NUMERIC WATER QUALITY TARGETS FOR LEMON BAY, CHARLOTTE HARBOR AND ESTERO BAY, FLORIDA

Charlotte Harbor National Estuary Program
Technical Report 06-3

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Executive Summary

Charlotte Harbor has generally been considered one of Florida's more unspoiled and productive estuaries because it is relatively undeveloped compared to nearby estuaries. Indeed, the Charlotte Harbor estuary is the sole estuary within the federal National Estuary Program (NEP) designated as a "maintenance" NEP rather than a "restoration" NEP. In the Southwest Florida region, including Tampa, Sarasota and Lemon Bays, research and restoration efforts have focused on seagrass areal coverage as an indication of estuarine condition, and as a result, Charlotte Harbor is generally considered to be fairly healthy. In much of the greater Charlotte Harbor region, there is little evidence of significant changes in seagrass areal coverage since systematic mapping efforts began in 1988, and nutrient loads have not been documented as a threat to seagrass extent to date in Charlotte Harbor (except Lemon Bay [see Tomasko et al. 1999]). Previous research has demonstrated that dissolved and suspended matter within the water column rather than chlorophyll *a* largely limits light availability for seagrass beds in Charlotte Harbor (McPherson and Miller 1987; McPherson and Miller 1994; Dixon and Kirkpatrick 1999) and that inter-annual seagrass coverage changes are largely resultant from changes in freshwater inflow from Charlotte Harbor's 3 major tributaries (Corbett et al. 2005; Tomasko et al. 2005).

However, there is reason for concern for the long-term health of this estuary as the southwest Florida region is one of the fastest growing areas in the U.S. In 1983 the Florida Department of Natural Resources (FDNR) documented a harbor-wide 29% decrease in seagrass extent in Charlotte Harbor, the majority of which was located in Pine Island Sound, Matlacha Pass and San Carlos Bay, from 1940s levels. A subsequent study (Corbett et al. 2005) documented a harbor-wide 6% loss from 1982 to 1999, again mostly from the Lower Charlotte Harbor region. Greenawalt-Boswell et al. (2006) documented a decline in seagrass density throughout Charlotte Harbor and Lemon Bay from 1999-2005, whereas declines in density may be a pre-cursor to losses in areal coverage. In the early 1990s, the FDNR reported that the Caloosahatchee River had reached its nutrient loading limits, indicated by elevated chlorophyll *a* and depressed dissolved oxygen levels, and water quality data collected in the tidal Peace River demonstrate that chlorophyll *a* levels exceeding 60-80 µg/L have occurred seasonally since monitoring began in 1976. Finally, a 2003 Charlotte Harbor NEP report determined significant increasing trends in total suspended solids throughout the coastal Charlotte Harbor region and increasing trends in turbidity, nutrients and others in the Lower Charlotte Harbor region. The creation of numeric water quality targets to serve as the basis for water quality restoration and maintenance activities can serve as a tool to stop these declining trends.

To offset future development and maintain current water quality into the future, we propose the use of an optical model to establish water quality targets for color, turbidity and chlorophyll *a* specific to each estuarine segment that encompasses the greater Charlotte Harbor estuarine complex including Lemon and Estero Bays. First we determined percent-light-at-depth targets required to achieve seagrass maximum depth distribution in each segment. Next we applied an optical model which describes total light attenuation as the sum of three partial light attenuation components: color, chlorophyll *a* and non-algal suspended solids. This allowed us to back-calculate the contribution to total light attenuation by each component in terms of concentration intercepts (e.g. µg/L chlorophyll). Finally, seasonal water quality data for each estuary segment were plotted with the intercepts overlaid, producing a plane of constant attenuation given our percent-light-at-depth goal. It is this plane of constant attenuation that is our proposed target. This plane allows the concentration for each component to assume any concentration between zero and its interecept; its value dependent on the concentrations of the other 2 components. This objective is in contrast to many water quality targets that set a discrete maximum for each specific analyte without regard to concentrations of other relevant constituents affecting the targeted outcome. Water quality data points located outside of the plane of constant attenuation identify times and locations when water quality did not meet our goals for that estuary segment. These water quality targets will be used by resource managers and NEP partners to hold the line on water quality in the greater Charlotte Harbor estuary, especially those parameters influencing water clarity and seagrass coverage. Resource managers can in the future determine if seagrass and water quality restoration targets are appropriate and easily modify this approach to encompass such targets if so.

Subsequent to the approval of this document, the next step for these targets is to develop a Water Quality Management Strategy Working Group consisting of NEP Management Conference members. This group will take the lead role in determining whether segments within the Lemon Bay, Charlotte Harbor and Estero Bay are exceeding the targets herein and resulting pollutant reduction management strategies. The Working Group will also take the lead role in further refining the targets, such as whether seagrass restoration targets are appropriate and refining the partial attenuation coefficients of the optical model included in this approach.

Introduction

In southwest Florida, substantial research and restoration efforts have focused on seagrass meadows as an environmental indicator for coastal environmental conditions. Charlotte Harbor, FL is contiguous to the northwest with Lemon, Sarasota and Tampa Bays where seagrass management strategies focus on nutrient load and phytoplankton concentration reductions. Charlotte Harbor confronts different issues, and phytoplankton concentrations do not have as large an influence on light attenuation in Charlotte Harbor as dissolved and suspended matter (McPherson and Miller 1987; McPherson and Miller 1994; Dixon and Kirkpatrick 1999). Also, analyses of seagrass coverage data from the recent past demonstrate that seagrass coverage in Upper Charlotte Harbor is stable since mapping began in 1988 (Kurz et al. 1999; Corbett et al. 2005; Tomasko et al. 2005; Corbett 2006) and in both Upper and Lower Charlotte Harbor since 1982 (Corbett 2006). Seagrass management strategies in the Charlotte Harbor region have not focused on nutrient load reductions, and currently, resource managers have not established restoration goals for seagrass coverage.

In Tampa Bay, where historical losses have been linked to both direct and indirect impacts, resource managers have set goals for restoring seagrass coverage to approximately ninety-five percent of the coverage present in 1950. Reductions in nitrogen loads since 1982 have led to reduced phytoplankton concentrations and increased water clarity, a cascade of effects which has allowed increases in seagrass extent (Johansson 1991; Johansson and Ries 1997; Lewis et al. 1998; Johansson and Greening 1999). Increases in seagrass coverage is also a restoration objective for seagrass managers in Sarasota Bay, where recent increases (1988-1996) may be linked to decreased nitrogen loads to the bay by the City of Sarasota and Manatee and Sarasota counties (Kurz et al. 1999). In both Tampa and Sarasota Bays, water clarity and quantity of light reaching the tops of seagrass blades is related to nitrogen loading and its effects on phytoplankton populations (cited in Tomasko et al. 2005); thus, seagrass restoration strategies in these areas have focused on nitrogen load reductions.

Lemon Bay, a comparatively small estuary that connects Sarasota Bay to the north to the Venice inlet and Charlotte Harbor in the south, is included within the larger Charlotte Harbor estuarine complex. It is very similar to Tampa and Sarasota Bays in that its water clarity is strongly tied to phytoplankton levels and nitrogen loads (Tomasko et al. 2001). Phytoplankton biomass was calculated to contribute 12 to 39 % of light attenuation within the water column with a mean of 29 %, and depth distribution of seagrasses in Lemon Bay is largely a factor of chlorophyll *a* concentrations (Tomasko et al. 2001). Seagrass mapping efforts have not documented trends in seagrass coverage in Lemon Bay since 1988 (Tomasko et al. 2001; Tomasko et al. 2005). Nonetheless, estimated nitrogen loads to the bay have increased an estimated 59% from historical levels and are expected to increase further with future urbanization (Tomasko et al. 2001; Tomasko et al. 2005). Thus, seagrass management strategies within Lemon Bay region also focus on nutrient load reductions.

South of Lemon and Sarasota Bays along the southwest Florida coast lies the Charlotte Harbor estuarine complex, which includes a number of interconnected estuaries. The Charlotte Harbor watershed extends approximately 210 km (130 mi) from its northern headwaters of the Peace River to southern Estero Bay, and three large rivers, the Peace, Myakka and Caloosahatchee, are the major sources of freshwater (Hammett 1990). Relative to Tampa, Sarasota and Lemon Bays to its northwest, Charlotte Harbor is strongly influenced by the freshwater inflows from its large watershed. One result of this large watershed is that the water clarity of the harbor is greatly influenced by dissolved and suspended matter, as opposed to the dominant influence of phytoplankton found in Tampa and Lemon Bays. Using data collected in Charlotte Harbor, McPherson and Miller (1987) found that non-chlorophyll suspended matter (including detritus, cellular material and minerals) accounts for an average of 72 % of light attenuation in the water column, color (dissolved organic matter) accounts for 21% and phytoplankton chlorophyll for only 4%. In the 1994 study, McPherson and Miller found that light attenuation and water quality analytes varied spatially with the highest light attenuation coefficients found near the mouths of freshwater inputs. They found color contributed 13-49% to total light attenuation, chlorophyll *a* contributed 16-18%, non-chlorophyll suspended matter contributed 30-55% and seawater contributed 3-6%. Dixon and Kirkpatrick (1999) found that color, turbidity and chlorophyll accounted for 66%, 31% and 4% of light attenuation, respectively. Hence, there are clear differences in the components of water column light attenuation between Charlotte Harbor and Tampa, Sarasota and Lemon Bays.

Six species of seagrass are found within the Charlotte Harbor and Lemon and Estero Bay regions: *Halodule wrightii, Thalassia testudinum, Syringodium filiforme, Halophila englemanni, Halophila decipiens* and *Ruppia maritima.* Despite the recent (1982-2004) stability of seagrass meadows in the Charlotte Harbor region, there is historical evidence of catastrophic losses in Charlotte Harbor. Harris et al. (1983) documented a 29% harbor-wide decrease in seagrass coverage from 1940s to 1982, excluding Lemon and southern Estero Bays, and postulated some of this loss resulted from seagrasses receding from deeper depths because of decreasing water clarity resulting from hydrologic changes and increased pollutant loads. From 1982 to 1999, Charlotte Harbor as a whole demonstrated a 6% decrease in seagrass extent, with 77% of that loss located in the Lower Charlotte Harbor region (Corbett et al. 2005). Subsequently, from 1999 to 2003 seagrass areal extent displayed increases in the Lower Charlotte Harbor region, and no significant trend was found in the Upper Charlotte Harbor region since 1982 (Corbett 2006). However, analyses of seagrass data on a smaller scale indicate that seagrass densities have declined throughout Charlotte Harbor and Lemon Bay over the last 6 years (Greenawalt-Boswell et al. 2006). Declines in seagrass density may be a pre-cursor to larger-scale losses such as areal coverage losses. Net losses of seagrass along the FDEP transects were also documented from 1999-2005, especially in the Upper Charlotte Harbor region (Greenawalt-Boswell et al. 2006). Although the cause of thinning seagrass meadows is not known and may reflect natural variability, these trends are starting to point to the need to protect these resources before more large scale areal coverages losses are detectable.

In addition, in the early 1990s, the Florida Department of Natural Resources reported that the Caloosahatchee River had reached its nutrient loading limits, indicated by elevated chlorophyll *a* and depressed dissolved oxygen levels, and water quality data collected in the tidal Peace River demonstrate that chlorophyll *a* levels exceeding 60-80 µg/L have occurred seasonally since monitoring began in 1976 (cited in Corbett et al. 2005). More recent analyses of water quality data demonstrate significant increases in total suspended solids (TSS) in the Lower Charlotte Harbor and Upper Charlotte Harbor regions and increasing turbidity and nutrients in the Lower

Charlotte Harbor region (Janicki Environmental Inc. 2003). At the same time, the Charlotte Harbor region is facing rapid urbanization pressure along the coast and more intensive landuse changes in its watershed, which may result in further degradation of water quality. Increases in rainfall and freshwater inflows over the previous several decades are projected for the near future (Kelly, 2004), and in turn, pollutant loads that are strongly associated with stormwater runoff will also increase (Tomasko et al., 2005). These trends do not bode well for the long-term maintenance of the region's aquatic resources, and thus, resource management strategies in this area need to focus on water quality improvements and the long-term maintenance of seagrass coverage.

This effort presents an optical model that looks at all components of light attenuation and can be used regardless of which component is the most influential to establish water clarity goals to maintain percent-light-at-depth requirements to achieve seagrass maximum depth distribution by segment within the Charlotte Harbor estuarine complex. The water clarity goals proposed herein are meant to maintain the present seagrass coverage and depth distribution into the future. This strategy is in line with the Charlotte Harbor NEP designation as a "maintenance" NEP rather than a "restoration" NEP. The Charlotte Harbor NEP has contracted to map 1950s seagrass coverage using methods comparable to current seagrass coverage maps. If this effort documents significant losses of seagrass areal coverage have occurred in the harbor from the 1950s, these water clarity targets can easily be modified to encompass restoration targets for those areas of losses.

These water clarity targets helps implement Quantifiable Objective WQ-2 of the Charlotte Harbor NEP updated Comprehensive Conservation and Management Plan (CCMP). This objective is as follows:

> **WQ-2**: Develop and meet site specific alternative criteria which are protective of living resources for dissolved oxygen, chlorophyll *a*, turbidity/total suspended solids, salinity, and pesticides by 2015.

Methods for Setting Water Quality Targets

There are several methods in which resource managers may determine numeric water quality targets. These include amongst others accepting water quality standards or regulations as targets; establishing a baseline or historic conditions to which conditions should be maintained or restored; identifying an appropriate reference site and accepting its water quality conditions as a target or developing resource-based targets using the requirements of relevant living resources.

Regulatory

The Florida Impaired Waters Rule (IWR) (Chapter 62-303, Florida Administrative Code) provides guidelines for chlorophyll *a*, dissolved oxygen, turbidity and transparency in surface waters. The IWR guidelines for these variables are as follows:

1. the annual average for chlorophyll *a* concentrations shall not exceed 11 ug/L and/or exceed historical values by 50% based on trend analysis;

2. dissolved oxygen concentrations shall not average less than 5.0 mg/L in a 24-hour period and shall never be less than 4.0;
3. turbidity shall be less than 29 NTU above natural background conditions; and
4. transparency shall not be reduced by more than 10% as compared to the natural background value.

Resource managers may accept these water quality standards as numeric targets for the coastal Charlotte Harbor region. However, it should be noted that despite annual seasonal hypoxia in upper Charlotte Harbor bottom waters, significant increasing trends in total suspended solids throughout coastal Charlotte Harbor and turbidity in Lower Charlotte Harbor, both with rates of change greater than or equal to 5% of the median value per year (Janicki Environmental Inc. 2003), these areas have not been designated impaired under the IWR for these variables. Previous studies have documented that suspended matter, along with dissolved matter, constitute the dominant influences on the light available for seagrass beds in most areas of the coastal Charlotte Harbor region (McPherson and Miller 1987; McPherson and Miller 1994; Dixon and Kirkpatrick 1999), with the exception of Lemon Bay. It is therefore possible that Florida water quality standards are not sufficiently protective of the Charlotte Harbor estuarine ecosystem.

Historic Conditions

Resource managers may instead wish to identify the water quality conditions of Charlotte Harbor and surrounding waterbodies in pre-development or a specified historic time period and use those conditions as numeric water quality targets. An issue with this method is determining scientifically-defensible baseline conditions if water quality data are rare, nonexistent or collected in a manner not comparable with current protocols for the time period in question, which is often the case.

Reference Site

An alternative course to follow in the determination of numeric water quality targets is to identify an appropriate reference site, a waterbody with little to no anthropogenic impacts that is physically, biologically and chemically similar to Charlotte Harbor and Lemon and Estero Bays. The water quality conditions of the reference site(s) could then be used as a goal for resource managers to emulate for the Charlotte Harbor region. Nevertheless, as each system in Florida is dynamic, it is difficult to identify similar systems or systems with little anthropogenic impacts.

Resource-Based

Arguably the most successful approach to date for setting numeric water quality targets has been the resource-based approach. In the Tampa Bay area, for instance, resource managers established the goal of restoring seagrass coverage to 95% of 1950's level (except those areas impacted by the direct impacts of dredge and fill activities), resulting in a restoration target of 12,350 more acres of seagrass. Water clarity in Tampa Bay is related to phytoplankton levels and chlorophyll *a* concentrations (cited in Tomasko et al. 2005), and nitrogen has been shown to be the limiting nutrient (Johansson 1991). Therefore, the focus of restoring 1950's level seagrass coverage is to reduce nutrients, specifically nitrogen, loading to the bay (Greening and Janicki

2006). Approximately 8200 metric tons of nitrogen was estimated to enter Tampa Bay annually in the mid 1970s from point sources, atmospheric deposition, nonpoint sources, groundwater and fertilizer losses at 55%, 22%, 16%, 3% and 5%, respectively (Greening and Janicki 2006). Resource managers established a nitrogen load reduction goal that maintains existing conditions by reducing future nitrogen emissions to the Bay by ca. 7% by 2010 or 17 tons per year. Reductions in nitrogen loadings from point sources (e.g., WWTP discharges from Cities of Tampa, St. Petersburg and Clearwater and port facilities) resulted in an estimated 60% reduction in nitrogen loading during the 1985-2003 period (cited in Greening and Janicki 2006). As a result, there was an increase in seagrass coverage between 1982-1996 (Tomasko et al. 2005), and in 2004, baywide seagrass areal coverage was the highest observed since 1950 (Greening and Janicki 2006).

Resource Managers in southern Indian River Lagoon have also established resource-based water quality targets using seagrass depth distribution. They partitioned the southern Lagoon into 5 segments and determined the depth distribution of seagrass meadows in each segment. They determined that Jupiter Inlet had the deepest growing seagrass beds and the most stable. They then used the median deep edges of Jupiter Inlet seagrass meadows as their depth target (1.3 meters) and evaluated the water quality conditions in those areas of the Lagoon that included beds growing at least 1.3 m deep (Crean 2002). The median values of these regions were used to set water quality targets for salinity, color, turbidity, dissolved oxygen, pH and photosynthetically active radiation (PAR) (Crean 2002).

