61	8.12	0.35	<0.001	762.00	25662.00

One Way Analysis of Variance
Data source: OH in 5-Year Macroalgae Percent Cover Analysis

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
Data source: OH in 5-Year Macroalgae Percent Cover Analysis

Group	N	Missing	Median	25%	75%
OH 2000	24	0	3.00	0.00	7.50

OH 2001	60	0	30.00	20.00	50.00
OH 2002	60	0	7.50	5.00	10.00

H = 61.16 with 2 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
OH 2001 vs OH 2000	67.90	6.74	Yes
OH 2001 vs OH 2002	46.50	6.11	Yes
OH 2002 vs OH 2000	21.40	2.12	No

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

Appendix 13. Statistical reports from SigmaStat software (SPSS, 1999) for the Southold Bay water quality parameters, eelgrass shoot density, and macroalgae percent cover.

Descriptive Statistics
Data source: SB in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SB 97 NOx	24	0	0.0059	0.0028	0.00056	0.0012
SB 98 NOx	15	0	0.0047	0.0010	0.00027	0.00057
SB 99 NOx	15	0	0.0094	0.0069	0.0018	0.0038
SB 00 NOx	11	0	0.019	0.021	0.0063	0.014
SB 01 NOx	13	0	0.024	0.023	0.0064	0.014
SB 02 NOx	11	0	0.023	0.016	0.0050	0.011

Column	Range	Max	Min	Median	25%	75%
SB 97 NOx	0.012	0.017	0.0050	0.0050	0.0050	0.0050
SB 98 NOx	0.0040	0.0050	0.00100	0.0050	0.0050	0.0050
SB 99 NOx	0.020	0.025	0.0050	0.0050	0.0050	0.015
SB 00 NOx	0.051	0.056	0.0050	0.0080	0.0050	0.037
SB 01 NOx	0.058	0.063	0.0050	0.0090	0.0065	0.049
SB 02 NOx	0.054	0.062	0.0080	0.020	0.0100	0.033

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
SB 97 NOx	3.38	11.89	0.50	<0.001	0.14	0.0010
SB 98 NOx	-3.87	15.00	0.54	<0.001	0.071	0.00035
SB 99 NOx	1.24	0.19	0.41	<0.001	0.14	0.0020
SB 00 NOx	1.19	-0.51	0.33	0.001	0.21	0.0082
SB 01 NOx	0.77	-1.36	0.34	<0.001	0.31	0.014
SB 02 NOx	1.39	2.11	0.18	0.399	0.26	0.0086

One Way Analysis of Variance
Data source: SB in 5-Year Water Quality Trend Analysis

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
Data source: SB in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
SB 97 NOx	24	0	0.0050	0.0050	0.0050
SB 98 NOx	15	0	0.0050	0.0050	0.0050
SB 99 NOx	15	0	0.0050	0.0050	0.015

SB 00 NOx	11	0	0.0080	0.0050	0.037
SB 01 NOx	13	0	0.0090	0.0065	0.049
SB 02 NOx	11	0	0.020	0.0100	0.033

H = 40.73 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
SB 02 NOx vs SB 98 NOx	46.16	4.50	Yes
SB 02 NOx vs SB 97 NOx	39.45	4.19	Yes
SB 02 NOx vs SB 99 NOx	29.53	2.88	No
SB 02 NOx vs SB 00 NOx	19.64	1.78	No
SB 02 NOx vs SB 01 NOx	10.56	1.00	No
SB 01 NOx vs SB 98 NOx	35.61	3.64	Yes
SB 01 NOx vs SB 97 NOx	28.89	3.25	Yes
SB 01 NOx vs SB 99 NOx	18.97	1.94	No
SB 01 NOx vs SB 00 NOx	9.08	0.86	No
SB 00 NOx vs SB 98 NOx	26.53	2.59	No
SB 00 NOx vs SB 97 NOx	19.81	2.11	No
SB 00 NOx vs SB 99 NOx	9.89	0.96	No
SB 99 NOx vs SB 98 NOx	16.63	1.76	No
SB 99 NOx vs SB 97 NOx	9.92	1.17	No
SB 97 NOx vs SB 98 NOx	6.72	0.79	No

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

Descriptive Statistics
Data source: SB in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SB 97 TKN	24	2	0.45	0.11	0.024	0.049
SB 98 TKN	15	0	0.35	0.17	0.044	0.095
SB 99 TKN	15	0	0.25	0.094	0.024	0.052
SB 00 TKN	6	0	0.21	0.067	0.027	0.070

Column	Range	Max	Min	Median	25%	75%
SB 97 TKN	0.40	0.68	0.28	0.44	0.36	0.48

SB 98 TKN	0.65	0.70	0.050	0.36	0.21	0.44
SB 99 TKN	0.39	0.44	0.050	0.26	0.18	0.30
SB 00 TKN	0.20	0.33	0.13	0.20	0.18	0.22

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
SB 97 TKN	0.57	-0.19	0.18	0.074	9.81	4.63
SB 98 TKN	0.037	0.046	0.11	0.778	5.20	2.21
SB 99 TKN	-0.11	0.78	0.12	0.710	3.70	1.04
SB 00 TKN	1.20	2.60	0.27	0.172	1.26	0.29

One Way Analysis of Variance
Data source: SB in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P = 0.185)

Equal Variance Test: Passed (P = 0.042)

Group Name	N	Missing	Mean	Std Dev	SEM
SB 97 TKN	24	2	0.45	0.11	0.024
SB 98 TKN	15	0	0.35	0.17	0.044
SB 99 TKN	15	0	0.25	0.094	0.024
SB 00 TKN	6	0	0.21	0.067	0.027

Source of Variation	DF	SS	MS	F	P
Between Groups	3	0.48	0.16	10.56	<0.001
Residual	54	0.81	0.015		
Total		57	1.29		

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

Power of performed test with alpha = 0.05: 0.998

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
SB 97 TKN vs. SB 00 TKN	0.24	4	5.90	<0.001	Yes
SB 97 TKN vs. SB 99 TKN	0.20	4	6.85	<0.001	Yes
SB 97 TKN vs. SB 98 TKN	0.099	4	3.41	0.087	No
SB 98 TKN vs. SB 00 TKN	0.14	4	3.26	0.110	No
SB 98 TKN vs. SB 99 TKN	0.10	4	3.15	0.128	No
SB 99 TKN vs. SB 00 TKN	0.037	4	0.87	0.926	No

Descriptive Statistics

Data source: SB in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SB 97 TDKN	24	2	0.41	0.14	0.030	0.062
SB 98 TDKN	15	0	0.32	0.16	0.041	0.088
SB 99 TDKN	15	0	0.19	0.088	0.023	0.049
SB 00 TDKN	6	0	0.16	0.070	0.029	0.074

Column	Range	Max	Min	Median	25%	75%
SB 97 TDKN	0.52	0.72	0.20	0.38	0.32	0.48
SB 98 TDKN	0.47	0.52	0.050	0.37	0.21	0.46
SB 99 TDKN	0.25	0.31	0.060	0.18	0.12	0.27
SB 00 TDKN	0.21	0.27	0.060	0.16	0.13	0.19

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
SB 97 TDKN	0.71	-0.19	0.17	0.116	9.03	4.12
SB 98 TDKN	-0.39	-1.08	0.17	0.316	4.75	1.86
SB 99 TDKN	-0.20	-1.43	0.19	0.146	2.83	0.64
SB 00 TDKN	0.18	0.83	0.18	0.660	0.97	0.18

One Way Analysis of Variance

Data source: SB in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 0.069)

Group Name	N	Missing	Mean	Std Dev	SEM
SB 97 TDKN	24	2	0.41	0.14	0.030
SB 98 TDKN	15	0	0.32	0.16	0.041
SB 99 TDKN	15	0	0.19	0.088	0.023
SB 00 TDKN	6	0	0.16	0.070	0.029

Source of Variation	DF	SS	MS	F	P
Between Groups	3	0.57	0.19	11.48	<0.001
Residual	54	0.90	0.017		
Total		57	1.47		

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

Power of performed test with alpha = 0.05: 0.999

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
SB 97 TDKN vs. SB 00 TDKN	0.25	4	5.92	<0.001	Yes
SB 97 TDKN vs. SB 99 TDKN	0.22	4	7.26	<0.001	Yes
SB 97 TDKN vs. SB 98 TDKN	0.094	4	3.06	0.146	No
SB 98 TDKN vs. SB 00 TDKN	0.16	4	3.52	0.073	No
SB 98 TDKN vs. SB 99 TDKN	0.13	4	3.85	0.042	No
SB 99 TDKN vs. SB 00 TDKN	0.027	4	0.61	0.972	No