Resource-Based Approach for Charlotte Harbor

We propose using a resource-based approach to establish water quality targets for Charlotte Harbor and Lemon and Estero Bays. The targets would be specific to each basin that encompasses this region. The Florida Fish and Wildlife Conservation Commission-Fisheries Independent Monitoring Program and the Coastal Charlotte Harbor Monitoring Network divide Charlotte Harbor into 12 hydrologic segments for their fisheries and water quality sampling programs (Figure 1). Using the methodology described below, we developed water quality goals specific for each segment.

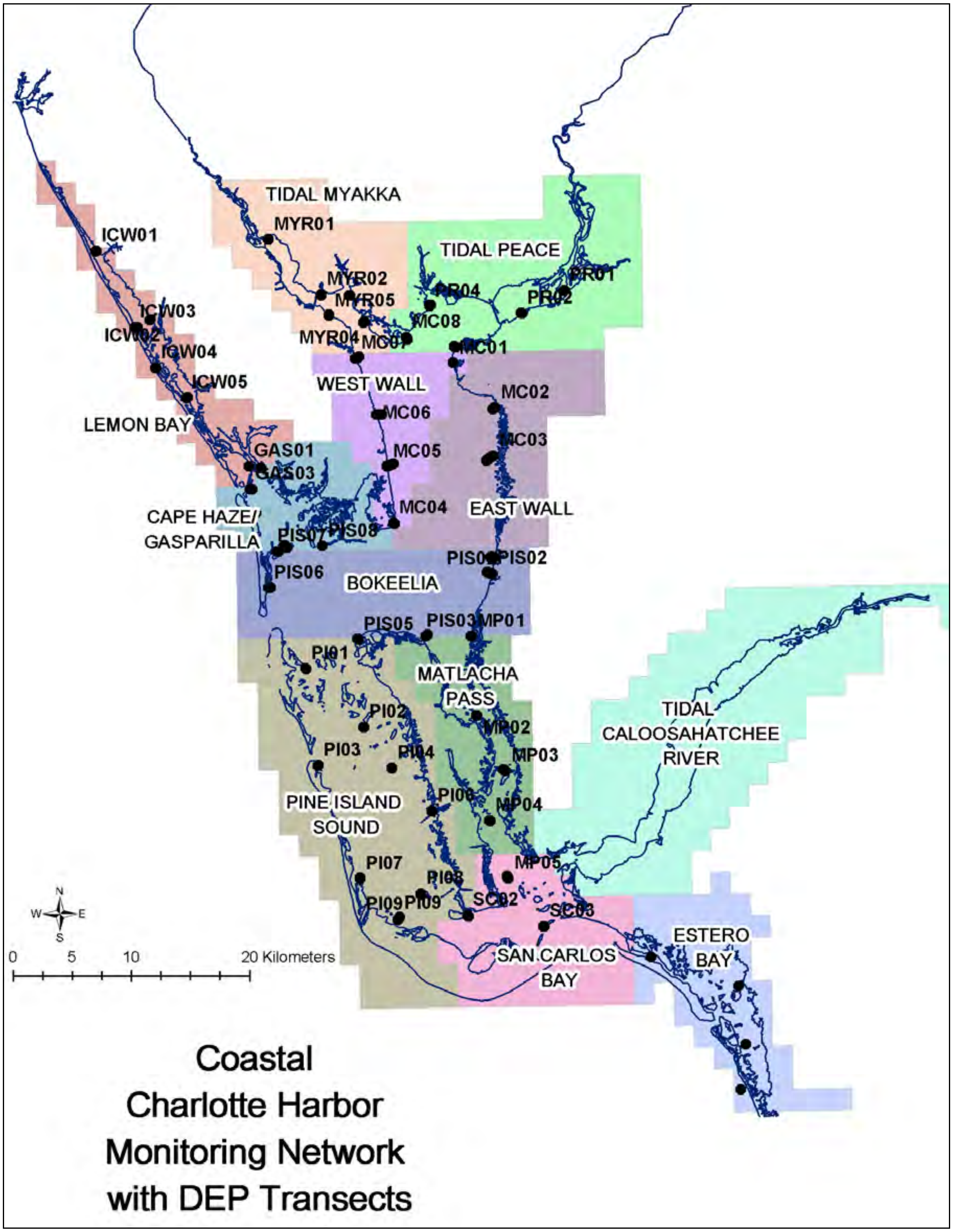


Figure 1.

Seagrass Light Requirements

Using published analyses, we estimated percent-light-at-depth targets required to achieve the current estimated seagrass maximum depth distribution in each segment. The 25% PAR target used herein is specific to subsurface irradiance; that is, our goal is 25% incident light that has already passed through the air-water interface.

Numerous estimates for percent-light-at-depth requirements of seagrass exist, and depending on the species composition of a bed, these estimates indicate a wide range of surface irradiance requirements reaching the deep edge of grass beds. For instance, Gallegos and Kenworthy (1996) cite a general range of 10-30 % for efforts documenting requirements of seagrass in other estuaries and 23-37% in Indian River Lagoon, Florida for *H. wrightii* and *S. filiforme*, specifically. Steward et al. (2005) recently estimated seagrass average annual maintenance light requirements as 33% of surface light at the median depth limit distribution (50th percentile) and 20% at the maximum (95th percentile). In more detail, this amounts to the following:

- Based upon 5-7 biennial seagrass areal coverage maps for the Lagoon and recent bathymetry data, the median (50th percentile) and maximum (95th percentile) depth limits for the 19 Indian River Lagoon segments are 0.8-1.8 meters and 1.2-2.8 meters, respectively;
- Based upon monthly PAR data from 1990-1999 the average annual subsurface light requirement at the median depth is 33±17% (34±17% in the growing season) and the minimum annual light requirement based on the maximum depth limit (95th percentile) is 20±14%. The minimum growing season requirement (March to mid Sept) is essentially the same 20±13%. (See Steward et al. 2005 for more information).

Grasses in Charlotte Harbor require between 15-30% photosynthetically active radiation penetrating to depth (Dixon, 2000). Tomasko and Hall (1999) found an average 23% subsurface irradiance reaching all study sites but documented declines in productivity of *T. testudinum* during the study period. Of the species of seagrass in Charlotte Harbor, *T. testudinum* may have the highest light requirements. Greenawalt (2005) determined that *S. filiforme* is found in areas with generally lower percent-light-at-depth than *H. wrightii* and *T. testudinum*, while Chamberlain theorizes that *H. wrightii* extends deeper and is found in areas with lower light conditions than *T. testudinum* (Chamberlain 2005). We propose a percent-light-at-depth goal of 25 % subsurface irradiance, which is on the high end of the estimate in Dixon (2000), an estimate specific to Charlotte Harbor, and higher than the annual average found in Tomasko and Hall (1999). Our 25% subsurface irradiance goal is also slightly higher than the 20.5% (Greening and Janicki 2006) of incident light target used in Tampa Bay's restoration activities.

Seagrass Depth Distribution Targets

Seagrass Transects

We calculated the annual mean maximum depth distribution of seagrass per segment based on the results of 50 fixed-transects monitored by the Florida Department of Environmental Protection Aquatic Preserves office throughout Charlotte Harbor and Lemon Bay since 1999 and 5 additional transects in Estero Bay established in 2002 (Figure 1). Each transect consists of a fixed line, determined by a compass heading and marked with PVC stakes, extending from the shoreward seagrass edge out to the deep edge of the meadow where seagrass was sparse or no longer existent. Program researchers collect depth measurements, seagrass species abundance (Braun-Blanquet cover scale [Braun-Blanquet 1965]), blade length, sediment type and epiphyte coverage and type at 50-meter intervals along each transect (or 10-meter intervals for transects shorter than 50 m) from shore to edge of bed (Staugler and Ott 2001). Depth measurements are adjusted to mean water depth by adjusting the tide level observed in the field to mean water based on the 12 National Oceanographic and Atmospheric Administration (NOAA) tide stations located throughout the study area (Staugler and Ott 2001). There are several transects for each segment for each year; we used the greatest annual value of the segment's mean maximum depths as the target depth. (The deep edge measurements and in turn targets were updated since the Corbett and Hale (2006) effort.) There were no comparable transect data for the Tidal Caloosahatchee River segment, so we used a goal of 1 meter based upon vertical scan hydro-acoustic research by Chamberlain (2005).

Segment	**Number of DEP Transects**	**Annual Mean Depth Distribution (meters)**							**Max Mean Depth**
		1999	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	
Lemon Bay	4-6	1.5	1.5	1.5	1.5	1.7	1.6	1.7	1.7
Cape Haze/ Gasparilla	4-5	1.5	1.7	1.6	1.8	1.6	1.9	1.9	1.9
West Wall	3-5	1.3	1.4	1.2	1.2	0.9	1.3	1.3	1.4
East Wall	1-2	NA	1.2	1.0	1.2	1.3	1.3	1.4	1.4
Tidal Myakka River	3-5	NA	0.8	0.5	0.8	0.7	0.8	0.6	0.8
Tidal Peace River	2-4	0.9	0.9	0.8	0.9	1.0	0.7	0.9	1.0
Bokeelia	3-5	1.4	1.4	1.1	1.0	1.2	1.3	1.5	1.5
Pine Island Sound	8-11	1.6	1.6	1.6	1.6	1.7	1.9	1.7	1.9
Matlacha Pass	2-4	0.9	1.5	1.2	1.3	1.1	1.3	1.2	1.5
San Carlos Bay	3-6	1.6	1.6	1.7	1.8	2.0	1.9	1.6	2.0
Estero Bay	4-5	NA	NA	NA	1.0	1.0	1.0	0.8	1.0

Table 1. Annual mean seagrass depth distribution by segment using FDEP transect data. The maximum deep edge for each segment was used as the preliminary depth target. The number of transects per year per segment varied slightly.

Comparison with Seagrass Maps and Bathymetry

We next quantified the seagrass areal coverage per segment growing within the depth distribution targets from the DEP transect data. We overlaid the 2003 seagrass polygon maps produced by SFWMD and SWFWMD onto NOAA and SFWMD-updated bathymetry data converted to polygon files. We used the 2003 maps because 2003 is 1 of 2 years in which seagrass areal coverage data encompasses the entire coastal study area (see Corbett 2006 for discussion). The second dataset that encompasses the entire area, the 1999 dataset, represents decreased seagrass areal coverage, as there were losses in most segments from the previous mapping event (Corbett 2006). The 2003 dataset represents increased seagrass coverage in most seagrass segments (Corbett unpublished); the data were acquired for both Upper and Lower Charlotte Harbor regions on the same day in January 2004.

We created an intersect coverage of each segment by combining the 2003 seagrass maps to the bathymetry data. This allowed us to determine the seagrass depth distribution per segment according to the seagrass polygon maps. We compared seagrass depth distributions estimated from the intersect coverages to our depth distribution targets from the DEP transect data. If less than 95% of seagrass areal coverage per segment fell within these depth targets, we calculated a deeper depth target using the intersected seagrass map and bathymetry coverages so that ≥95% of seagrass areal coverage shown by the maps occurred shallower than our depth targets. Those segments with larger values for seagrass coverage, such as Pine Island Sound and Matlacha Pass, we allowed a maximum of ~200 acres to fall deeper than our depth targets. The final depth targets are listed in Table 2. Cumulative frequency curves of seagrass coverage by depth (Figure 2) for each segment are included in Appendix A.

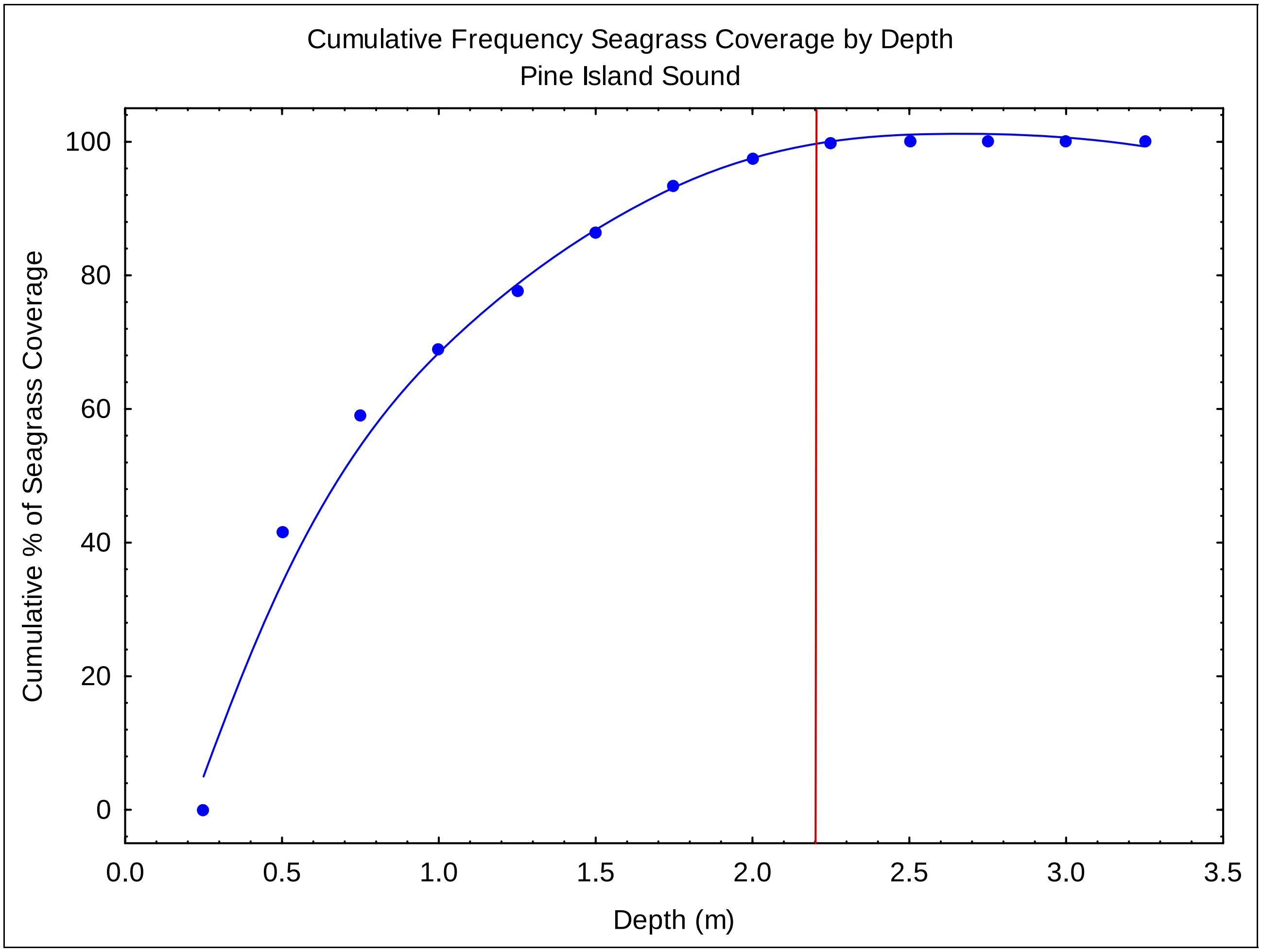


Figure 2. Cumulative frequency curve of seagrass coverage by depth in meters for the Pine Island Sound segment. The target depth for this segment is 2.2 meters and represented by the red arrow.

Segment	2003 Seagrass Coverage (acres)	Max Depth from DEP Transects (meters)	Depth Target from Intersected Seagrass and Bathymetry Coverages (meters)	% Coverage within target	Final Depth Target (meters)
Lemon Bay	2684*	1.7	2.0	99	**2.0**
Cape Haze/ Gasparilla	6,902	1.9	1.9	99	**1.9**
West Wall	1,680	1.4	1.4	100	**1.4**
East Wall	3,254	1.4	1.4	100	**1.4**
Tidal Myakka River	280	0.8	0.9	99	**0.9**
Tidal Peace River	246	1.0	0.9	100	**1.0**
Bokeelia	3,315	1.5	2.4	97	**2.4**
Pine Island Sound	27,837	1.9	2.2	99	**2.2**
Matlacha Pass	7,333	1.5	2.0	97	**2.0**
San Carlos Bay	5,114	2.0	2.2	96	**2.2**
Estero Bay	3,413	1.0	1.6	97	**1.6**
Tidal Caloosahatchee River	62	1.0**	1.2	72	**1.2**

* Southern 2/3 Lemon Bay only. **Estimate based on vertical scan hydro-acoustic research by Chamberlain (2005).

Table 2. Depth targets using DEP transect data and seagrass areal coverage and bathymetry data. Final depth targets are in the last column.

There were several issues with this last step. First, bathymetric data to the nearest tenth of a meter were not available for the northern 1/3 of the Lemon Bay segment at the time of this analysis. Second and perhaps the most important issue is that the seagrass polygon maps produced by the Water Management Districts may not accurately represent the deep edge of seagrass beds. The 2003 maps were produced at a 1:12,000 scale, and whether photointerpreters can capture deep edges correctly, especially in darkly colored waters or steeply sloped areas, requires caution in using these data. Also, the spatial accuracy of the seagrass maps may be off as much as 20 feet in some areas, while the bathymetry data may also add to these inaccuracies.

Optical Model

Light Attenuation Coefficient

To calculate a water clarity target, we used the Lambert-Beer Law to determine our light extinction coefficient:

$k = [\ln(I_o)-\ln(I_z)]/z$

where k equals the light extinction coefficient at depth, I_o is surface irradiance, I_z is the irradiance taken at depth and z equals the depth in meters. This equation is more commonly shown as follows:

$$\%\text{light at depth}/100 = e^{-k*z} \qquad (1)$$

where, in our case, the percent light-at-depth is the estimated minimum amount of subsurface incident light required by seagrasses, *e* is the base of the natural logarithm, k is the light attenuation coefficient (in m-1), and z equals the measured or estimated deep edge depth of seagrass distribution meters.