Descriptive Statistics

Data source: SB in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SB 00 TN	5	0	0.25	0.053	0.024	0.065
SB 01 TN	13	0	0.22	0.086	0.024	0.052
SB 02 TN	11	0	0.19	0.086	0.026	0.058

Column	Range	Max	Min	Median	25%	75%
SB 00 TN	0.14	0.34	0.20	0.24	0.22	0.28
SB 01 TN	0.27	0.39	0.12	0.18	0.16	0.26
SB 02 TN	0.24	0.35	0.11	0.16	0.12	0.23

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
SB 00 TN	1.31	2.28	0.25	0.327	1.27	0.33
SB 01 TN	1.08	0.017	0.28	0.007	2.81	0.70
SB 02 TN	1.24	0.30	0.26	0.035	2.06	0.46

One Way Analysis of Variance

Data source: SB in 5-Year Water Quality Trend Analysis

Normality Test: Failed (P = 0.004)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks
Data source: SB in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
SB 00 TN	5	0	0.24	0.22	0.28
SB 01 TN	13	0	0.18	0.16	0.26
SB 02 TN	11	0	0.16	0.12	0.23

H = 4.28 with 2 degrees of freedom. (P = 0.118)

The differences in the median values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.118)

Descriptive Statistics

Data source: SB in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SB 00 TDN	5	0	0.25	0.031	0.014	0.038
SB 01 TDN	13	0	0.20	0.081	0.022	0.049
SB 02 TDN	11	0	0.19	0.088	0.026	0.059

Column	Range	Max	Min	Median	25%	75%
SB 00 TDN	0.080	0.29	0.21	0.26	0.23	0.27
SB 01 TDN	0.24	0.35	0.11	0.18	0.13	0.24
SB 02 TDN	0.26	0.35	0.090	0.16	0.13	0.22

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
SB 00 TDN	-0.085	-0.66	0.23	0.464	1.25	0.32
SB 01 TDN	0.81	-0.56	0.18	0.321	2.61	0.60
SB 02 TDN	1.13	0.26	0.21	0.187	2.05	0.46

One Way Analysis of Variance

Data source: SB in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P = 0.153)

Equal Variance Test: Passed (P = 0.652)

Group Name	N	Missing	Mean	Std Dev	SEM
SB 00 TDN	5	0	0.25	0.031	0.014
SB 01 TDN	13	0	0.20	0.081	0.022
SB 02 TDN	11	0	0.19	0.088	0.026

Source of Variation	DF	SS	MS	F	P
Between Groups	2	0.014	0.0071	1.16	0.330
Residual	26	0.16	0.0061		
Total		28	0.17		

The differences in the mean values among the treatment groups are not great enough to exclude the possibility that the difference is due to random sampling variability; there is not a statistically significant difference (P = 0.330).

Power of performed test with alpha = 0.05: 0.070

The power of the performed test (0.070) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

Descriptive Statistics

Data source: SB in 5-Year Eelgrass Shoot Density Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SB 1999	12	0	805.33	237.65	68.60	150.99
SB 2000	60	0	471.17	238.09	30.74	61.50
SB 2001	60	0	466.83	247.46	31.95	63.93
SB 2002	60	0	384.33	120.71	15.58	31.18

Column	Range	Max	Min	Median	25%	75%
SB 1999	864.00	1392.00	528.00	768.00	632.00	864.00
SB 2000	930.00	1070.00	140.00	420.00	300.00	540.00
SB 2001	950.00	970.00	20.00	405.00	285.00	685.00
SB 2002	470.00	660.00	190.00	370.00	285.00	455.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
SB 1999	1.46	2.54	0.24	0.064	9664.00	8403968.00
SB 2000	0.99	0.36	0.15	0.001	28270.00	16664300.00
SB 2001	0.27	-0.85	0.12	0.027	28010.00	16688900.00
SB 2002	0.49	-0.53	0.083	0.372	23060.00	9722400.00

One Way Analysis of Variance
Data source: SB in 5-Year Eelgrass Shoot Density Analysis

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

Data source: SB in 5-Year Eelgrass Shoot Density Analysis

Group	N	Missing	Median	25%	75%
SB 1999	12	0	768.00	632.00	864.00
SB 2000	60	0	420.00	300.00	540.00
SB 2001	60	0	405.00	285.00	685.00
SB 2002	60	0	370.00	285.00	455.00

H = 24.09 with 3 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
SB 1999 vs SB 2002	85.96	4.89	Yes
SB 1999 vs SB 2001	68.37	3.89	Yes
SB 1999 vs SB 2000	68.34	3.89	Yes
SB 2000 vs SB 2002	17.62	1.74	No
SB 2000 vs SB 2001	0.025	0.0025	No
SB 2001 vs SB 2002	17.59	1.73	No

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

Descriptive Statistics

Data source: SB in 5-Year Macroalgae Percent Cover Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
SB 2000	24	0	1.67	4.82	0.98	2.03
SB 2001	60	0	63.67	32.15	4.15	8.31
SB 2002	60	0	32.62	36.23	4.68	9.36

Column	Range	Max	Min	Median	25%	75%
SB 2000	20.00	20.00	0.00	0.00	0.00	0.00
SB 2001	90.00	100.00	10.00	60.00	30.00	100.00
SB 2002	100.00	100.00	0.00	10.00	0.00	50.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
SB 2000	3.07	9.46	0.51	<0.001	40.00	600.00
SB 2001	-0.18	-1.45	0.20	<0.001	3820.00	304200.00
SB 2002	0.72	-0.88	0.25	<0.001	1957.00	141257.00

No
Data source: SB in 5-Year Macroalgae Percent Cover Analysis

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
Data source: SB in 5-Year Macroalgae Percent Cover Analysis

Group	N	Missing	Median	25%	75%
SB 2000	24	0	0.00	0.00	0.00
SB 2001	60	0	60.00	30.00	100.00
SB 2002	60	0	10.00	0.00	50.00

H = 59.25 with 2 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
SB 2001 vs SB 2000	73.24	7.27	Yes
SB 2001 vs SB 2002	35.28	4.63	Yes
SB 2002 vs SB 2000	37.96	3.77	Yes

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

Appendix 14. Statistical reports from SigmaStat software (SPSS, 1999) for the Three Mile Harbor water quality parameters, eelgrass shoot density, and macroalgae percent cover.

Descriptive Statistics
Data source: TMH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
TMH 97 NOx	18	0	0.0057	0.0021	0.00050	0.0010
TMH 98 NOx	13	0	0.0072	0.0059	0.0016	0.0036
TMH 99 NOx	16	0	0.0081	0.0064	0.0016	0.0034
TMH 00 NOx	18	0	0.021	0.030	0.0071	0.015
TMH 01 NOx	16	0	0.052	0.041	0.010	0.022

Column	Range	Max	Min	Median	25%	75%
TMH 97 NOx	0.0070	0.012	0.0050	0.0050	0.0050	0.0050
TMH 98 NOx	0.020	0.025	0.0050	0.0050	0.0050	0.0050
TMH 99 NOx	0.022	0.027	0.0050	0.0050	0.0050	0.0075
TMH 00 NOx	0.12	0.13	0.0050	0.0060	0.0050	0.032
TMH 01 NOx	0.14	0.15	0.0050	0.043	0.018	0.075

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
TMH 97 NOx	2.74	6.28	0.52	<0.001	0.10	0.00067
TMH 98 NOx	2.79	7.77	0.49	<0.001	0.094	0.0011
TMH 99 NOx	2.34	5.08	0.37	<0.001	0.13	0.0016
TMH 00 NOx	2.73	8.64	0.31	<0.001	0.38	0.024
TMH 01 NOx	1.00	0.69	0.15	0.437	0.83	0.068

One Way Analysis of Variance

Data source: TMH in 5-Year Water Quality Trend Analysis

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
Data source: TMH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
TMH 97 NOx	18	0	0.0050	0.0050	0.0050
TMH 98 NOx	13	0	0.0050	0.0050	0.0050
TMH 99 NOx	16	0	0.0050	0.0050	0.0075
TMH 00 NOx	18	0	0.0060	0.0050	0.032

TMH 01 NOx	16	0	0.043	0.018	0.075

H = 33.95 with 4 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
TMH 01 NOx vs TMH 97 NOx	37.05	4.58	Yes
TMH 01 NOx vs TMH 98 NOx	34.94	3.98	Yes
TMH 01 NOx vs TMH 99 NOx	30.25	3.64	Yes
TMH 01 NOx vs TMH 00 NOx	20.80	2.57	No
TMH 00 NOx vs TMH 97 NOx	16.25	2.07	No
TMH 00 NOx vs TMH 98 NOx	14.14	1.65	No
TMH 00 NOx vs TMH 99 NOx	9.45	1.17	No
TMH 99 NOx vs TMH 97 NOx	6.80	0.84	No
TMH 99 NOx vs TMH 98 NOx	4.69	0.53	No
TMH 98 NOx vs TMH 97 NOx	2.11	0.25	No