To use an example of the San Carlos Bay segment in the Lower Charlotte Harbor region (Table 2), inserting our percent-light-at-depth target of 25% PAR and depth of 2.2 meters, results in the following equation:

$$0.25 = e^{-k*2.2} \qquad (1a)$$
$$\ln(0.25) = \ln(e^{-k*2.2}) \qquad (1b)$$
$$-1.4 = -k*2.2 \qquad (1c)$$
$$k = 0.6$$

Partial Contributions to Light Attenuation

Light attenuation in the water column is caused by scattering and absorption of light by water quality constituents (Kirk 1983). Light absorbing water column components can be grouped into 3 categories: water itself, dissolved yellow substances (gilvin) and particulates (tripton/phytoplankton) (Kirk 1994). Scattering itself does not remove light (photons) from the water column but impedes the vertical penetration of light by increasing the total pathlength it travels before it is absorbed (Kirk 1994). Thus, scattering increases the likelihood of light absorption by water column constituents (before it can reach seagrass beds), and it can cause some photons to be scattered back in an upwards direction. Scattering constituents of the water column include the particulates: mineral particles from land or bottom sediments, phytoplankton, bacteria, dead cells or fragments of cells, etc. (Kirk 1994).

Lorenzen (1972) partitioned absorption and scattering components of the water column into 4 parts: water, phytoplankton, dissolved matter and non-chlorophyll suspended matter. This can be written as follows:

$$k = k_1 + k_2 + k_3 + k_4 \quad (2)$$

where k_1 is the attenuation coefficient of water, 0.0384 m^{-1} (Lorenzen 1972); k_2 is the attenuation coefficient of phytoplankton, [often approximated by multiplying 0.0138 $m^2\ mg^{-1}$ (Lorenzen 1972) by the concentration of chlorophyll *a*]; k_3 is the attenuation coefficient of dissolved matter determined by absorptivity times concentration and k_4 is the attenuation coefficient of non-algal suspended matter, determined by absorptivity and scatter times concentration (from McPherson and Miller 1987). This partitioning of light attenuation components is an approximation as the distribution and availability of light is not a linear function of concentration (Kirk 1983).

For management purposes, light requirements of grass beds can be translated into concentrations of these constituents that meet the specified light availability target (Gallegos and Kenworthy 1996). To do this, we adapted an optical model derived by McPherson and Miller (1994: eq. 8) which describes total light attenuation as the sum of three partial light attenuation components: color, chlorophyll *a* and turbidity:

$$k = 0.014{*}C_2 + 0.062{*}\ C_3 + 0.049{*}C_4 + 0.30 \quad (3)$$

where k equals the light extinction coefficient at depth, C_2 is water color in Pt-Co units, C_3 is turbidity in NTU and C_4 is chlorophyll *a* in micrograms per liter. The partial attenuation coefficients for color and chlorophyll *a* were derived by stepwise multiple regression analysis and multiplied by concentrations to yield the contribution of each to light attenuation, adjusted for sun angle (see McPherson and Miller (1994) for complete discussion). Total suspended solids and turbidity were tested by stepwise multiple regression analysis as surrogates for non-algal suspended matter. However, both analytes included only part of the attenuation attributable to non-algal suspended matter, so this component was estimated by subtraction [field collected $k - k_{(water)} - k_{(color)} - k_{(chlorophyll)}$] (see McPherson and Miller (1994) for complete discussion). Gallegos (1994) also uses turbidity in lieu of total suspended solids for the non-algal suspended matter component in his optical models due to its ease in measurements, superior analytical precision and use in many monitoring programs.

To determine the maximum concentration of each partial light attenuation component that meets a given rate of light attenuation (calculated from the percent-light-at-depth target), set two components to zero and solve for the third. Continuing to use the San Carlos Bay segment as an example, we solved for color in the following case:

$$0.6 = 0.014{*}C_2 + 0.062{*}\ (0) + 0.049{*}(0) + 0.30 \quad (3a)$$
$$0.3 = 0.014{*}C_2 \quad (3b)$$
$$C_2 = 24.0 \text{ Pt-Co}$$

The resulting values we call our “intercepts”.

Table 3 lists the intercepts for each partial light attenuation component for given depths using the optical model above, and Table 4 lists our intercepts given our seagrass depth and light targets.

Depth (meters)	**k**	**Color Intercept (Pt-Co)**	**Turbidity Intercept (NTU)**	**Chlorophyll *a* Intercept (ug/L)**
0.5	2.8	178.6	40.3	51.0
0.6	2.3	145.2	32.8	41.5
0.7	2.0	121.4	27.4	34.7
0.8	1.8	103.6	23.4	29.6
0.9	1.6	89.7	20.3	25.6
1.0	1.4	78.6	17.7	22.4
1.1	1.3	69.5	15.7	19.9
1.2	1.2	61.9	14.0	17.7
1.3	1.1	55.5	12.5	15.9
1.4	1.0	50.0	11.3	14.3
1.5	0.9	45.2	10.2	12.9
1.6	0.9	41.1	9.3	11.7
1.7	0.8	37.4	8.4	10.7
1.8	0.8	34.1	7.7	9.8
1.9	0.7	31.2	7.0	8.9
2.0	0.7	28.6	6.5	8.2
2.1	0.7	26.2	5.9	7.5
2.2	0.6	24.0	5.4	6.9
2.3	0.6	22.0	5.0	6.3
2.4	0.6	20.2	4.6	5.8
2.5	0.6	18.6	4.2	5.3
2.6	0.5	17.0	3.8	4.9
2.7	0.5	15.6	3.5	4.5
2.8	0.5	14.3	3.2	4.1
2.9	0.5	13.1	2.9	3.7
3.0	0.5	11.9	2.7	3.4

Table 3. Extinction Coefficients and Intercepts for each partial light attenuation component at specified depths calculated from Equation 3.

Segment	Final Depth Target (meters)	k	Color Intercept (Pt-Co)	Turbidity Intercept (NTU)	Chlorophyll *a* Intercept (ug/L)
Lemon Bay	2.0	0.7	28.6	6.5	8.2
Cape Haze/ Gasparilla	1.9	0.7	31.2	7.0	8.9
West Wall	1.4	1.0	50.0	11.3	14.3
East Wall	1.4	1.0	50.0	11.3	14.3
Tidal Myakka River	0.9	1.6	89.7	20.3	25.6
Tidal Peace River	1.0	1.4	78.6	17.7	22.4
Bokeelia	2.4	0.6	20.2	4.6	5.8
Pine Island Sound	2.2	0.6	24.0	5.4	6.9
Matlacha Pass	2.0	0.7	28.6	6.5	8.2
San Carlos Bay	2.2	0.6	24.0	5.4	6.9
Estero Bay	1.6	0.9	41.1	9.3	11.7
Tidal Caloosahatchee River	1.2	1.2	61.9	14.0	17.7

Table 4. Seagrass Depth Targets with partial attenuation intercepts.

The Target—Plane of Constant Attenuation

To describe water clarity with respect to seagrass depth limits, we overlaid the intercepts calculated above onto seasonal water quality data collected for coastal Charlotte Harbor and Estero and Lemon Bays. This produced a plane of constant attenuation for variable concentrations of the water quality parameters, given our percent-light-at-depth goal, when combining the 3 components of the optical model. When reviewing only 2 components (see Figures 5 and 6 for examples), a line of constant attenuation is produced. For the remainder of this document, we discuss the 3-D graphs and plane of constant attenuation. Water quality data points located above this plane identify instances when water clarity did not meet our target.

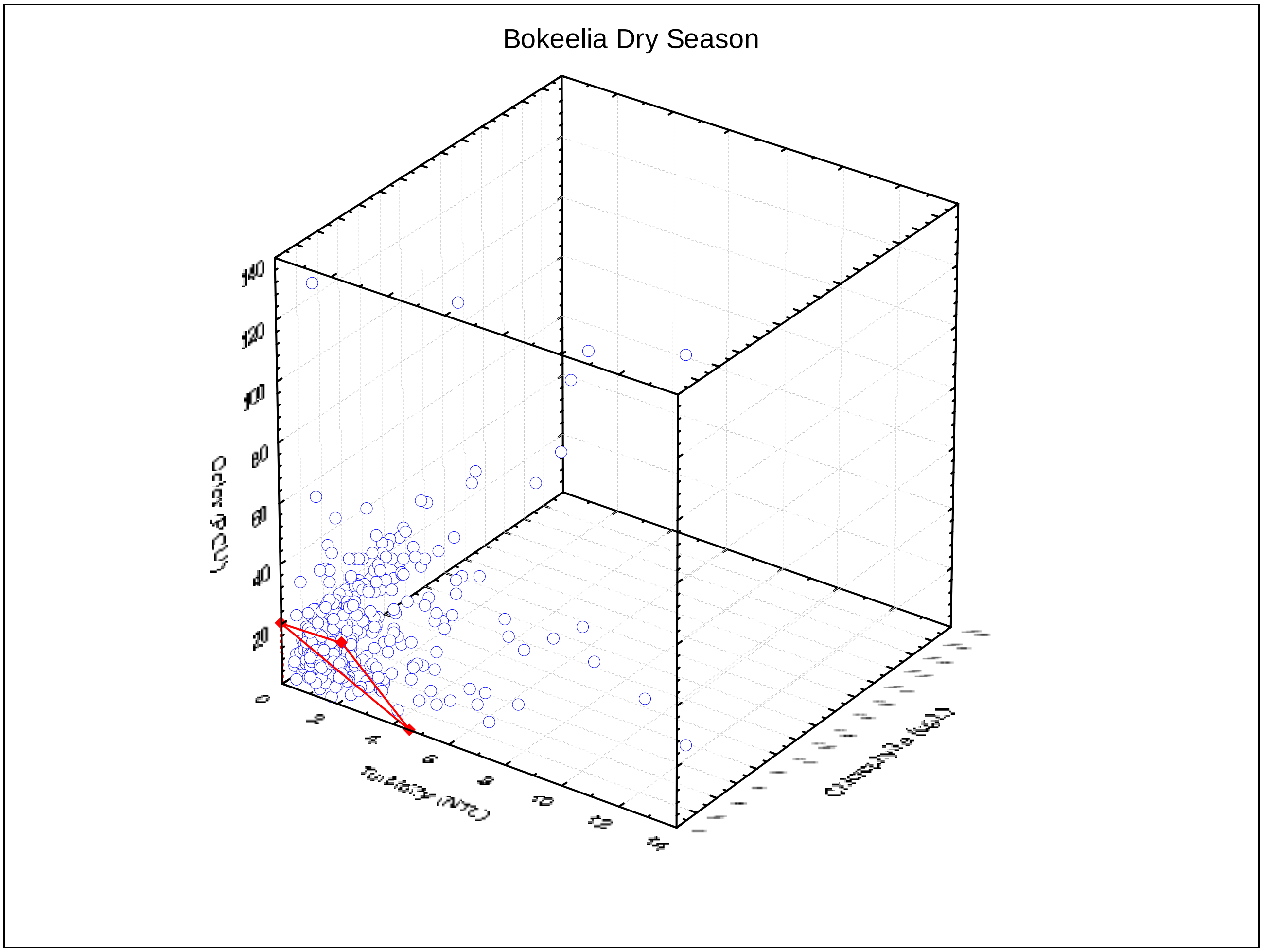


Figure 3. 3-D Scatterplot with the Bokeelia dry season water quality intercepts (Table 4) and the plane of constant attenuation are overlaid in red. Water quality data points located above the plane of constant attenuation identify instances when water clarity did not meet these targets.

Monthly water quality data from surface water samples collected between 2001 to 2006 were provided by the Coastal Charlotte Harbor Monitoring Network for 12 segments. Additional fixed station, monthly water quality data were provided by Lee County for the Pine Island Sound, Matlacha Pass, San Carlos Bay, Caloosahatchee River and Estero Bay segments; these data include the entire period of record for these segments collected by Lee County. Also, fixed station data for 12 stations within the West Wall, East Wall, Bokeelia, Tidal Peace River and Tidal Myakka River segments from the Southwest Florida Water Management District from January 1993 through December 2000 were also included. All data were divided into “wet” and “dry” seasons, defined as data collected during the months of July-October and November-June, respectively. Salinity data analyses support this delineation (see Greenawalt-Boswell et al. 2006).

Segment	Period of Record
Lemon Bay (southern)	April 2001-March 2005
Gasparilla/Cape Haze	April 2001-March 2006
West Wall	Jan 1993-March 2006
East Wall	Jan 1993-March 2007
Tidal Peace	Jan 1993-March 2008
Tidal Myakka	Jan 1993-March 2009
Bokeelia	Feb 1993-July 2006
Matlacha Pass	Dec 2000-June 2006
San Carlos Bay	Dec 2000-June 2006
Pine Island Sound	Dec 2000-July2006
Estero Bay	Dec 2000-Aug 2006
Tidal Calooshatachee	April 1999-July 2006

Table 5. Water Quality Data Period of Record by Segment

Immediately visible from the concentration intercepts listed in Table 4 is that some of these values are relatively high. For instance, the chlorophyll *a* values for multiple segments are higher than the Florida water quality standards for chlorophyll *a* of an annual average of 11 µg/L for marine and estuarine waters. These intercepts are the maximum potential concentration of the analytes and are acceptable for meeting the percent-light-at-depth goal only when the concentrations for both the other 2 analytes are zero, an unlikely situation except when color is sufficiently high to limit phytoplankton production. Excepting those periods when chlorophyll *a* concentrations are very low due to high color concentrations, the concentrations for all 3 light attenuation components will be greater than zero, thereby requiring concentrations of all 3 components to be less than these intercepts to maintain the percent-light-at-depth goal. The intercepts are a necessary step in developing the resulting plane of constant attenuation, which denotes the acceptable concentration of a component of light attenuation in relation to the concentrations of the other components. This plane allows the concentration for each component to assume any concentration between zero and its maximum; its value dependent on the concentrations of the other 2 components. This objective is in contrast to many water quality targets that set a discrete maximum for each specific analyte without regard to concentrations of other relevant constituents affecting the targeted outcome.

The results from plotting the derived planes of constant attenuation over water quality data collected in the recent past show that there are times and locations within each segment that current water quality would not meet the percent-light-at-depth goals proposed in this effort. The locations in which these data were collected may support seagrass if, for instance, they are shallower than the depth target. Also, some data points on the scatterplots may represent locations in which data were collected that are deeper than our depth goal. However, both the seagrass light requirements and maximum seagrass depth distribution targets are reasonable goals based upon current observations. The light requirements for seagrass are based upon an average value, whereas the water quality data are point values.

Multiplying the optical model partial attenuation coefficients in Equation 3 above with color, chlorophyll *a* and turbidity concentrations collected monthly in the Pine Island Sound segment by Lee County for the Coastal Charlotte Harbor Monitoring Network and fixed station monitoring from December 2000 through July 2006 demonstrates that 26% of the collected data met the water clarity targets (N=443): 33% in the dry season (N=304) and 10% in wet season (N=139). In this segment, the seagrass depth target is 2.2 meters with an extinction coefficient target of 0.6. The mean extinction coefficient value was 0.8 ± 0.3 in the dry season and 1.3 ± 0.6 in the wet season. In comparison, 51% of the water quality data collected between 1993 and 2006 in the East Wall segment were equal to or less than the target extinction coefficient of 1.0 (N=470). The seagrass depth target for this segment is shallower than that for Pine Island Sound at 1.4 meters. 66% of the data collected in the dry season (N=316) fell within the plane of constant attenuation, while 22% of the data collected in the wet season (N=154) did. The mean extinction coefficient for this segment was 1.0 ± 0.5 in the dry season and 2.03 ± 1.2 in the wet season. Table 6 lists the median, mean and standard deviation for color, chlorophyll *a* and turbidity concentrations, the attenuation due to these concentrations and the percent of the total light extinction coefficient attributable to these concentrations for the water quality period of record (Table 5).

Nomographs

Lastly, for additional comparison purposes we could plot chlorophyll *a* and turbidity concentrations for specified depths and color values in terms of optical depth, k-z. Optical depth is the extinction coefficient multiplied by depth (in meters). Using the San Carlos Bay segment again as an example, we define our 25% subsurface irradiance at 2.2 meters as our target optical depth of 1.4 (see Light Attenuation Coefficient section above for steps to calculate this). This step allows researchers to use any combination of depth (z) and attenuation coefficient (k) that equaled 1.4 (e.g., k = 0.7 and z = 2 m) to derive multiple lines of constant attenuation. Thus, it allows us to review the results if we change either our 25% subsurface irradiance target or our depth targets for seagrass depth distribution.

For selected depths, 0.5, 0.75, 1.0, 1.5, 2.0 and 2.5 meters, we plotted our chlorophyll *a* and turbidity concentrations, given a range of color values in 10-step increments. This process allows one to determine a combination of the maximum color and chlorophyll *a* or color and turbidity concentrations for a depth of interest that meets our minimum light objective. Similar plots of turbidity and color given a specified range of chlorophyll *a* concentrations or chlorophyll *a* and color given a specified turbidity range could also be developed.

Segment	Chlorophyll *a* (ug/L)	Color (PCU)	Turbidity (NTU)	k color	k turbidity	k chlorophyll *a*	kd	% color	% turb	% chla	% intercept
Lemon Bay											
Median	4.38	15.00	3.83	0.21	0.24	0.21	1.07	20.1	22.7	21.5	27.9
Mean	6.28	22.55	5.03	0.32	0.31	0.31	1.24	22.8	25.1	22.4	29.7
St Dev	6.56	28.43	3.80	0.40	0.24	0.32	0.72	13.2	13.3	10.9	11.8
Gasparilla/Cape Haze											
Median	4.00	25.00	2.77	0.35	0.17	0.20	1.06	31.1	15.1	19.0	28.2
Mean	7.09	36.40	3.62	0.51	0.22	0.35	1.38	32.1	17.4	22.0	28.5
St Dev	7.58	41.56	2.75	0.58	0.17	0.37	0.91	15.3	10.0	13.2	12.7
Tidal Myakka											
Median	5.87	68.00	3.20	0.95	0.20	0.29	1.90	51.1	10.2	16.5	15.8
Mean	8.68	101.08	3.91	1.42	0.24	0.43	2.38	52.8	12.0	18.4	16.8
St Dev	10.45	86.63	2.53	1.21	0.16	0.51	1.38	19.1	7.6	12.7	8.7
Tidal Peace											
Median	6.43	60.00	3.30	0.84	0.20	0.32	1.87	44.6	10.9	20.7	16.0
Mean	9.92	89.11	4.09	1.25	0.25	0.49	2.29	48.1	12.7	21.3	17.9
St Dev	12.13	79.09	2.97	1.11	0.18	0.59	1.35	20.2	7.4	14.3	10.0
West Wall											
Median	4.69	36.50	2.00	0.51	0.12	0.23	1.26	41.7	9.4	17.5	23.8
Mean	7.38	61.16	2.53	0.86	0.16	0.36	1.67	43.8	10.8	20.2	25.2
St Dev	9.19	64.31	2.03	0.90	0.13	0.45	1.16	18.3	7.0	13.1	13.1
East Wall											
Median	3.68	25.00	1.70	0.35	0.11	0.18	0.98	36.9	9.5	17.3	30.5
Mean	5.97	43.76	2.11	0.61	0.13	0.29	1.34	38.8	10.8	19.7	30.6
St Dev	7.14	50.18	2.19	0.70	0.14	0.35	0.95	17.3	6.7	12.3	14.2
Bokeelia											
Median	3.28	16.85	1.14	0.24	0.07	0.16	0.80	30.2	7.6	19.1	37.3
Mean	5.50	26.94	1.46	0.38	0.09	0.27	1.04	31.2	10.2	21.4	37.2
St Dev	7.58	27.81	1.24	0.39	0.08	0.37	0.69	15.1	7.8	11.9	15.7
Pine Island Sound											
Median	3.90	13.80	1.48	0.19	0.09	0.19	0.83	24.0	10.2	23.8	36.2
Mean	5.86	19.05	1.81	0.27	0.11	0.29	0.98	25.2	12.0	26.1	36.6
St Dev	5.52	16.40	1.47	0.23	0.09	0.27	0.48	12.4	7.6	13.3	14.0
Matlacha Pass											
Median	4.65	27.00	1.37	0.38	0.08	0.23	1.01	38.3	7.1	21.4	29.8
Mean	6.83	37.99	1.54	0.53	0.10	0.33	1.28	38.9	7.9	23.4	29.9
St Dev	6.84	30.35	0.82	0.42	0.05	0.33	0.74	12.2	3.3	12.3	12.8
San Carlos Bay											
Median	3.77	18.00	1.66	0.25	0.10	0.18	0.89	30.7	10.9	19.7	33.7
Mean	5.22	28.61	2.03	0.40	0.13	0.26	1.09	31.7	12.8	21.2	34.3
St Dev	4.82	29.02	1.37	0.41	0.08	0.24	0.62	15.6	8.0	11.2	14.1
Tidal Caloosahatchee											
Median	5.19	66.00	2.40	0.92	0.15	0.25	1.97	50.9	8.0	16.0	15.2
Mean	10.50	86.41	3.70	1.21	0.23	0.51	2.25	52.6	10.7	20.1	16.7
St Dev	17.08	58.06	3.79	0.81	0.24	0.84	1.22	18.7	8.7	16.4	7.8
Estero Bay											
Median	4.00	22.15	2.90	0.31	0.18	0.20	1.09	31.6	16.3	18.3	27.6
Mean	4.94	30.74	3.92	0.43	0.24	0.24	1.20	31.8	18.9	20.0	29.2
St Dev	4.53	26.33	3.72	0.37	0.23	0.22	0.54	16.3	10.0	11.1	11.2

Table 6. Median, mean and standard deviations for color, chlorophyll *a* and turbidity concentrations, the attenuation (k) due to these concentrations, total light attenuation using

equation 3, and the percent of the total extinction attributable to each partial attenuation component, including the 0.3 intercept, for the water quality period of record.

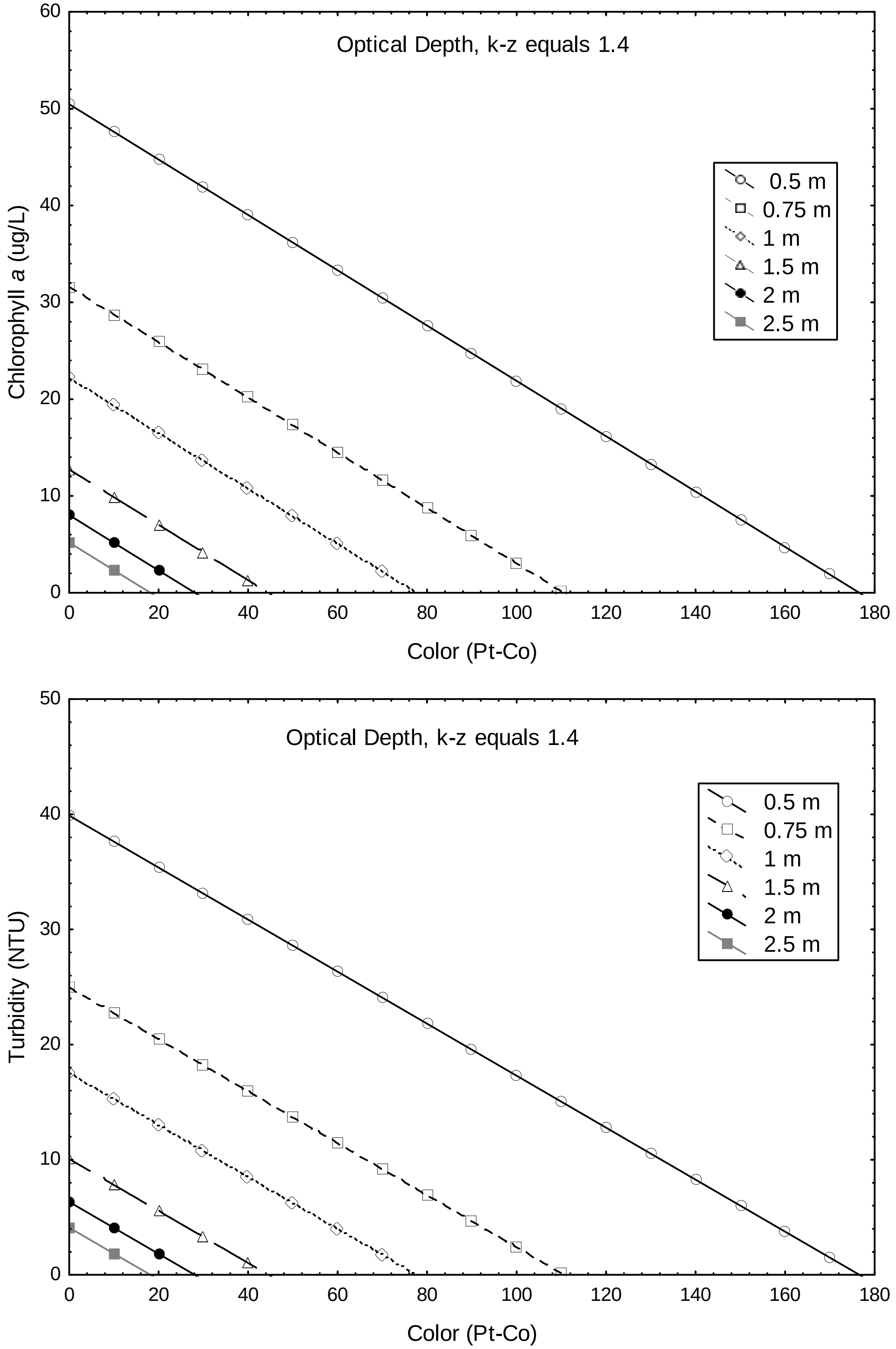
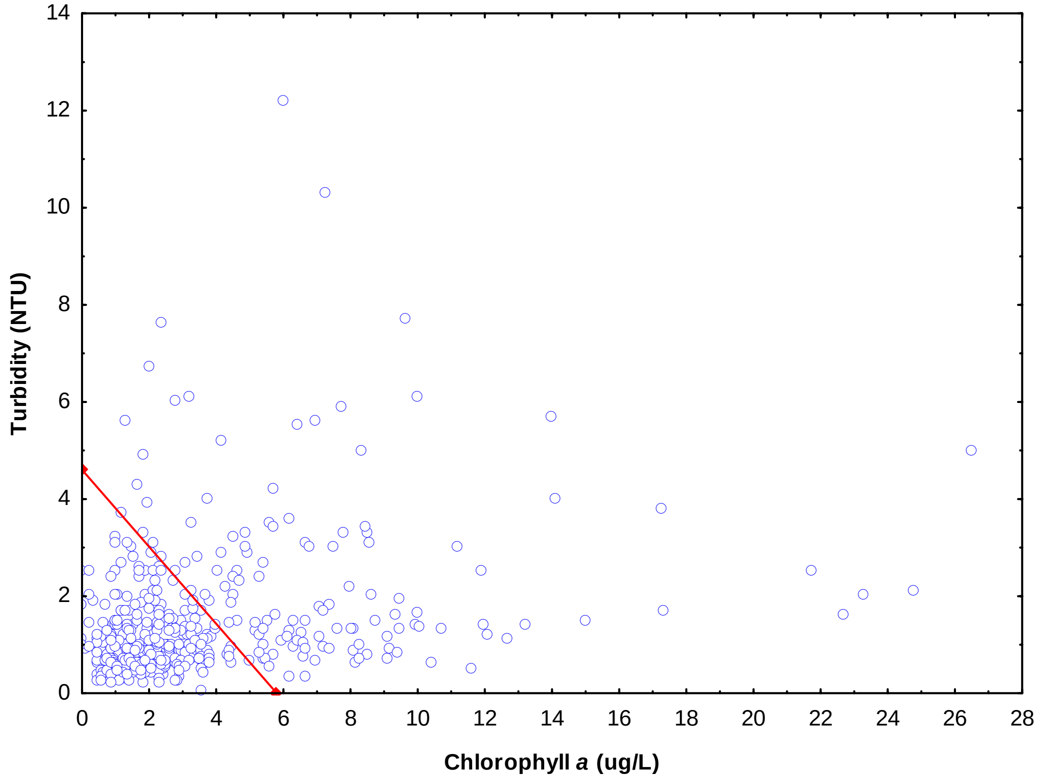


Figure 4. Nomographs of Chlorophyll *a* Concentrations and Color and Turbidity and Color for Specified Depths. For a given depth, combinations of color and chlorophyll *a* concentrations can reach the values under the line and maintain our light attenuation target.



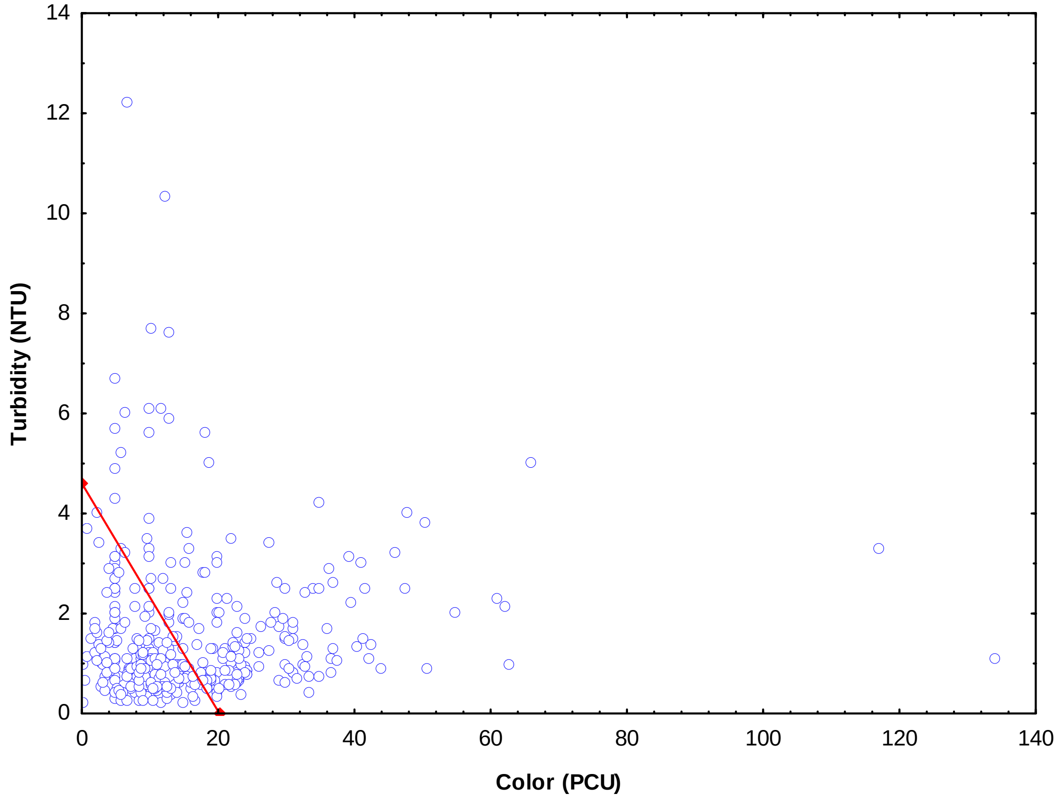
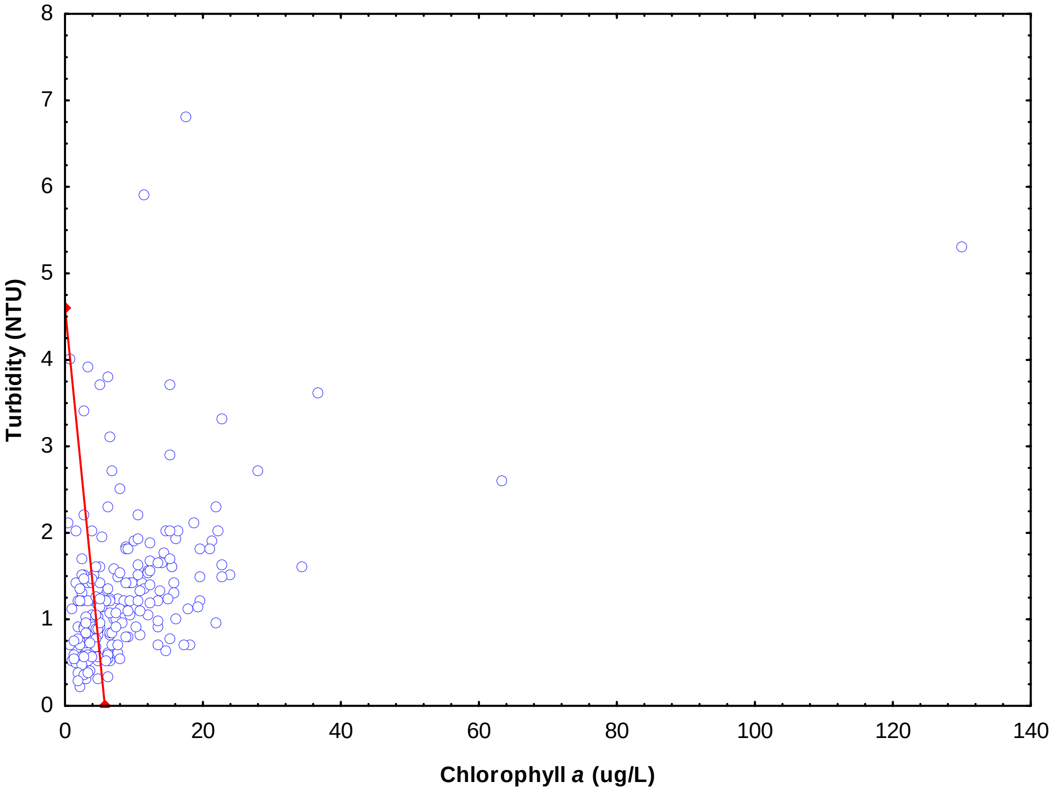


Figure 5. Instances of dry season water quality which met (below line) or exceeded (above line) water quality goals for chlorophyll *a* and turbidity and color and turbidity in the Bokeelia segment.



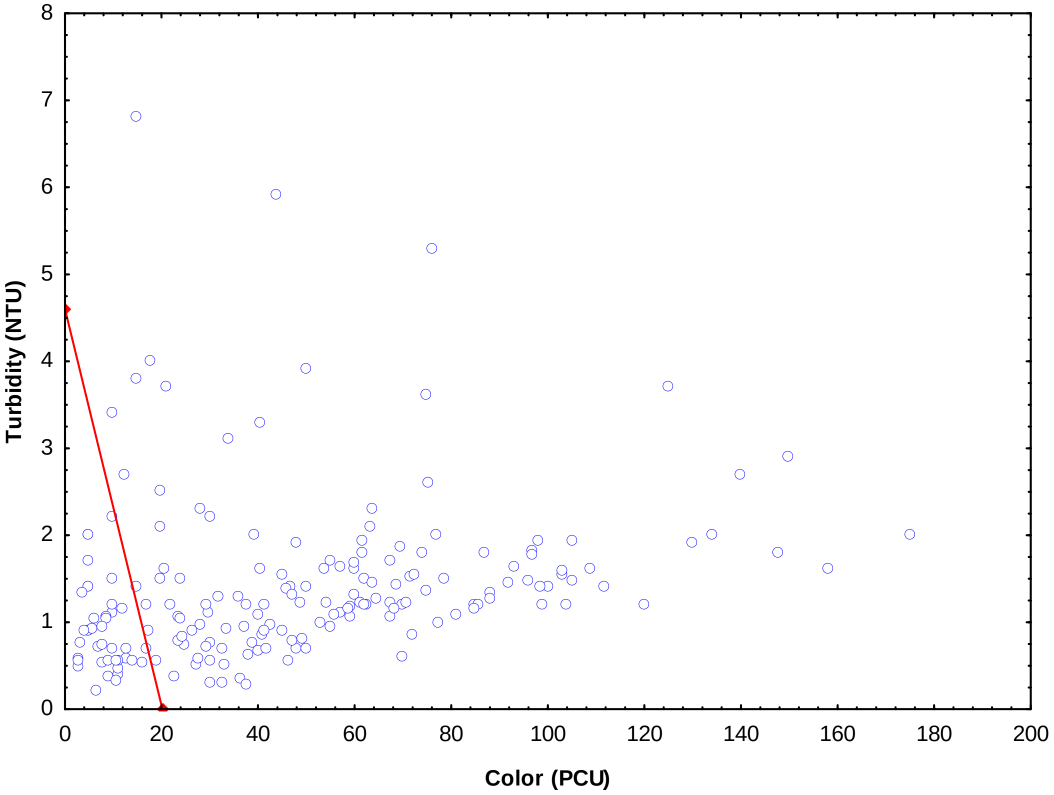


Figure 6. Instances of wet season water quality which met (below line) or exceeded (above line) water quality goals for chlorophyll *a* and turbidity and color and turbidity in the Bokeelia segment.