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

Descriptive Statistics

Data source: TMH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
TMH 97 TKN	18	2	0.49	0.19	0.047	0.10
TMH 98 TKN	13	0	0.27	0.12	0.034	0.075
TMH 99 TKN	16	0	0.20	0.070	0.017	0.037
TMH 00 TKN	9	0	0.20	0.12	0.038	0.088

Column	Range	Max	Min	Median	25%	75%
TMH 97 TKN	0.65	0.80	0.15	0.49	0.38	0.60
TMH 98 TKN	0.49	0.64	0.15	0.24	0.21	0.29
TMH 99 TKN	0.24	0.33	0.090	0.20	0.15	0.25
TMH 00 TKN	0.34	0.39	0.050	0.20	0.098	0.28

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
TMH 97 TKN	-0.057	-0.62	0.11	0.782	7.82	4.36
TMH 98 TKN	2.42	7.30	0.24	0.047	3.50	1.13

TMH 99 TKN	0.30	-0.53	0.10	0.802	3.16	0.70
TMH 00 TKN	0.31	-0.79	0.10	0.812	1.76	0.45

One Way Analysis of Variance

Data source: TMH in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P = 0.124)

Equal Variance Test: Passed (P = 0.029)

Group Name	N	Missing	Mean	Std Dev	SEM
TMH 97 TKN	18	2	0.49	0.19	0.047
TMH 98 TKN	13	0	0.27	0.12	0.034
TMH 99 TKN	16	0	0.20	0.070	0.017
TMH 00 TKN	9	0	0.20	0.12	0.038

Source of Variation	DF	SS	MS	F	P
Between Groups	3	0.85	0.28	15.76	<0.001
Residual	50	0.90	0.018		
Total		53	1.75		

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

Power of performed test with alpha = 0.05: 1.000

All Pairwise Multiple Comparison Procedures (Tukey Test):

Comparisons for factor:

Comparison	Diff of Means	p	q	P	P<0.050
TMH 97 TKN vs. TMH 00 TKN	0.29	4	7.43	<0.001	Yes
TMH 97 TKN vs. TMH 99 TKN	0.29	4	8.70	<0.001	Yes
TMH 97 TKN vs. TMH 98 TKN	0.22	4	6.21	<0.001	Yes
TMH 98 TKN vs. TMH 00 TKN	0.074	4	1.79	0.588	No
TMH 98 TKN vs. TMH 99 TKN	0.072	4	2.03	0.485	No
TMH 99 TKN vs. TMH 00 TKN	0.0019	4	0.049	1.000	No

Descriptive Statistics

Data source: TMH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
TMH 97 TDKN	18	2	0.41	0.19	0.047	0.099
TMH 98 TDKN	13	0	0.23	0.098	0.027	0.059
TMH 99 TDKN	16	0	0.16	0.061	0.015	0.033
TMH 00 TDKN	9	0	0.12	0.080	0.027	0.061

Column	Range	Max	Min	Median	25%	75%
TMH 97 TDKN	0.68	0.73	0.050	0.39	0.30	0.55
TMH 98 TDKN	0.36	0.43	0.070	0.24	0.15	0.27
TMH 99 TDKN	0.22	0.28	0.060	0.16	0.13	0.20
TMH 00 TDKN	0.23	0.28	0.050	0.11	0.050	0.17

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
TMH 97 TDKN	0.051	-0.42	0.10	0.811	6.55	3.20
TMH 98 TDKN	0.39	0.23	0.15	0.570	2.97	0.79
TMH 99 TDKN	-0.062	-0.40	0.12	0.655	2.57	0.47
TMH 00 TDKN	1.08	0.48	0.18	0.471	1.10	0.19

One Way Analysis of Variance

Data source: TMH in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P = 0.037)

Equal Variance Test: Failed (P = 0.005)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks

Data source: TMH in 5-Year Water Quality Trend Analysis

Group	N	Missing	Median	25%	75%
TMH 97 TDKN	18	2	0.39	0.30	0.55
TMH 98 TDKN	13	0	0.24	0.15	0.27
TMH 99 TDKN	16	0	0.16	0.13	0.20
TMH 00 TDKN	9	0	0.11	0.050	0.17

H = 23.78 with 3 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
TMH 97 TDKN vs TMH 00 TDKN	27.91	4.26	Yes
TMH 97 TDKN vs TMH 99 TDKN	21.81	3.92	Yes
TMH 97 TDKN vs TMH 98 TDKN	12.76	2.17	No
TMH 98 TDKN vs TMH 00 TDKN	15.15	2.22	No
TMH 98 TDKN vs TMH 99 TDKN	9.05	1.54	No
TMH 99 TDKN vs TMH 00 TDKN	6.10	0.93	No

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

Descriptive Statistics
Data source: TMH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
TMH 00 TN	9	0	0.28	0.048	0.016	0.037
TMH 01 TN	16	0	0.22	0.085	0.021	0.045

Column	Range	Max	Min	Median	25%	75%
TMH 00 TN	0.14	0.32	0.18	0.29	0.26	0.32
TMH 01 TN	0.27	0.39	0.12	0.19	0.17	0.26

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
TMH 00 TN	-1.32	1.24	0.20	0.338	2.52	0.72
TMH 01 TN	1.08	-0.14	0.25	0.010	3.51	0.88

t-test

Data source: TMH in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P > 0.200)

Equal Variance Test: Passed (P = 0.432)

Group Name	N	Missing	Mean	Std Dev	SEM
TMH 00 TN	9	0	0.28	0.048	0.016
TMH 01 TN	16	0	0.22	0.085	0.021

Difference 0.061

t = 1.96 with 23 degrees of freedom. (P = 0.062)

95 percent confidence interval for difference of means: -0.0033 to 0.12

The difference in the mean values of the two groups is not great enough to reject the possibility that the difference is due to random sampling variability. There is not a statistically significant difference between the i nput groups (P = 0.062).

Power of performed test with alpha = 0.05: 0.352

The power of the performed test (0.352) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

Descriptive Statistics
Data source: TMH in 5-Year Water Quality Trend Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
TMH 00 TDN	9	0	0.28	0.046	0.015	0.036
TMH 01 TDN	16	0	0.20	0.081	0.020	0.043

Column	Range	Max	Min	Median	25%	75%
TMH 00 TDN	0.15	0.33	0.18	0.27	0.26	0.32
TMH 01 TDN	0.24	0.37	0.13	0.17	0.16	0.21

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
TMH 00 TDN	-1.14	1.81	0.23	0.182	2.51	0.72
TMH 01 TDN	1.52	0.81	0.30	<0.001	3.25	0.76

t-test

Data source: TMH in 5-Year Water Quality Trend Analysis

Normality Test: Passed (P = 0.020)

Equal Variance Test: Passed (P = 0.819)

Group Name	N	Missing	Mean	Std Dev	SEM
TMH 00 TDN	9	0	0.28	0.046	0.015
TMH 01 TDN	16	0	0.20	0.081	0.020

Difference 0.076

t = 2.58 with 23 degrees of freedom. (P = 0.017)

95 percent confidence interval for difference of means: 0.015 to 0.14

The difference in the mean values of the two groups is greater than would be expected by chance; there is a statistically significant difference between the input groups (P = 0.017).

Power of performed test with alpha = 0.05: 0.623

The power of the performed test (0.623) is below the desired power of 0.800.
You should interpret the negative findings cautiously.

Descriptive Statistics
Data source: TMH in 5-Year Eelgrass Shoot Density Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
TMH 1999	12	0	361.33	169.12	48.82	107.45
TMH 2000	60	0	192.83	129.80	16.76	33.53
TMH 2001	60	0	208.83	99.12	12.80	25.60
TMH 2002	60	0	135.38	74.00	9.55	19.12

Column	Range	Max	Min	Median	25%	75%
TMH 1999	480.00	576.00	96.00	376.00	208.00	504.00
TMH 2000	560.00	600.00	40.00	165.00	100.00	255.00
TMH 2001	450.00	470.00	20.00	205.00	140.00	265.00
TMH 2002	260.00	260.00	0.00	150.00	110.00	190.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
TMH 1999	-0.29	-1.23	0.14	0.616	4336.00	1881344.00
TMH 2000	1.31	1.44	0.16	<0.001	11570.00	3225100.00
TMH 2001	0.29	-0.13	0.069	0.635	12530.00	3196300.00
TMH 2002	-0.66	-0.36	0.15	0.001	8123.00	1422809.00

One Way Analysis of Variance
Data source: TMH in 5-Year Eelgrass Shoot Density Analysis

Normality Test: Passed (P = 0.034)