A comparison of wet and dry season water quality data from the each segment (Appendix B) suggests how water quality parameters differ by season. Generally, more water quality data fall within the plane of constant attenuation in the dry season (December through June) than the wet. More than half of the data collected during the wet season fall outside the plane of constant attenuation and would not meet minimum water clarity goals to provide 25% subsurface irradiance at the target maximum seagrass depth distribution for this segment.

Nomographs of chlorophyll *a* and color as well as turbidity and color demonstrate that as color values rise, the concentrations of the other partial constituents must simultaneously decrease to meet our optical depth goal. The graphs also demonstrate that as depths increase from 0.5 to 2.5, the concentrations of all 3 partial constituents must then decrease. It follows then that the deeper our depth target, the lower the concentrations of the partial attenuation constituents must be to meet our light goal.

Next Steps

Water Quality Management Strategy Working Group

These water quality targets are a first step in maintaining water quality of the Lemon Bay, Charlotte Harbor and Estero Bay regions. These targets should be adapted over time as scientific knowledge of various parts of the approach is gained and implementation management strategies improved. These targets and the approach herein should be revisited systematically in the future.

As adaptive targets, an imperative first step in the implementation of these targets is the formation of a Working Group of scientists, researchers and managers. This Working Group will meet regularly and will be tasked with determining when segments are failing to meet the targets herein and developing pollutant load management strategies to improve the water quality of those segments so that they meet these targets in the future. In this, it is expected that this Working Group will work similarly as the Tampa Bay Nitrogen Management Consortium and other groups in the implementation of the Tampa Bay water quality targets. The Working Group will also be tasked with developing further refinements of this approach including whether seagrass restoration goals are appropriate. The Charlotte Harbor Working Group will need to determine and fill knowledge gaps for the implementation of these targets, including determining regulatory, monitoring and management gaps. It is expected that the Working Group will encompass members of the NEP Technical Advisory Committee, Management Committee and others as needed, and that the NEP Senior Scientist will staff the Working Group. Consultant services may be required to support this process and shown in the CHNEP workplan with partner funding. However, as in the other implementation steps for these targets and the NEP CCMP objectives, it is expected that Working Group members will take on the lead role in implementation.

Further Refinements of Approach

Other region-specific maximum depth distribution goals could be developed. The plane of constant attenuation is based upon seagrass bed depth goals derived from fixed transect data collected between 1999 and 2005 and seagrass areal coverage maps from 2003. The depth targets were created using the greatest annual average maximum seagrass deep edge per segment. A different strategy in the future could be to determine restoration depth targets based upon the 1950s seagrass maps currently being developed.

Light requirements of seagrasses within Charlotte Harbor could be refined as well. We used the estimate of 25% subsurface irradiance, but future research may document that more light is needed to be protective of seagrasses. Salinity can affect seagrass photosynthesis (e.g., Torquemada et al. 2005), productivity (Tomasko and Hall 1999) and abundance (Montague and Ley 1993). As both Tomasko and Hall (1999) and Dixon and Kirkpatrick (1999) cite salinity stress as possible reasons for reduced *T. testudinum* productivity in this area, seagrasses in Charlotte Harbor would benefit from research to determine actual light requirements based on environmental gradients such as salinity as well as water clarity.

The partial coefficients within this optical model could be refined in several ways. McPherson and Miller (1994) used water quality samples collected in Tampa Bay and Charlotte Harbor to derive the partial attenuation coefficients used in this effort, and the model could be improved by including only data collected from Charlotte Harbor. Also, although other researchers have calculated partial light attenuation coefficients to support seagrass growth that differ from those in this effort (e.g., Gallegos and Kenworthy 1996), the coefficients used here are locally derived and the best available estimates for environmental conditions in Charlotte Harbor.

The “non-algal suspended matter” partial light attenuation coefficient is an important parameter to accurately estimate, as this component is generally responsible for over 50% of light attenuation in these areas (McPherson and Miller 1987; Dixon and Kirkpatrick 1999). Furthermore, the actual composition of “non-algal suspended matter”, represented by the turbidity term in McPherson and Miller (1994), will differ by segment and by season. Turbidity is a mixture of inorganic suspended matter, such as silt or clay, as well as plankton or other microscopic organisms (APHA 1985). Turbidity values in Charlotte Harbor are significantly different in dry and wet seasons (Ott and Corbett 2005), and phytoplankton communities, which also differ from season to season and from region to region, will have a variable impact on light scattering and absorption (see Kirk 1994 and Jeffrey et al. 1997). However, McPherson and Miller (1987) suggested that re-suspended sediments may largely contribute to the non-algal suspended matter parameter in at least some of the areas in Charlotte Harbor and later estimated its value by accounting for the contribution of chlorophyll to the difference in attenuation between filtered and unfiltered water samples (McPherson and Miller 1994). Therefore, while this effort uses the best available data appropriate for the Charlotte Harbor region, management strategies incorporating our approach to setting water clarity goals should be prepared to estimate the “non-algal suspended matter” parameter by both season and estuary segment.

Quality of Light

These targets should be modified in the future to reflect the importance of the *quality* of light reaching seagrass beds in addition to the quantity of light. For example, the model can be modified to reflect the importance of the blue region of the visible spectrum for seagrass photosynthesis in lieu of our current 25% incident light target, that consists of all wavelengths between 400-700 nm.

Photosynthetically active radiation (PAR) constitutes the 400-700 nm spectral range, while the ultraviolet and infrared spectral ranges have shorter and longer wavelengths than PAR, respectively. To become available for aquatic resources, this light energy must first cross the air-water interface. Some of this light will be reflected at this interface, and the amount of light entering the water column will depend on sun angle, clouds, the roughness of the water surface and other conditions (Kirk 1994). Light will then be either scattered or absorbed once it enters the water column (again scattering only increases the pathlength of photons before they are absorbed unless the photons are scattered upwards). The 25% PAR target used herein is specific to subsurface irradiance; that is, our goal is 25% incident light that has already passed through the air-water interface.

Absorption of light energy in the water column can essentially be broken down into 4 components of the aquatic ecosystem: water, dissolved yellow pigments (gilvin), photosynthetic biota (phytoplankton and macrophytes) and inanimate particulate matter (tripton) (Kirk 1994). Water itself absorbs light energy weakly in the blue and green regions of the spectrum; it increases its absorption above 550 nm and strongly absorbs in the red region of the PAR spectrum (Kirk 1994). Gilvin, or dissolved organic matter, depending on its chemical composition, absorbs strongly in the blue and green spectrums, decreasing as wavelengths get longer until it absorbs weakly in the red region (Kirk 1994). Gilvin is formed as plant tissue decomposes in soil or waterbodies by microbial actions or ultraviolet light to ultimately carbon dioxide and inorganic forms of nitrogen, phosphorous and sulfur. In the course of this decomposition process, a complex group of “humic substances” is formed, which vary in size from freely soluble compounds to insoluble macromolecular aggregates (Kirk 1994). Much of the soluble humic substances from fresher waters particulates out when it comes into contact with higher salinity water, although a fraction remains in solution (cited in Kirk 1994). Humic substances in receiving waterbodies arise not only indirectly from decomposing plant material leached from soils, but also decomposing phytoplankton and *live* aquatic plants, such as brown algal beds. The latter excrete phenolic compounds that give rise to humic substances as a result of oxidation and other processes (Kirk 1994).

Tripton, inanimate particulate matter, does not absorb light strongly but scatters intensely. Its absorption spectrum is similar to gilvin in that it absorbs strongly in the blue and green spectrums, decreasing as wavelengths get longer until it absorbs weakly in the red region (Kirk 1994). Tripton is separate from the next absorption component and consists of freely floating particles from land or marine sediments or humic substances as well as humics bound to minerals.

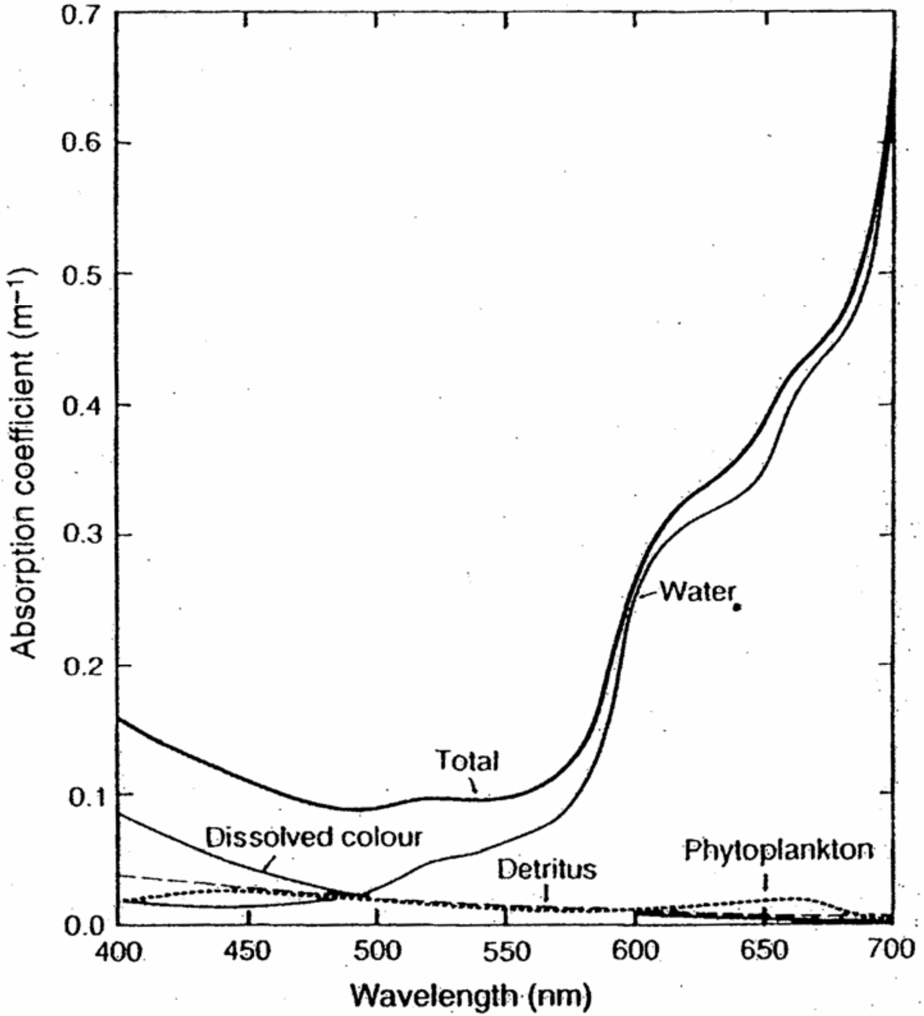


Figure 7. Total absorption spectrum of a model coastal waterbody with spectra of individual absorbing components. Chlorophyll *a* concentrations represent 1 µg/L in this graphic. (Extracted from Kirk, J. T. O. 1994. 2nd edition. Light and Photosynthesis in Aquatic Ecosystems. Cambridge University Press, New York, NY.).

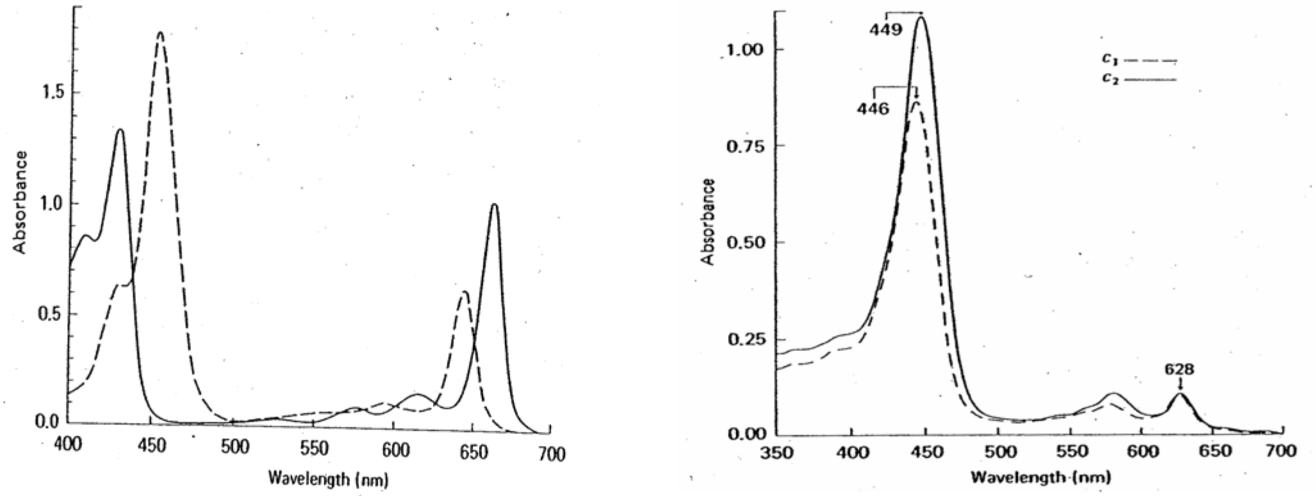


Figure 8. Left graphic is the absorption spectra of chlorophylls *a* (—) and *b* (---) at concentrations of 10 μg/ml. Graphic on right is absorption spectra of chlorophyll c_1 and c_2. (Extracted from Kirk, J. T. O. 1994. 2nd edition. Light and Photosynthesis in Aquatic Ecosystems. Cambridge University Press, New York, NY.).

The spectral absorption of light by photosynthetic pigments-chlorophylls, carotenoids, biliproteins vary by the composition of pigments present. All photosynthetic plants, including seagrass, contain chlorophyll and carotenoid, while the red algae, blue-green algae and others contain biliprotein also. The chlorophylls *a*, *b*, c_1 and c_2 have 2 main spectral absorption bands: in the blue region less than 500 nm and within the red region ca 625-670 nm (Kirk 1994). Absorption is very low, but not zero, in the middle, green region of the spectrum. Carotenoids absorb at shorter wavelengths in the blue spectral range. The spectral range of biliproteins vary but essentially has 2 peaks: a very strong peak at the higher visible wavelengths over 500 nm and a weaker peak in the ultraviolet range. Higher plants and green algae rely mainly on the chlorophylls for light harvesting. It is, thus, the 2 spectral regions in which the chlorophylls absorb strongly—the blue less than 500 nm and the red ca 625-670 that are most important for seagrass photosynthesis. Previous research has documented that light quality in addition to quantity determined the maximum depth of submerged aquatic vegetation distribution in lakes [i.e., Chambers and Prepas (1988) cited in McPherson and Miller 1994].

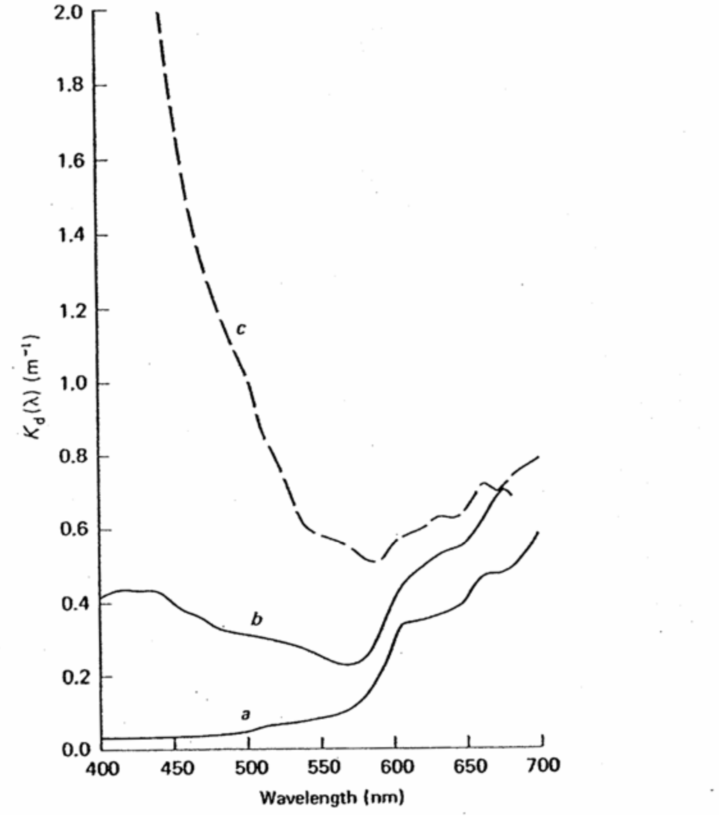


Figure 9. Comparison of spectral variations of the vertical attenuation coefficient for irradiance across the photosynthetic range in the following: a) unproductive oceanic waters, b) a productive (upwelling) oceanic water and c) an inland impoundment. (Extracted from Kirk, J. T. O. 1994. 2^{nd} edition. Light and Photosynthesis in Aquatic Ecosystems. Cambridge University Press, New York, NY.).