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

Data source: TMH in 5-Year Eelgrass Shoot Density Analysis

Group	N	Missing	Median	25%	75%
TMH 1999	12	0	376.00	208.00	504.00
TMH 2000	60	0	165.00	100.00	255.00
TMH 2001	60	0	205.00	140.00	265.00
TMH 2002	60	0	150.00	110.00	190.00

H = 24.95 with 3 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
TMH 1999 vs TMH 2002	75.70	4.31	Yes
TMH 1999 vs TMH 2000	57.63	3.28	Yes
TMH 1999 vs TMH 2001	39.33	2.24	No
TMH 2001 vs TMH 2002	36.37	3.58	Yes
TMH 2001 vs TMH 2000	18.30	1.80	No
TMH 2000 vs TMH 2002	18.07	1.78	No

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

Descriptive Statistics

Data source: TMH in 5-Year Macroalgae Percent Cover Analysis

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
TMH 2000	24	0	47.08	42.37	8.65	17.89
TMH 2001	60	0	38.37	35.15	4.54	9.08
TMH 2002	60	0	22.83	29.12	3.76	7.52

Column	Range	Max	Min	Median	25%	75%
TMH 2000	100.00	100.00	0.00	45.00	0.00	90.00
TMH 2001	100.00	100.00	0.00	30.00	0.00	75.00
TMH 2002	100.00	100.00	0.00	5.00	0.00	50.00

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum Squares
TMH 2000	0.072	-1.81	0.20	0.014	1130.00	94500.00
TMH 2001	0.41	-1.16	0.17	<0.001	2302.00	161202.00

TMH 2002	1.00	-0.38	0.29	<0.001	1370.00	81300.00

One Way Analysis of Variance
Data source: TMH in 5-Year Macroalgae Percent Cover Analysis

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 , 13:20:53

Data source: TMH in 5-Year Macroalgae Percent Cover Analysis

Group	N	Missing	Median	25%	75%
TMH 2000	24	0	45.00	0.00	90.00
TMH 2001	60	0	30.00	0.00	75.00
TMH 2002	60	0	5.00	0.00	50.00

H = 7.71 with 2 degrees of freedom. (P = 0.021)

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 = 0.021)

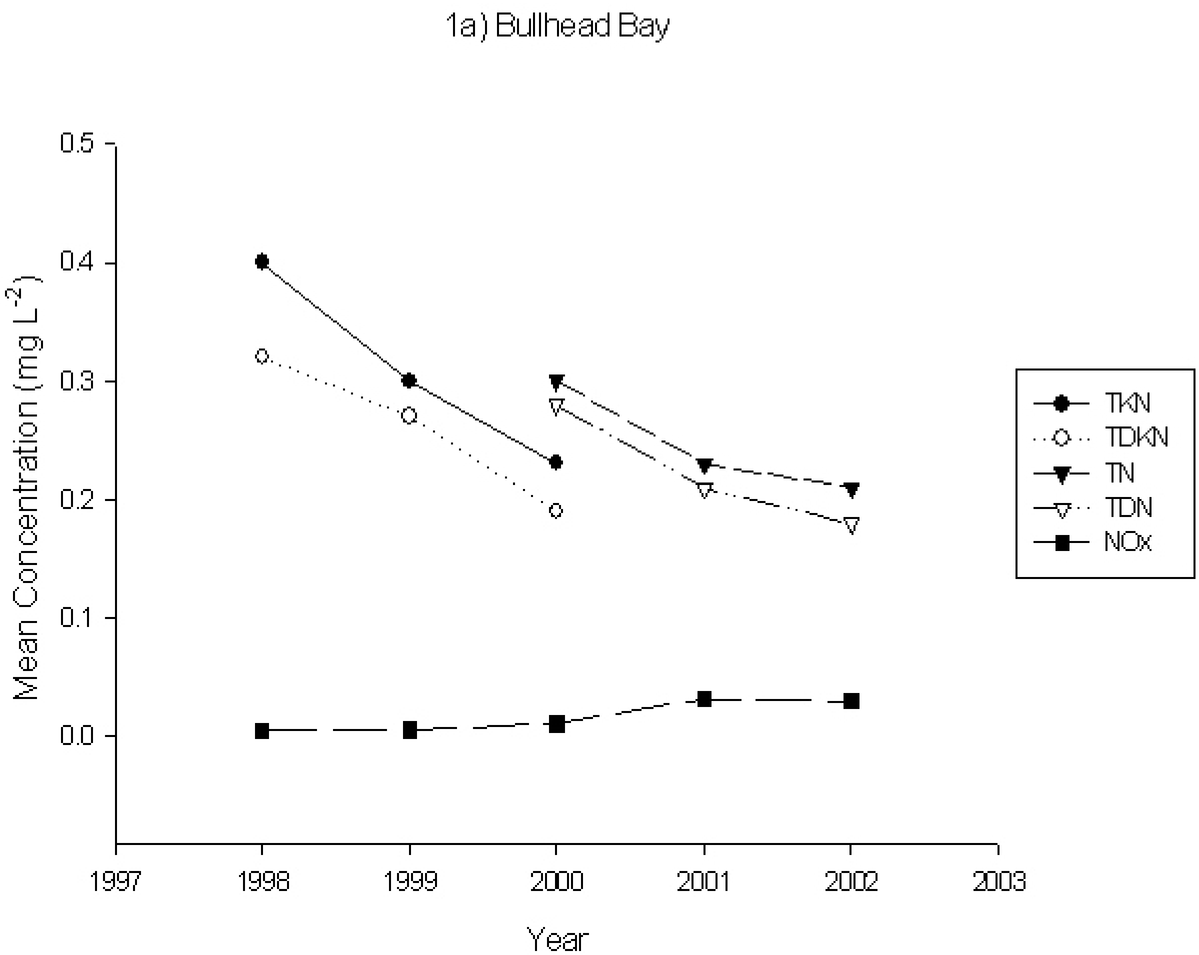
To isolate the group or groups that differ from the others use a multiple comparison procedure.

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

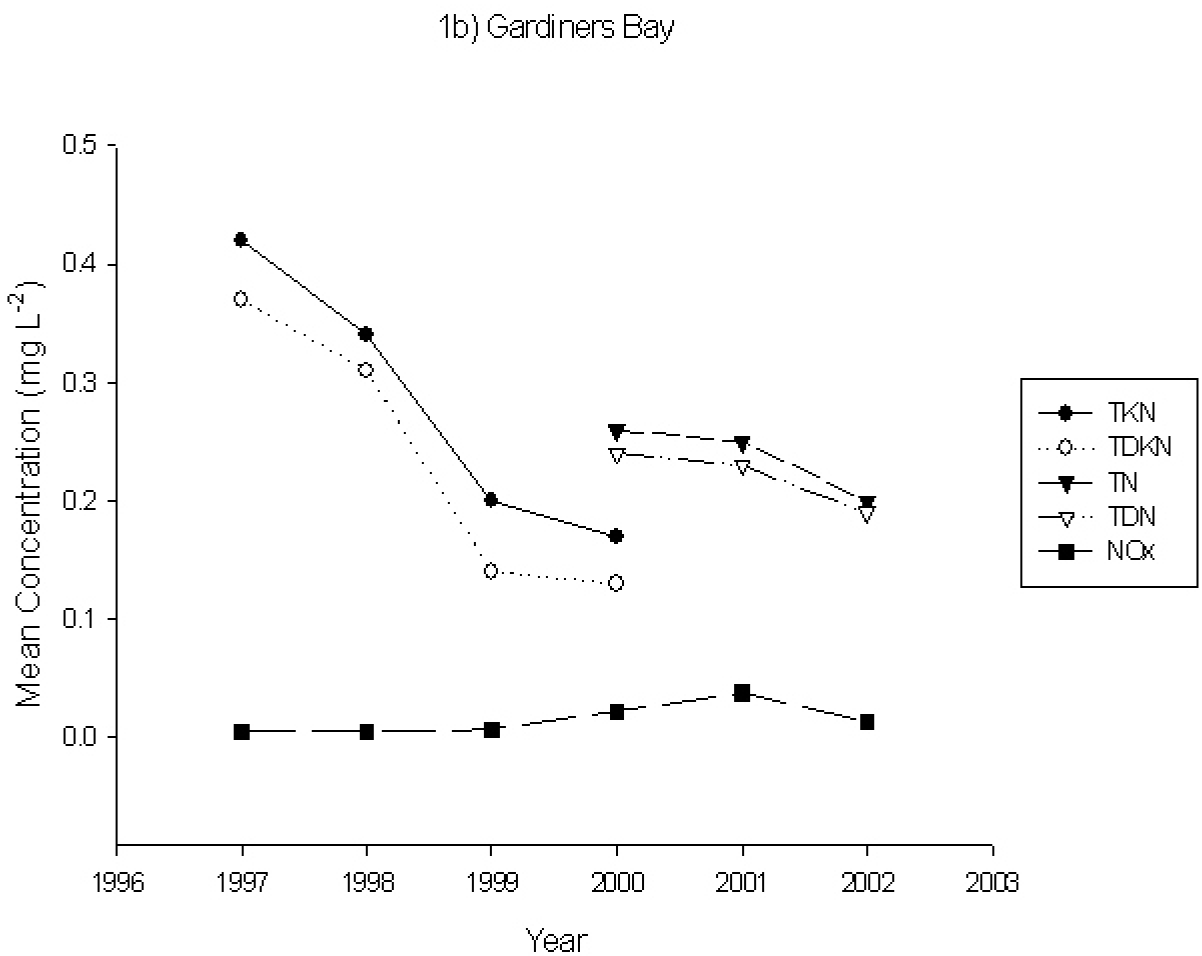
Comparison	Diff of Ranks	Q	P<0.05
TMH 2000 vs TMH 2002	23.14	2.30	No
TMH 2000 vs TMH 2001	6.36	0.63	No
TMH 2001 vs TMH 2002	16.78	2.20	No