Inherent and Apparent Optical Properties

As sunlight enters a waterbody, it is either absorbed or scattered when it interacts with the particulates and the dissolved materials within the water. When light is scattered, the direction of the light can be changed, and some light may be absorbed by particulates and changed into other forms or wavelengths of energy (e.g. fluorescence). These processes change the intensity of light as a function of direction, the light field. The light field is the intensity of light as a function of direction, depth and wavelength. Since absorbance and scattering processes are a function of the wavelength of light, they change the spectrum of the light field. Thus, particulates and dissolved materials have spectral scattering and absorption characteristics that change the spectral light field. The spatiotemporal changes to the spectral light field within Charlotte Harbor and Lemon and Estero Bays are important with respect to the quality of light issue above. However, the measurement of scattering and absorption components of a waterbody, or inherent optical properties, is difficult and not usually undertaken *in situ*.

The scattering and absorption characteristics of a waterbody are called **Inherent Optical Properties** of a waterbody. Their magnitudes depend only on the components of the waterbody and not on the geometric structure of the light field. Properties that depend on the inherent optical properties *and* the light field are called **Apparent Optical Properties**. For example, a cloud moving in front of the sun causes shadowing and can immediately change the apparent optical properties of a waterbody, but not the inherent optical properties. The diffuse attenuation coefficient, K_d, is an apparent optical property; its value depends on depth, sun angle, sky conditions and shadowing by objects on the water surface. However, as depth increases, the influence of surface illumination characteristics decreases, and K_d eventually approximates a value representing the inherent optical properties.

The quantity and spectral quality of PAR in the water column affects photosynthesis of aquatic plants. The full spectrum of PAR from ca. 400-700 nm is usually measured in the southwest Florida by either 2 pi or 4 pi Licor instruments; the former in Upper Charlotte Harbor and Lemon Bay and the latter in Lower Charlotte Harbor and Estero Bay. The values derived from a 2 pi instrument reflects downward irradiance, while upward irradiance scattered from estuary bed sediments is additionally collected by 4 pi instruments. Both instruments also collect light reflected from vessel bottoms, and values can be influenced by the air-water interface, sun angle, waves and currents at the time of collection. Secchi disk depth measurements are a separate method in southwest Florida of estimating water clarity. Secchi disk measurements are subject to the same errors as those listed above for the Licor instruments and several additional errors associated with the visual acuity and subjectivity of the observer (Preisendorfer 1986). The human eye also does not detect the low and high ends of the PAR spectrum, less than 450 nm and above 650 nm (Johansson 2006). Thus, secchi disk measurements are of limited use in estimating the full spectrum of PAR; however, secchi disk measurements are inexpensive and easy. They are thus, widely used in field sampling and by volunteer groups, making secchi disk depth data widely available.

Downward irradiance diminishes with depth in an approximately exponential manner depending on wavelength and attenuation components of the water column; the rates of light attenuation for the different wavelengths are determined largely by the absorption spectrum of the attenuation components (Kirk 1994). In clear unproductive, oceanic waters, water is the main light absorber; thus blue and green light penetrate deeply, while red light is attenuated much more rapidly (see Fig. 7). In coastal waters that contain colored dissolved organic matter and phytoplankton, the green wavelengths penetrate the most deeply, whereas in clear, productive areas, blue light is attenuated more strongly than green but not as strongly as red (the latter due to absorbance by water itself and the former due to absorbance by phytoplankton pigments) (Kirk 1994). In highly colored coastal waters influenced by major river discharge, blue light is attenuated as strongly as red light (Kirk 1994). The contribution to total light attenuation by each partial attenuation component is not strictly a linear function of the concentrations of each component. However, simplification and approximation by linear equations, such as the optical model herein, is useful for management purposes (Kirk 1983; McPherson and Miller 1994; Gallegos and Kenworthy 1996). There are on-going efforts to better approximate the spectral distribution of the absorbance and scattering partial components in an optical model (e.g. Gallegos 1994), that can be used in the future in this region.

Pollutant Load Management Strategies

Analysis of recently-collected water quality data show that in all regions of the harbor, less than half of the water quality data meet the percent-light-at-depth goals proposed by the NEP and even less data meet the goals during the wet season. Thus, load reductions for these analytes may be necessary for at minimum, the wet season that lasts July-November.

One method in which pollutant load reduction goals can be determined is to use existing landuse models. Sarasota County has created a pollutant load model for the County which includes northern Lemon Bay. A landuse model (WMM) for the Caloosahatchee River and Estero Bay was created by CDM for the South Florida Water Management District. A WamView model for the Myakka River was completed by EPA in 2001 for the TMDL program. However, many of these models may not include runoff coefficients for dissolved matter and/or turbidity. Thus, spreadsheet models may be the preferred methods of determining preliminary load or yield estimates for each segment.

The Charlotte Harbor NEP hopes to better understand the role that landuse changes play with dissolved organic matter and concentrations in receiving water bodies. At present, in implementing these targets, the Charlotte Harbor NEP hopes to manage for chlorophyll *a* and turbidity and better understand color. However, there is anecdotal and other evidence supporting increasing trends in color concentrations in different regions of Charlotte Harbor and Estero Bay. These trends may be a result of decreased ultraviolet radiation breakdown of color by decreases in residence times from an overall loss of natural wetlands, changes in precipitation and flushing of sediments since monitoring of color concentrations began, changes in landuse practices and/or other causes. As color is such a large influence on light availability to aquatic resources in this region, resource managers need to question whether color can and should be managed. The program and its partners should design research and monitoring projects to shed some light on this issue.

Implementation

It should be noted that the program itself relies very heavily on its partners for the implementation of its objectives, including regulation, research, education, monitoring and restoration. For instance, the program does not acquire conservation lands, monitor water quality or submerged aquatic vegetation or establish Minimum Flows and Levels or Total Maximum Daily Loads rules, each of which are imperative to the successful implementation of CCMP objectives. The success and strength of the Charlotte Harbor NEP rests on the diligent support and enthusiastic participation of its partnering agencies, citizens, industries, not-for-profit entities and others. The program itself acts more as a consensus-based facilitative and coordinating entity than a *de facto* restoration, monitoring or research entity, with the exception of its central data compilation and warehouse role. The implementation of the numeric water clarity targets will not differ in this regard. Thus, in the coming years, the program and its partners will need to review how resource management regulations, plans and policies of its member agencies and others implement these NEP water quality targets. A Water Quality Management Strategy Working Group will take the lead role in facilitating this.

There are many mechanisms in which the program will help its partners implement these numeric water quality targets, mostly by compiling and analyzing data and information to support implementation. The program will use consultant services in workplan projects as necessary, Research and Restoration Partners grants, leveraged grants and program staff projects to help partners with implementation. Others, such as the NEP Legislative Agenda, Research Needs Inventory and Restoration Plan are on-going efforts to inventory program and partner research and restoration needs that can be used to keep track of knowledge gaps for the implementation of these targets.

Conclusion

The target light attenuation estimate presented here is based upon current seagrass distribution, and the water clarity goals proposed in this effort are meant to maintain the present seagrass coverage and depth distribution into the future. However, recent analysis of water quality data has demonstrated significant increases in total suspended solids in Lower Charlotte Harbor and Upper Charlotte Harbor regions and increasing turbidity in the Lower Charlotte Harbor region (Janicki Environmental Inc. 2003). These water quality constituents, along with dissolved matter, constitute the dominant influences on the light available for seagrass beds in most areas of Charlotte Harbor. In addition, there is evidence that seagrass has receded from deeper depths from historic periods (Harris et al. 1983). Seagrass coverage in the Upper Charlotte Harbor region is stable since mapping began in 1988 (Kurz et al. 1999; Corbett et al. 2005; Tomasko et al. 2005; Corbett 2006) and in both Upper and Lower Charlotte Harbor since 1982 (Corbett 2006). Nonetheless, if seagrass depth distribution is light limited (Dixon and Kirkpatrick 1999; Tomasko and Hall 1999), resource management strategies in this area should focus on the long-term maintenance of present seagrass coverage through the implementation of water clarity targets. If on-going research efforts determine that seagrass meadows within Charlotte Harbor have indeed receded or catastrophic losses occurred since historic conditions, depth distribution goals reflecting restoration targets could be created from historic data. It should be noted then that water clarity would in turn need to improve to meet those restoration targets. Water quality that meets the goals derived in this report should allow appropriate water clarity conditions for the maximum depth distribution of seagrass meadows that currently exist.

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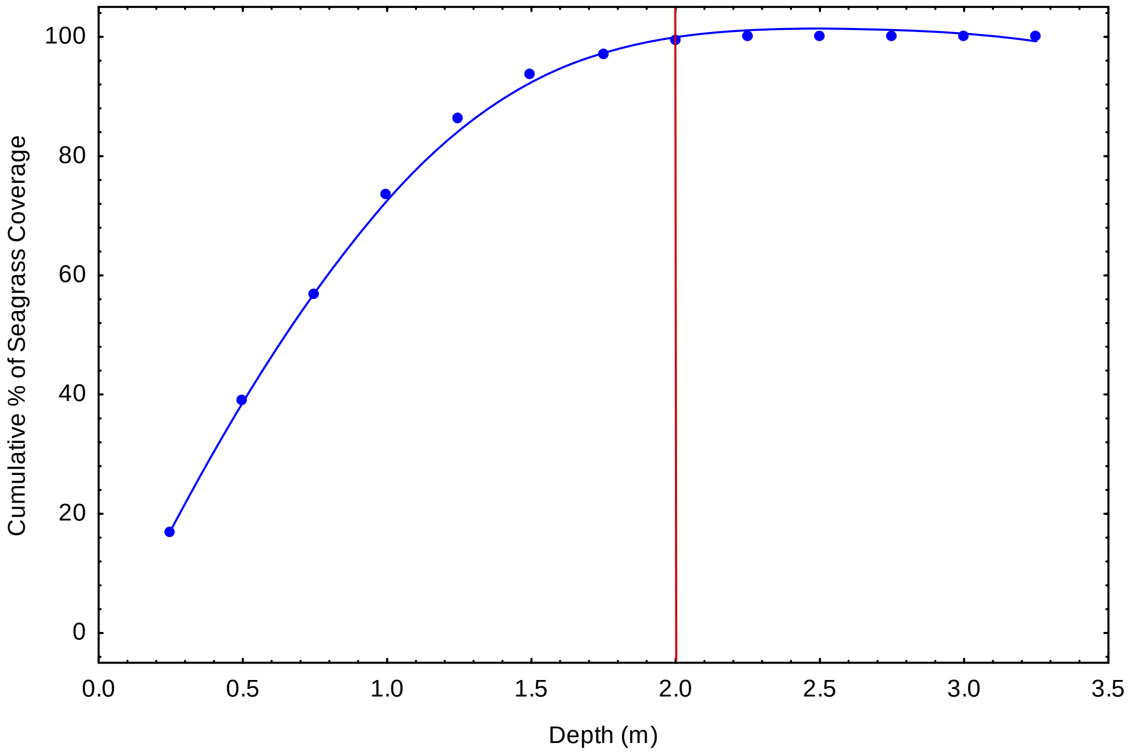
Appendix A

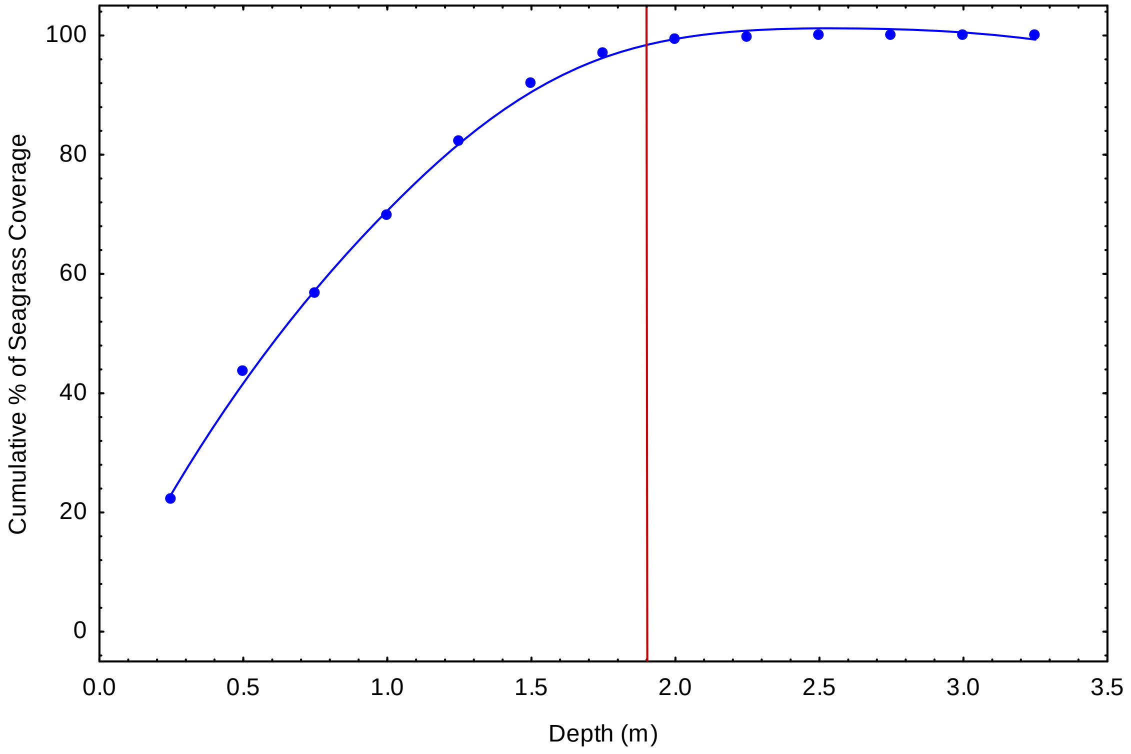
Cumulative Frequency Curves of Seagrass Coverage by Depth

(Target Seagrass Deep edge is represented by red line)

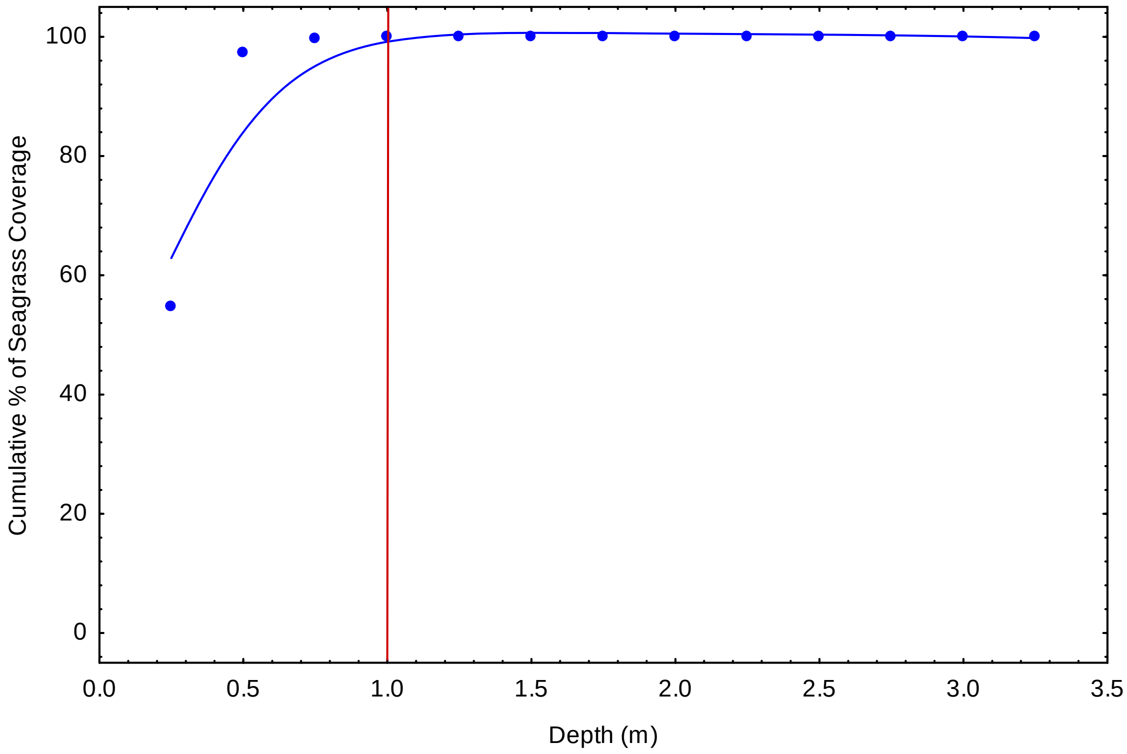
Cumulative Frequency Seagrass Coverage by Depth
Lemon Bay