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

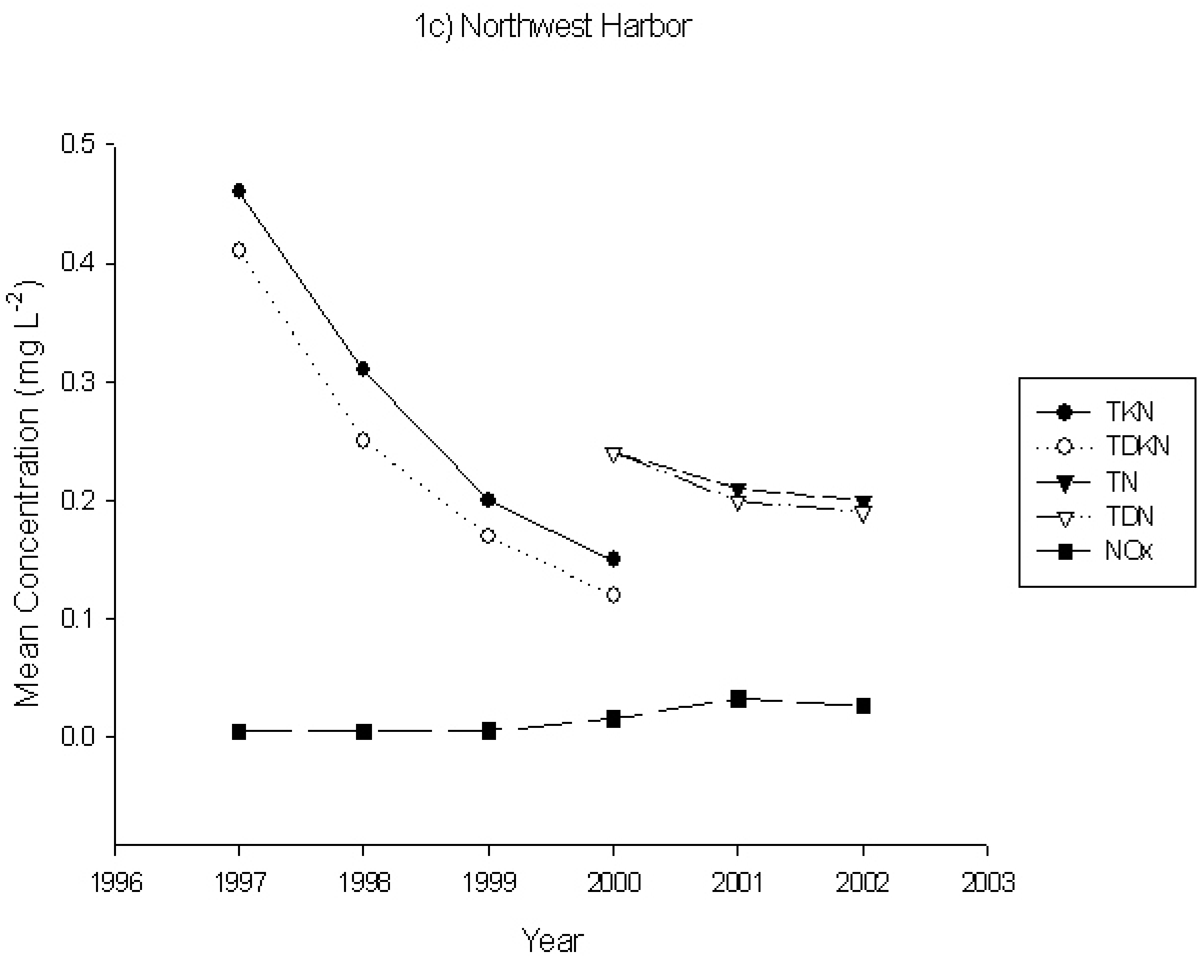
Appendix 15. Graphs 1a-f, enlarged.



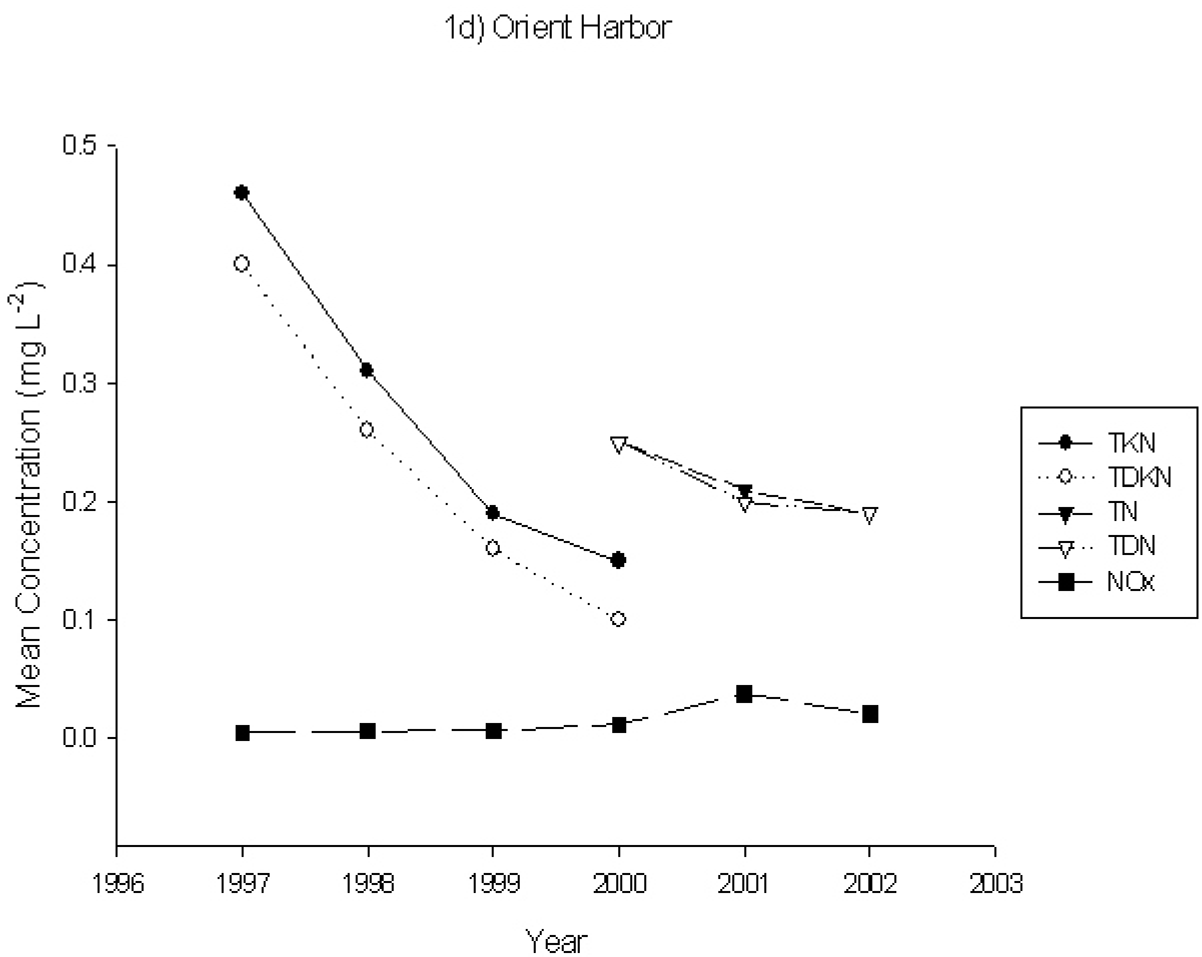
Appendix 15 continued.