Cumulative Frequency Seagrass Coverage by Depth
Cape Haze/Gasparilla



Cumulative Frequency Seagrass Coverage by Depth
Tidal Peace



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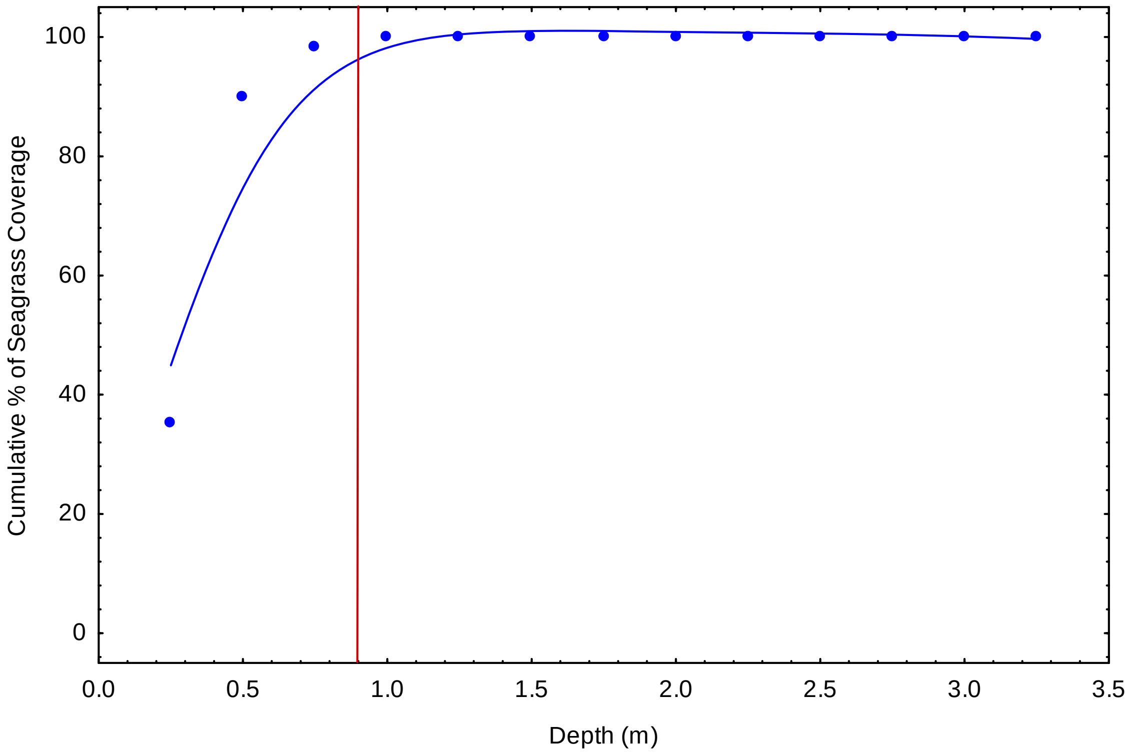
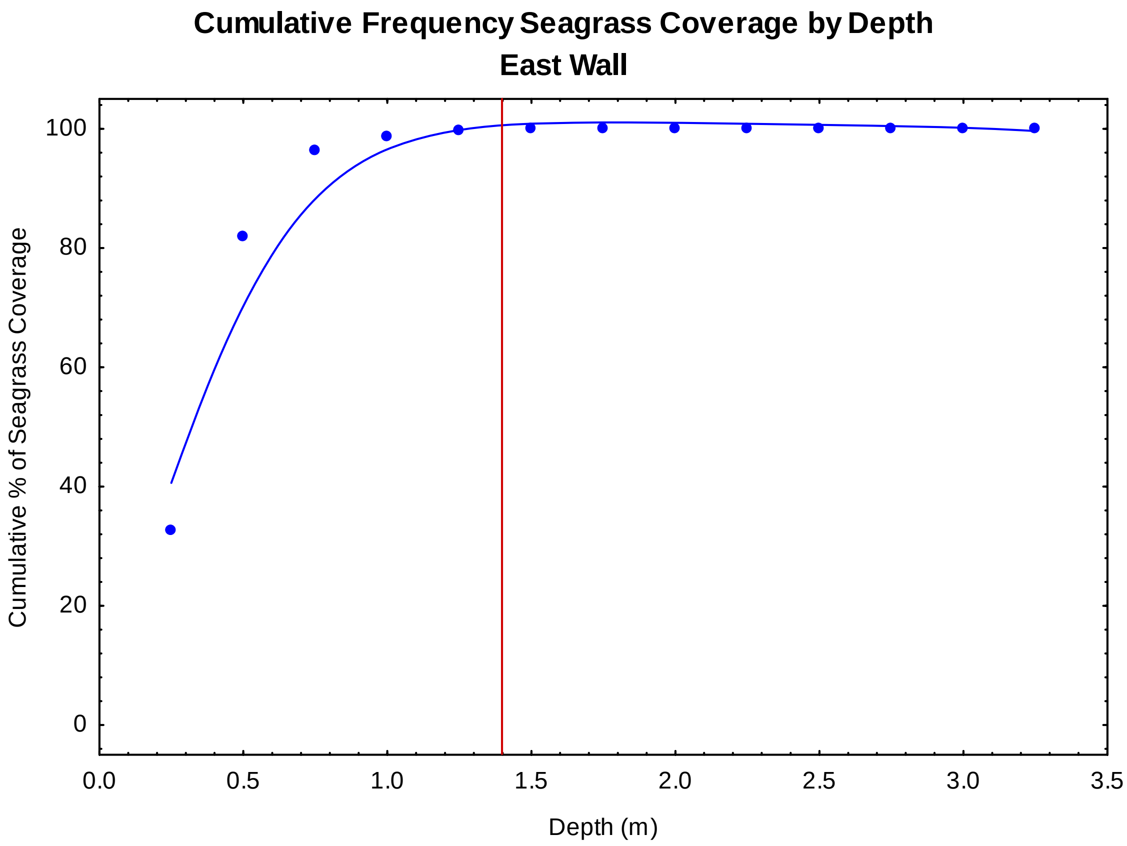
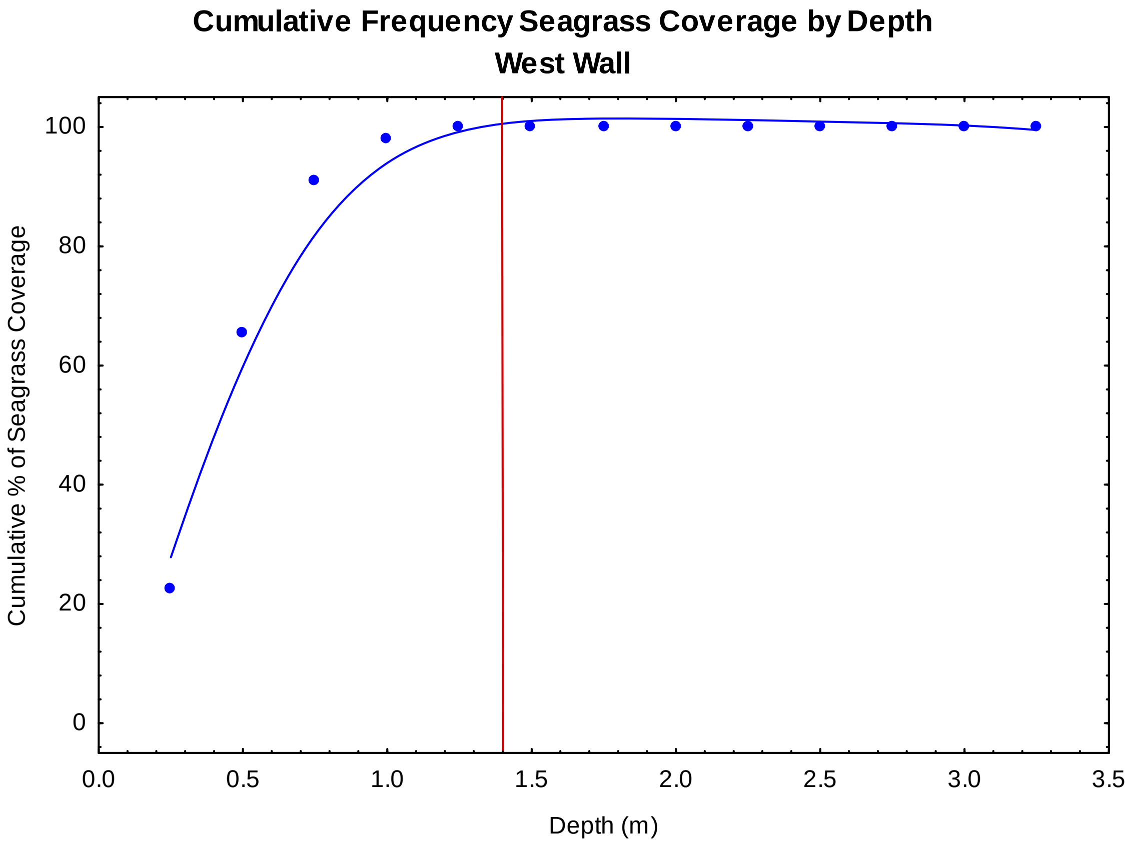
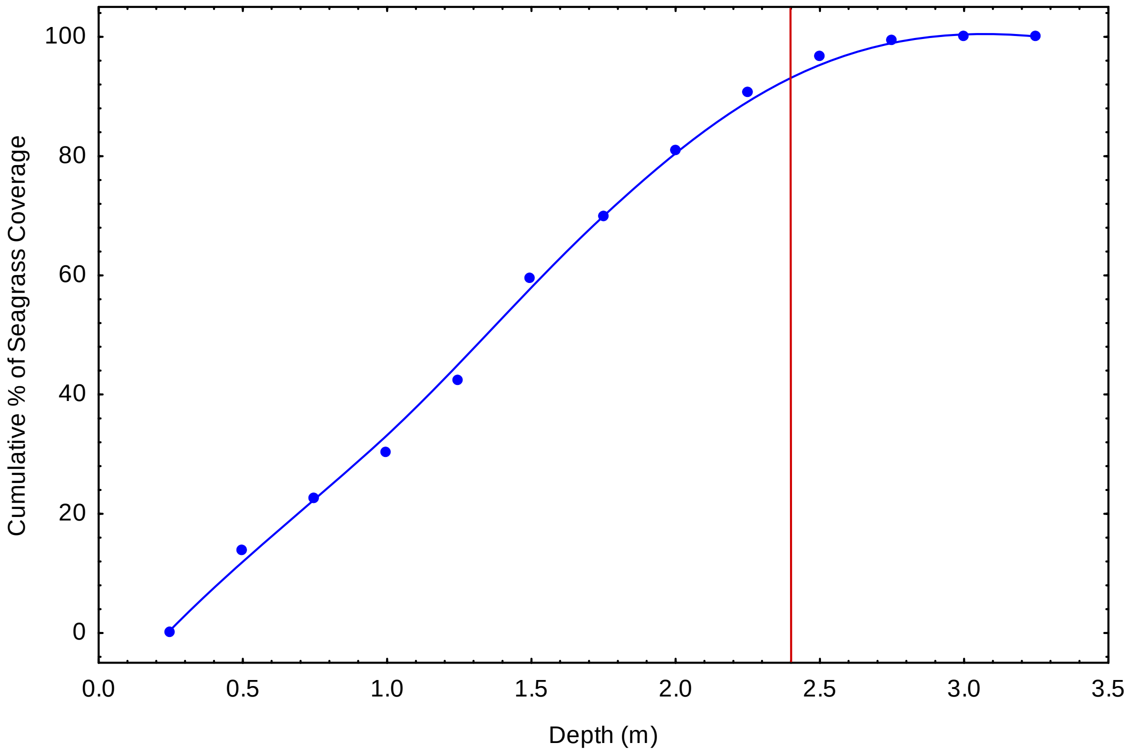
Tidal Myakka



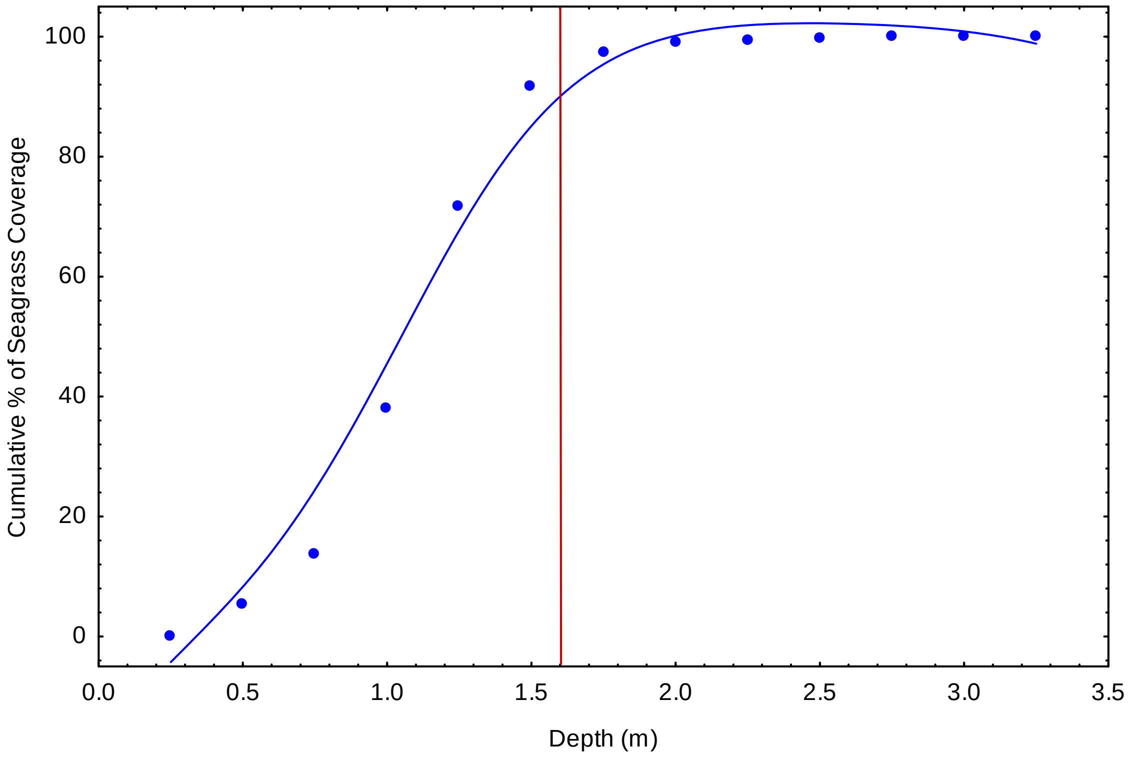

Cumulative Frequency Seagrass Coverage by Depth
East Wall


Cumulative Frequency Seagrass Coverage by Depth
West Wall

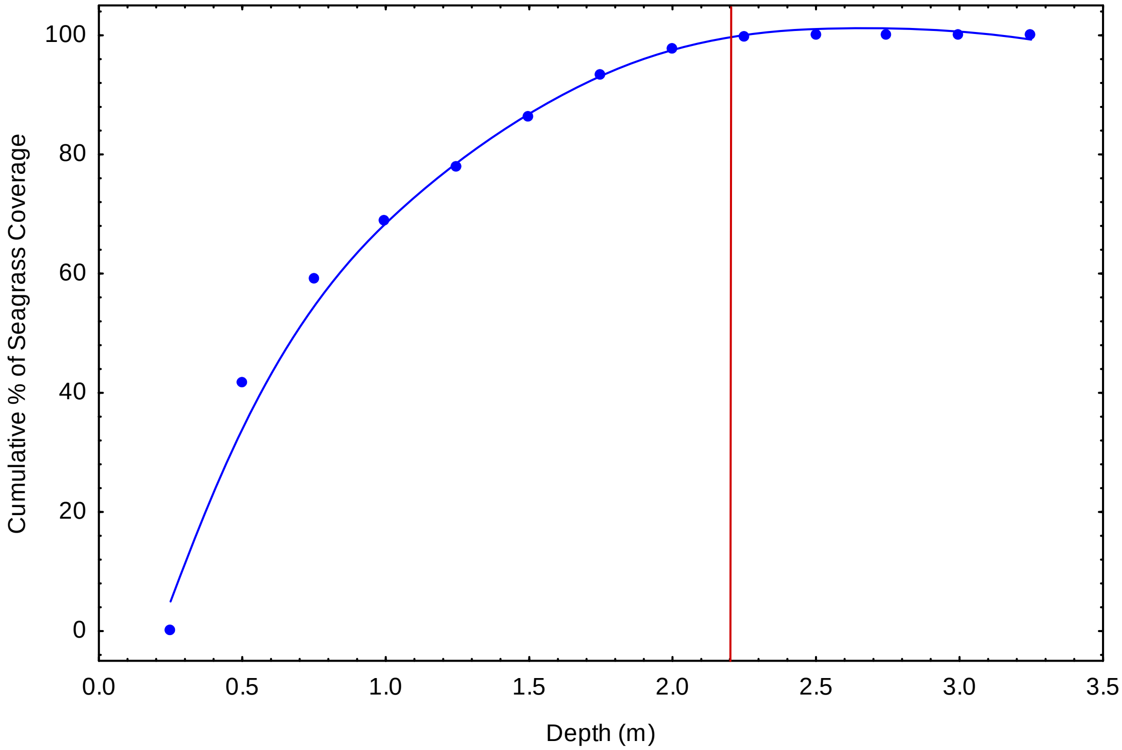
Cumulative Frequency Seagrass Coverage by Depth
Bokeelia



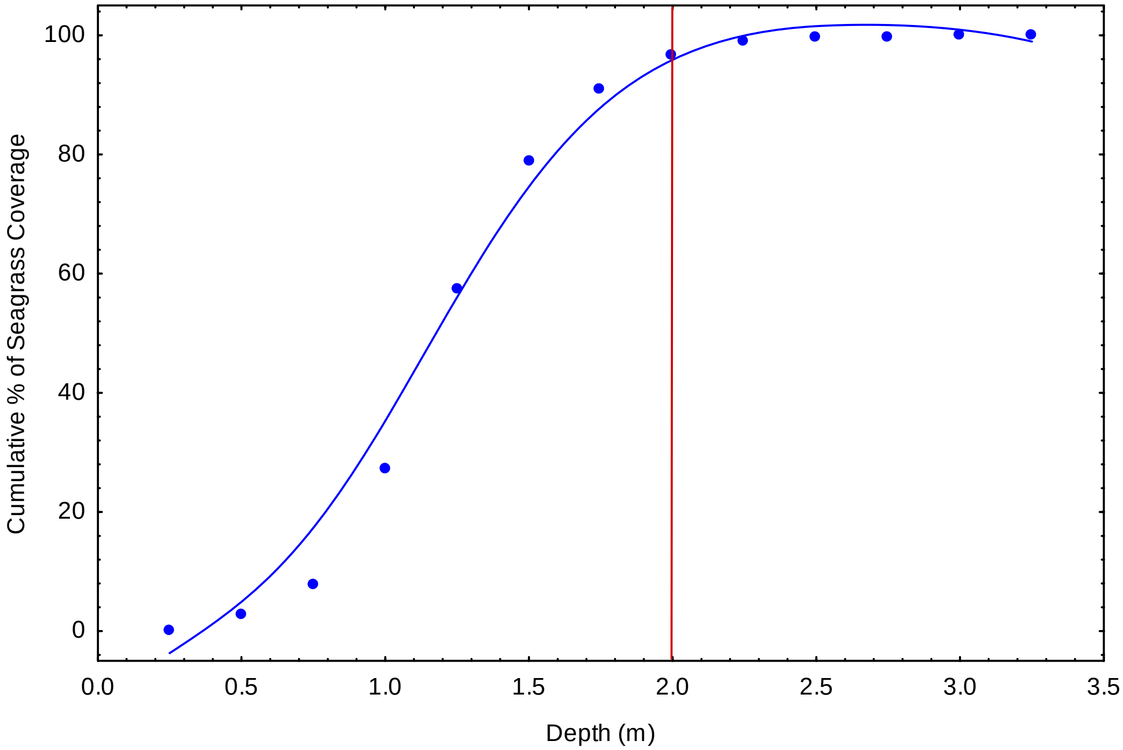
Cumulative Frequency Seagrass Coverage by Depth
Estero Bay