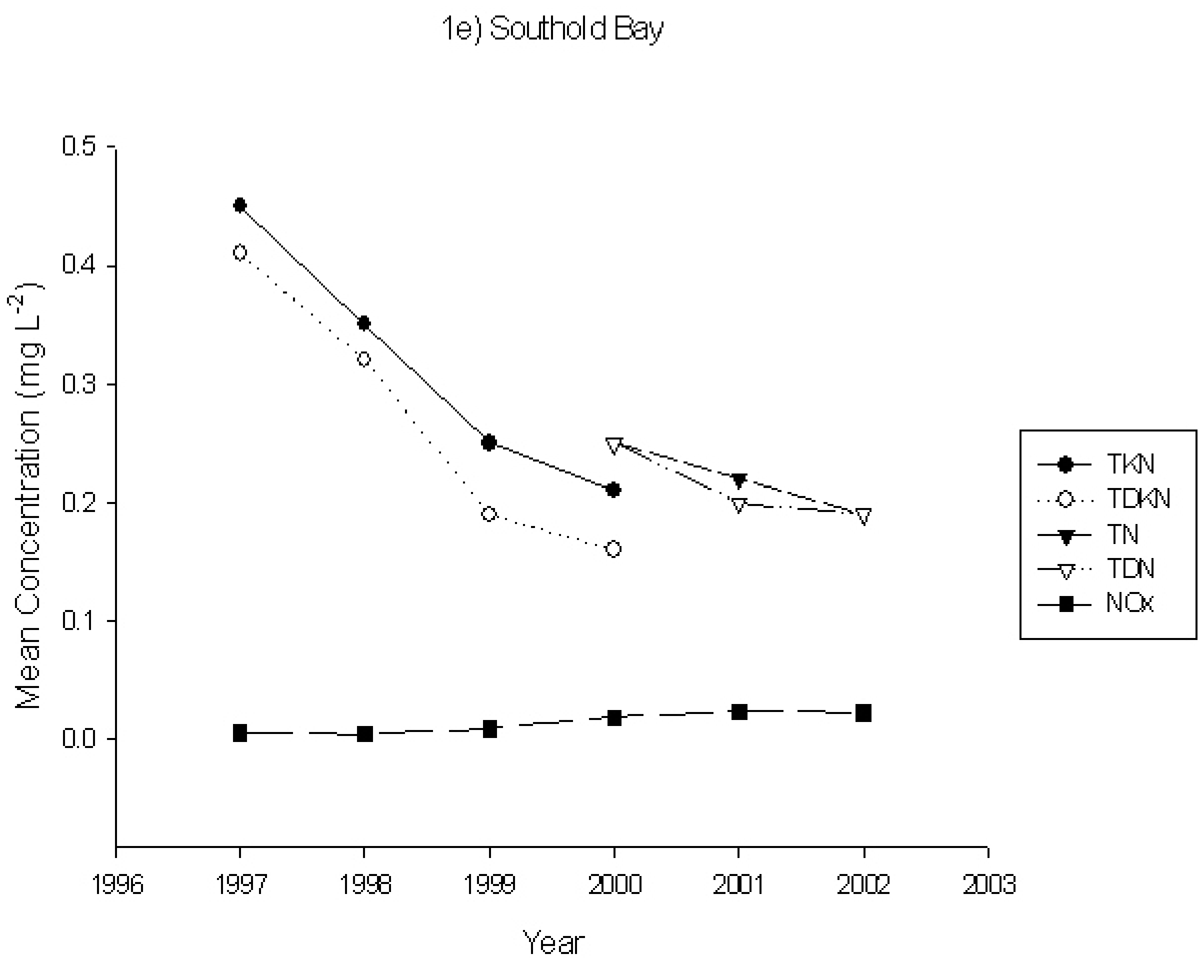
Appendix 15 continued.



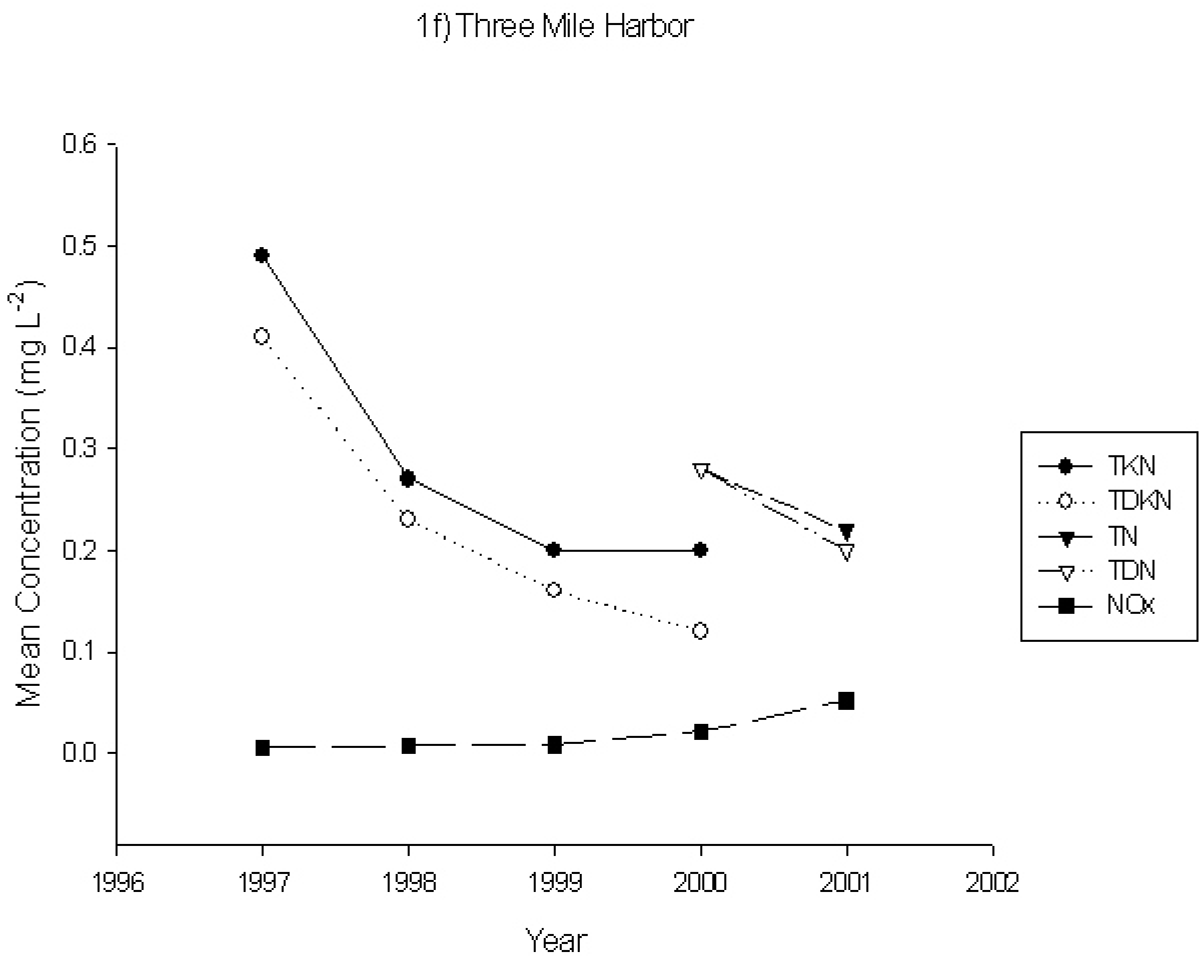
Appendix 15 continued.



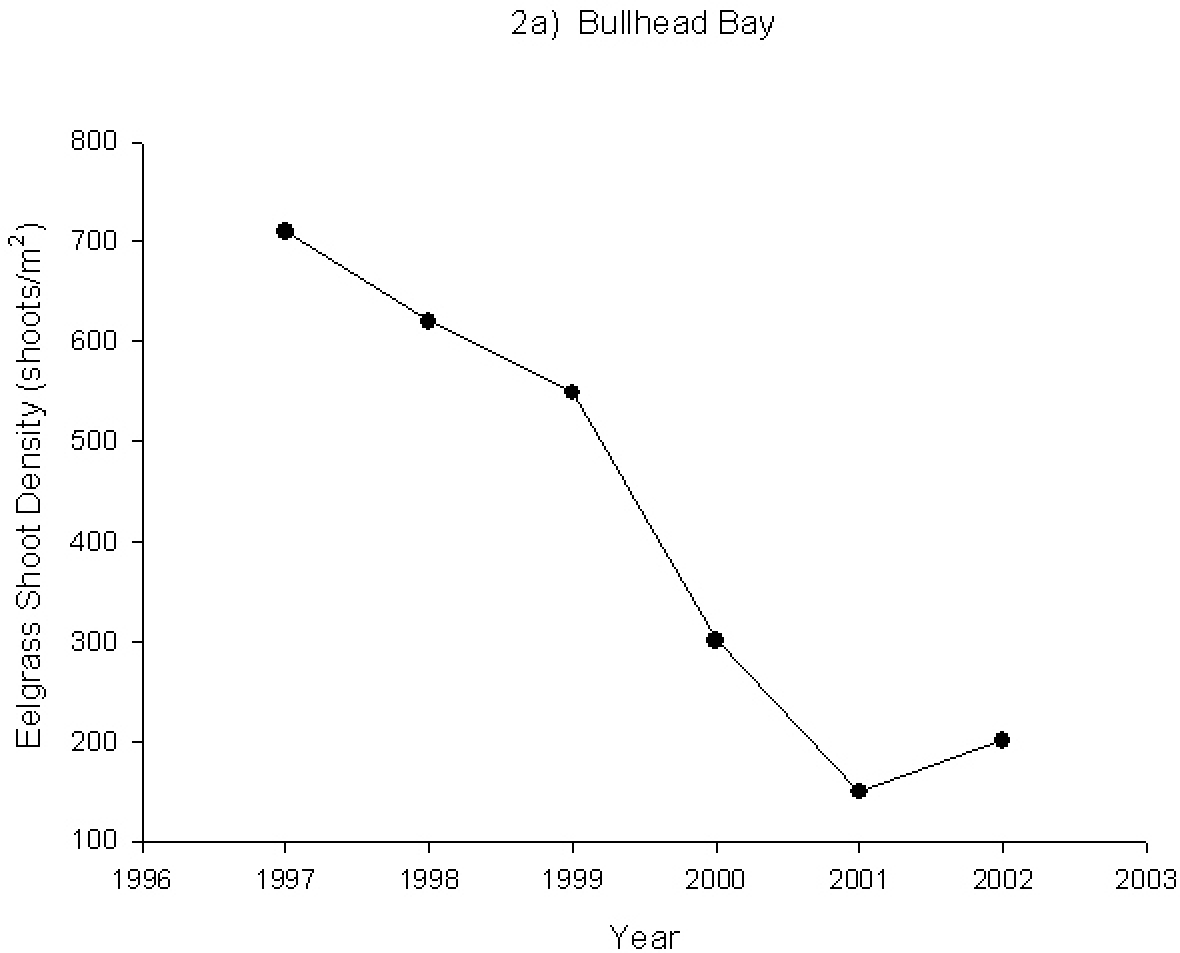
Appendix 15 continued.



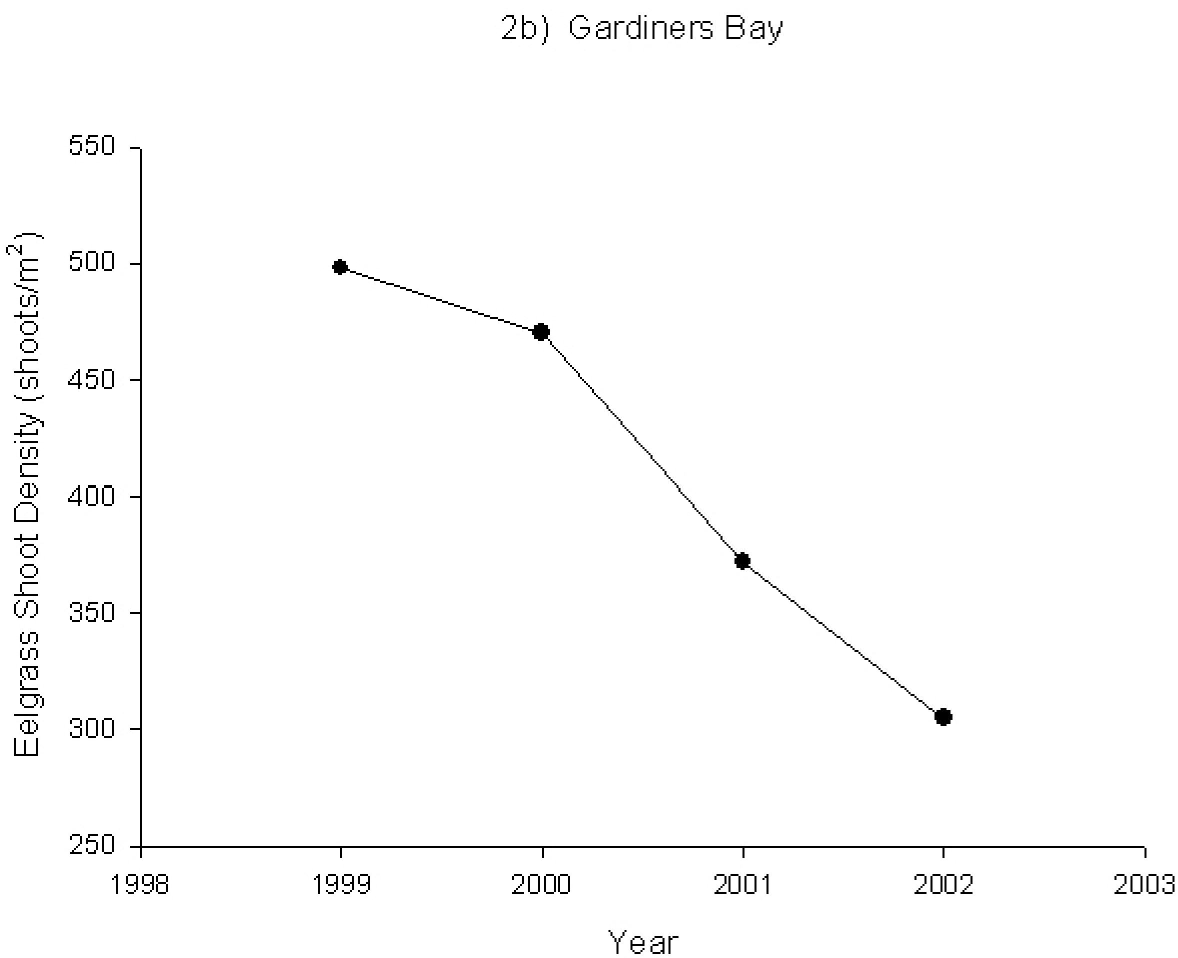
Appendix 15 continued.



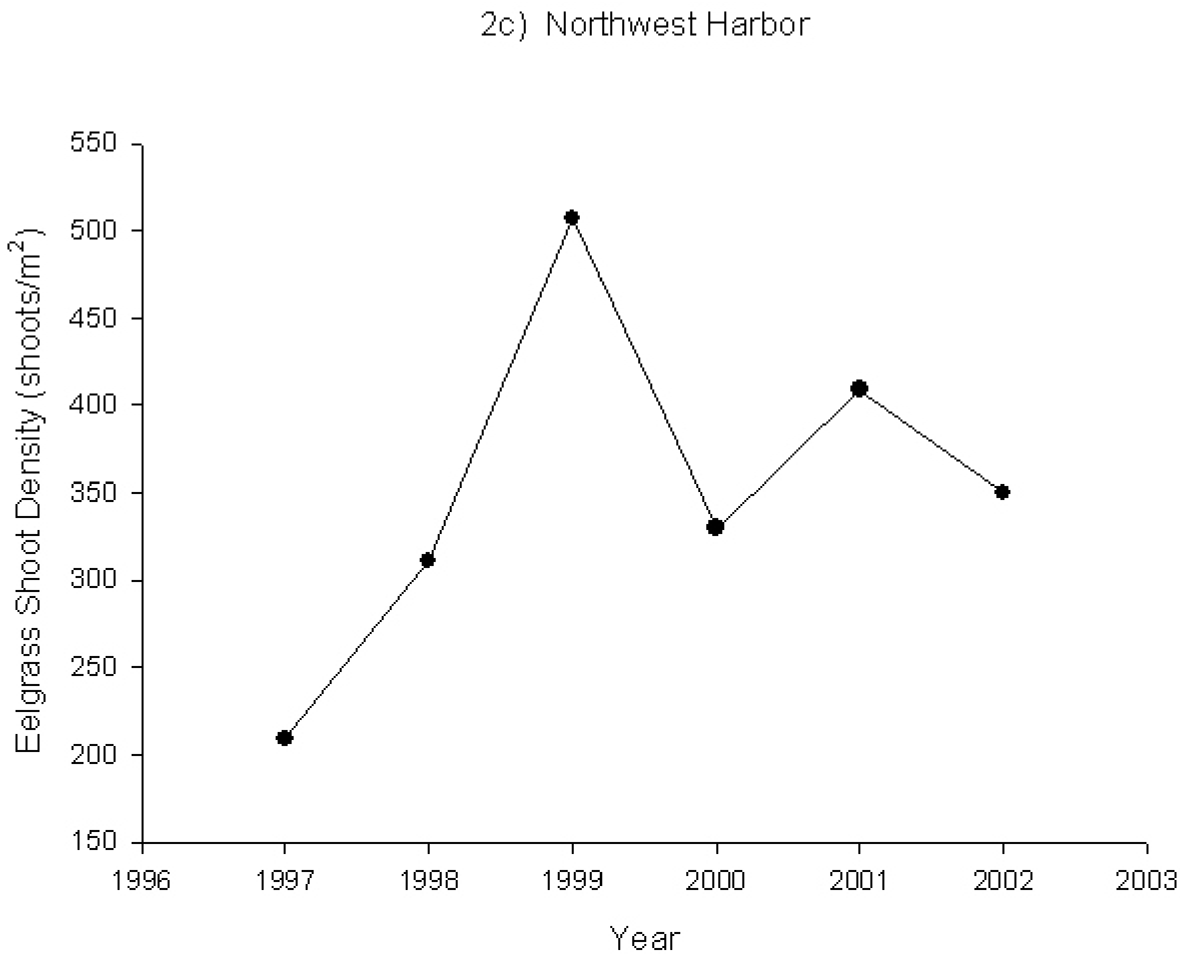
Appendix 16. Graphs 2a-f, enlarged.



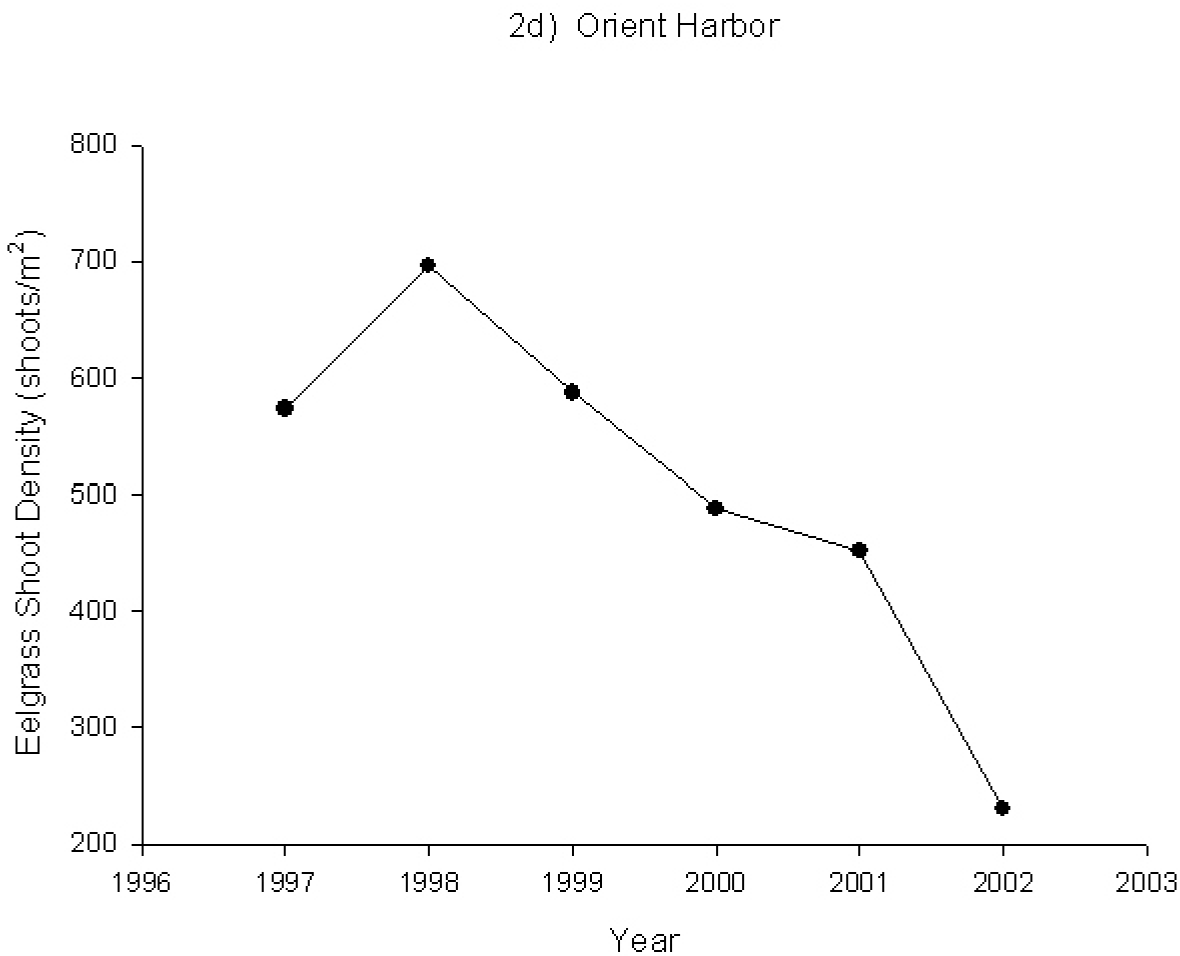
Appendix 16 continued.



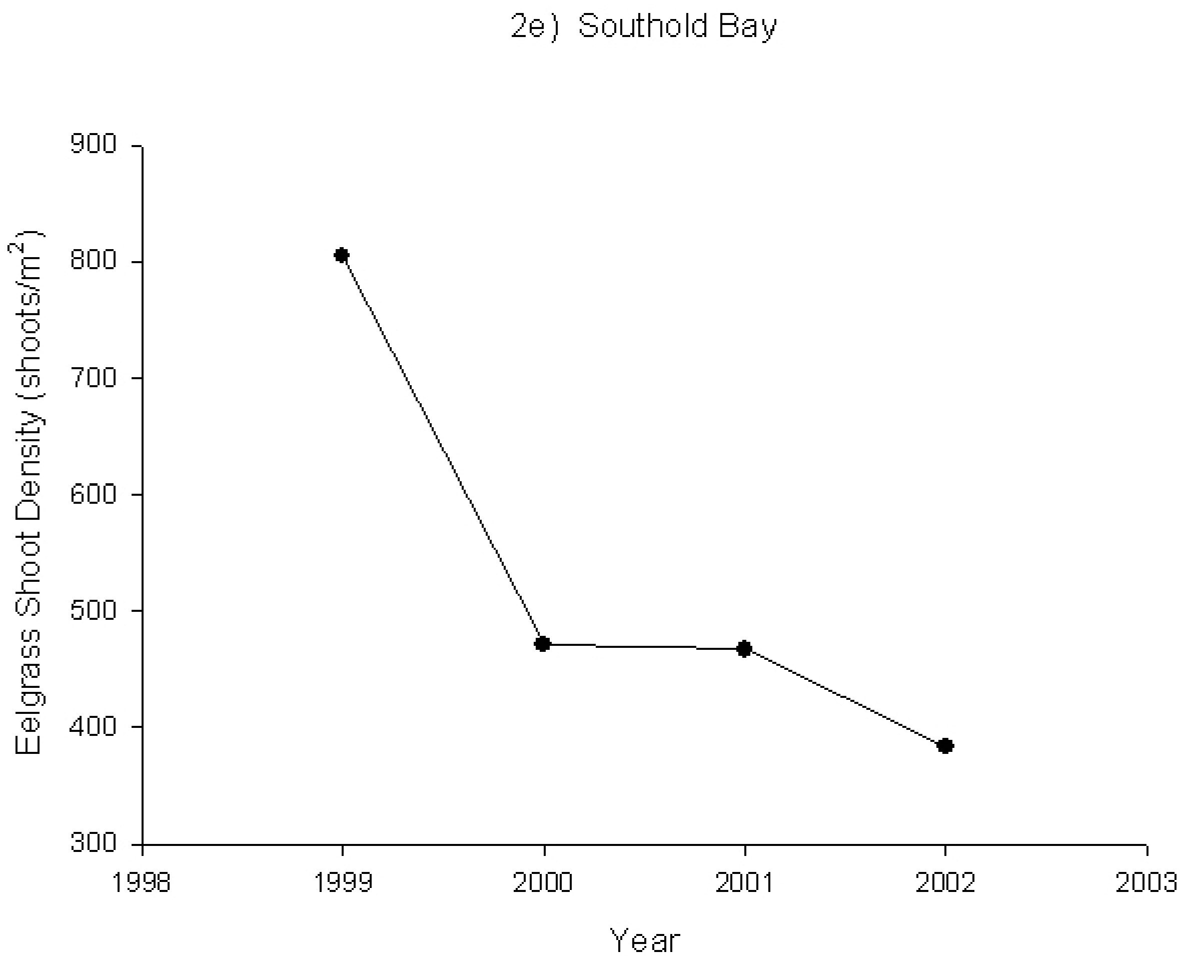
Appendix 16 continued.



Appendix 16 continued.



Appendix 16 continued.



Appendix 16 continued.

Appendix 17. Enlarged version of Graph 3.