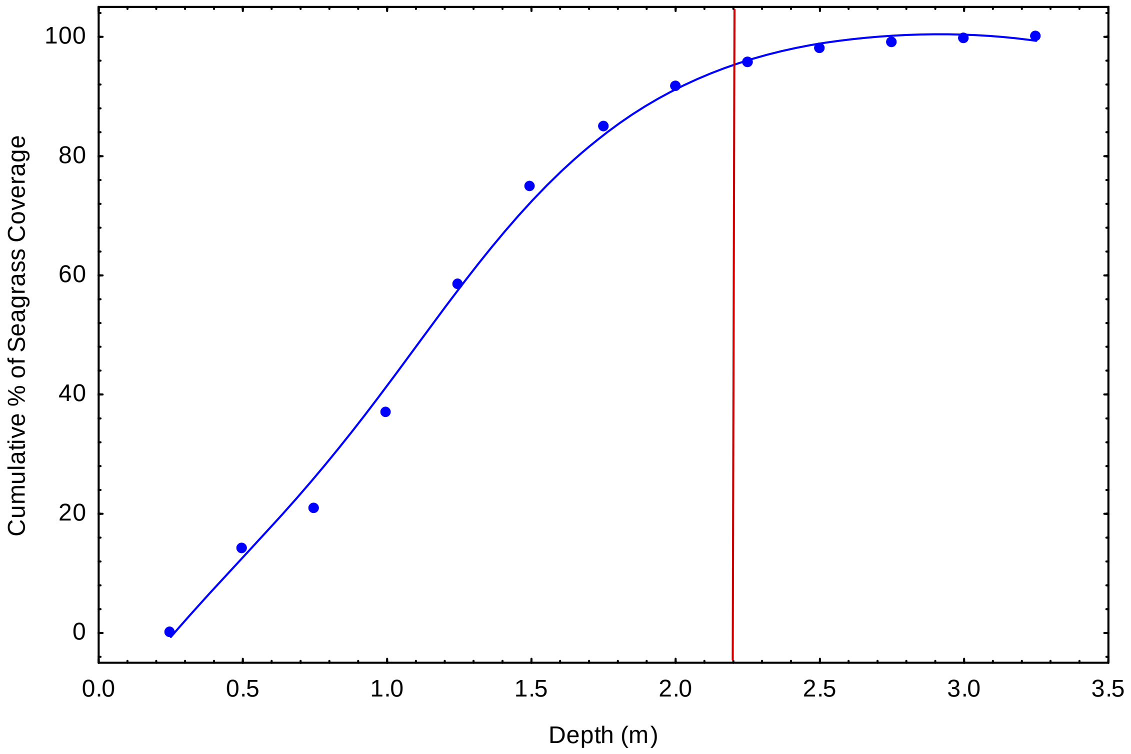


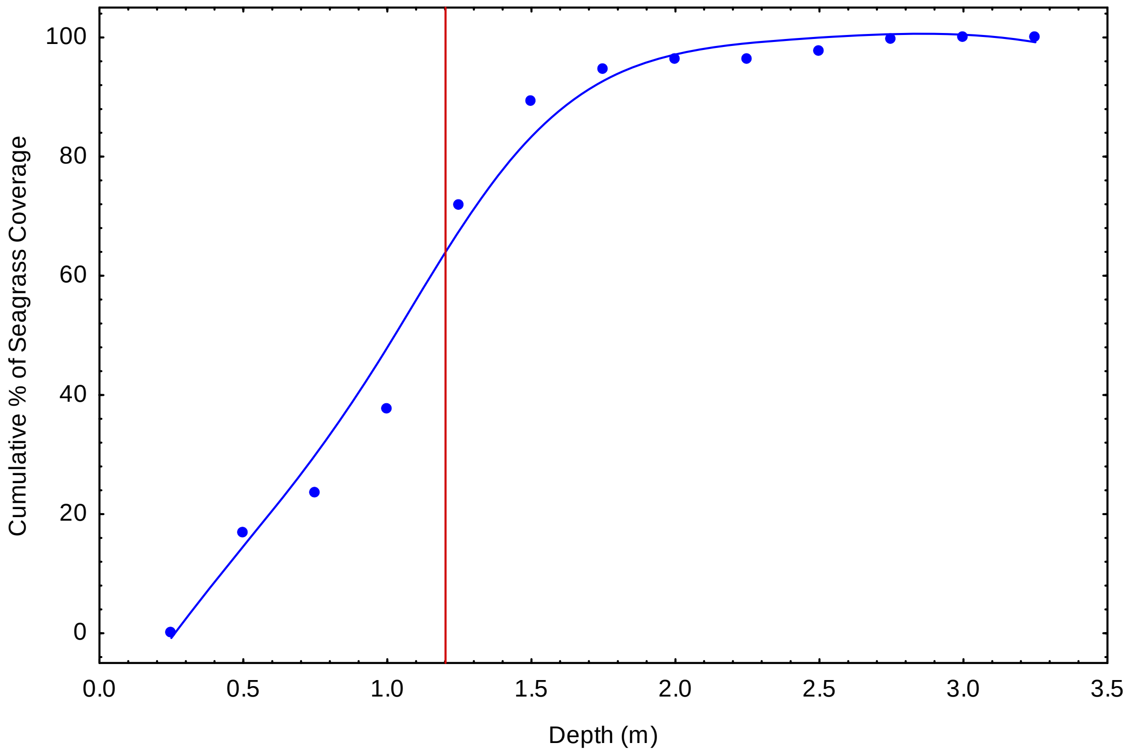
Cumulative Frequency Seagrass Coverage by Depth
Pine Island Sound



Cumulative Frequency Seagrass Coverage by Depth
Matlacha Pass



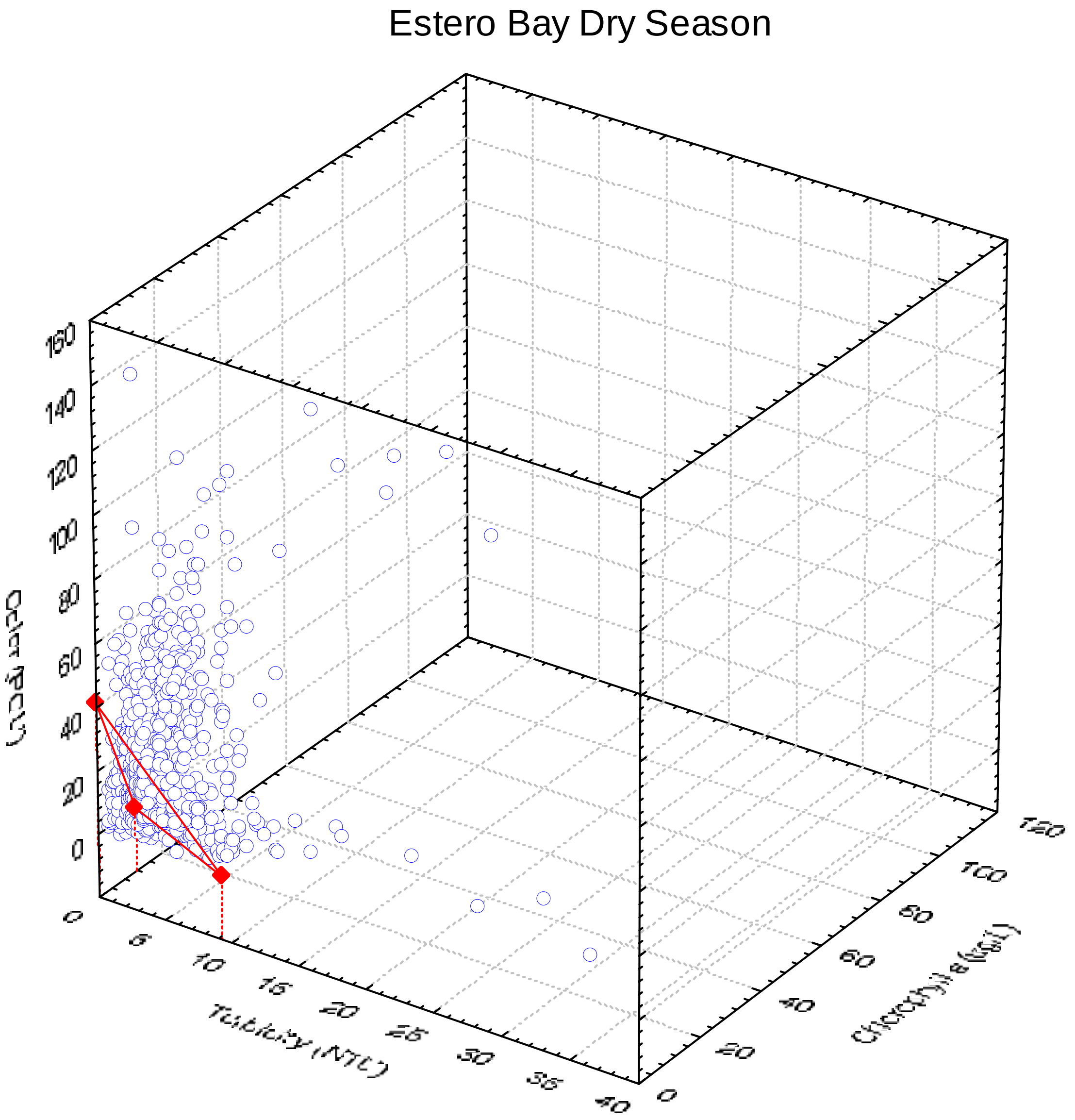

Cumulative Frequency Seagrass Coverage by Depth
San Carlos Bay


Cumulative Frequency Seagrass Coverage by Depth
Tidal Caloosahatchee River

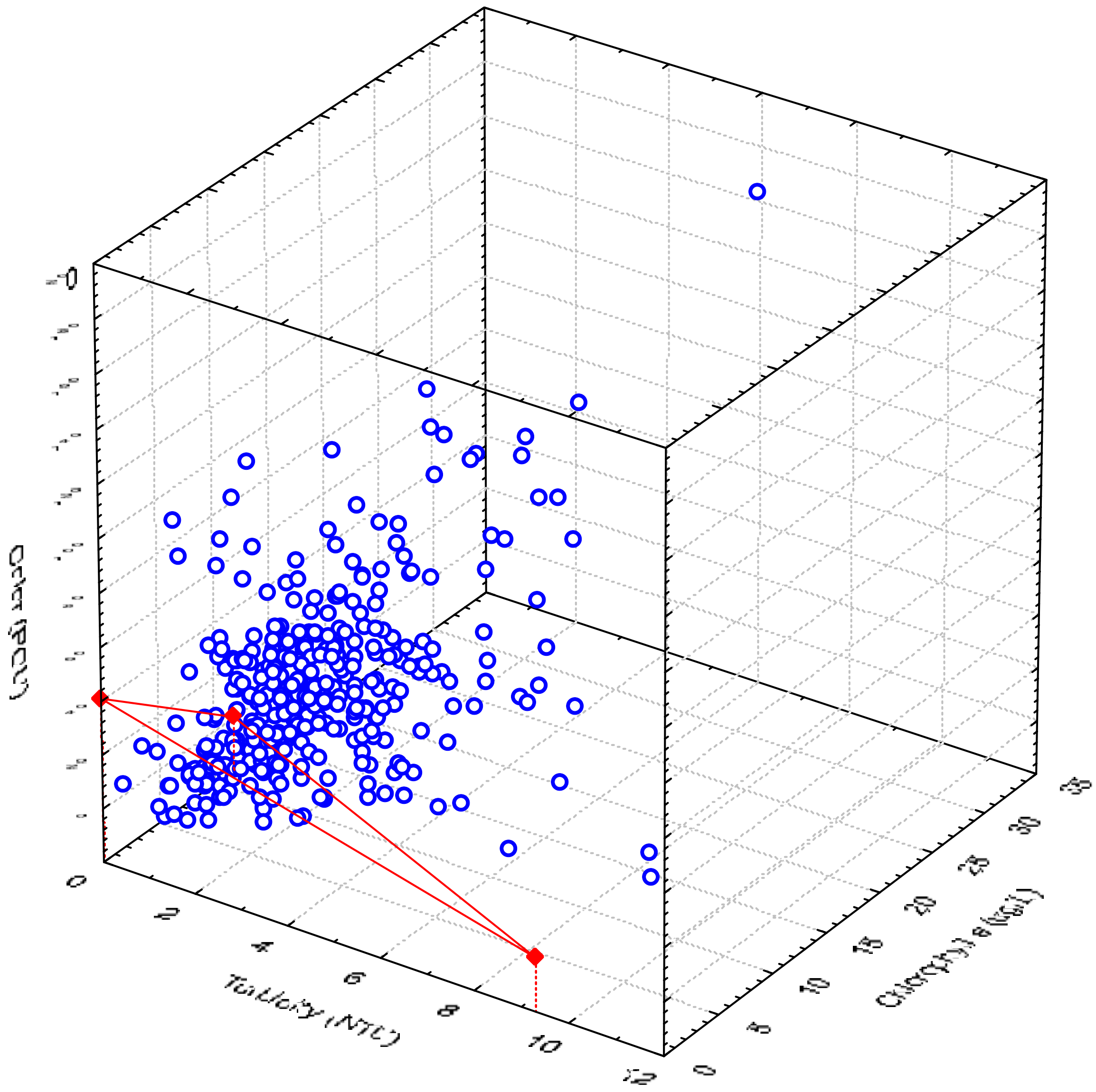
Appendix B

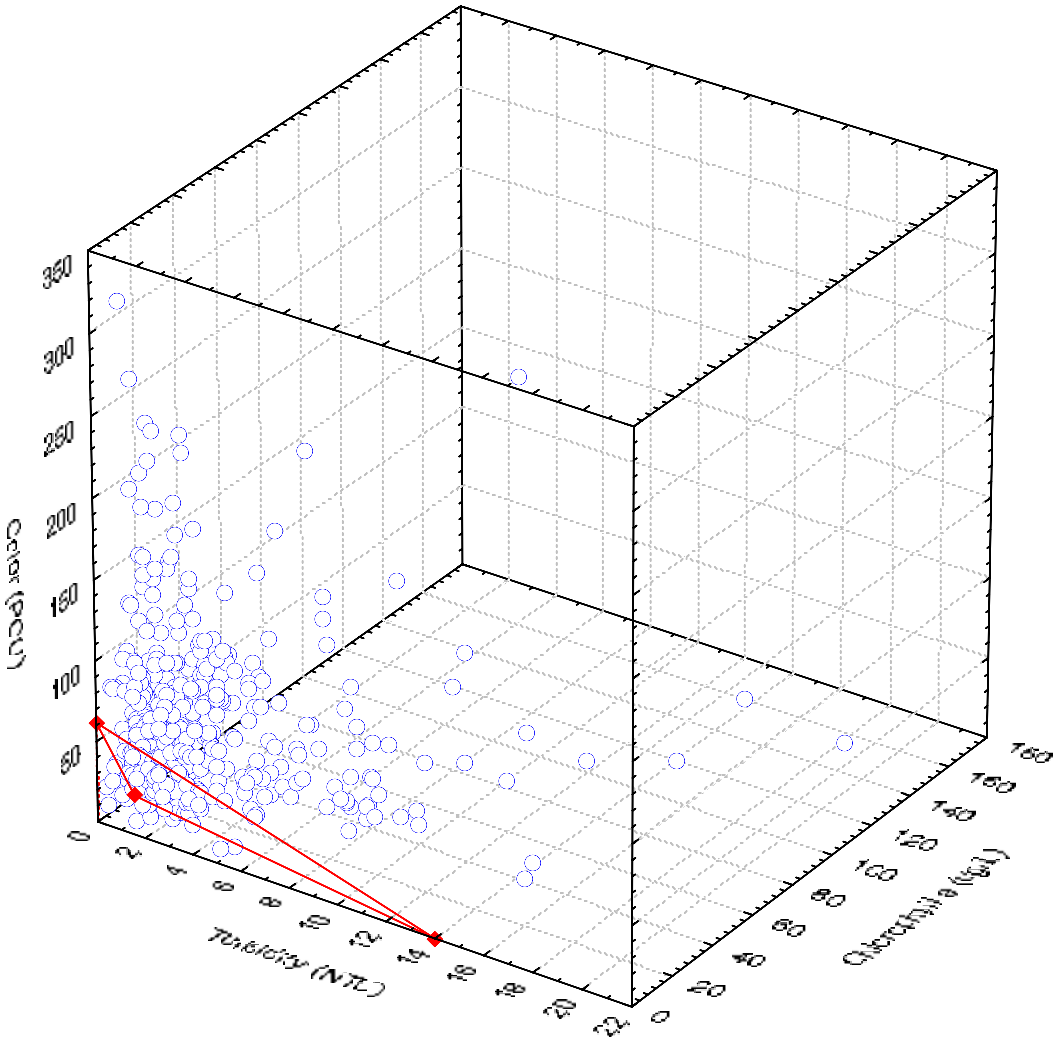
3-D Graphs

(Plane of constant attenuation is in red)

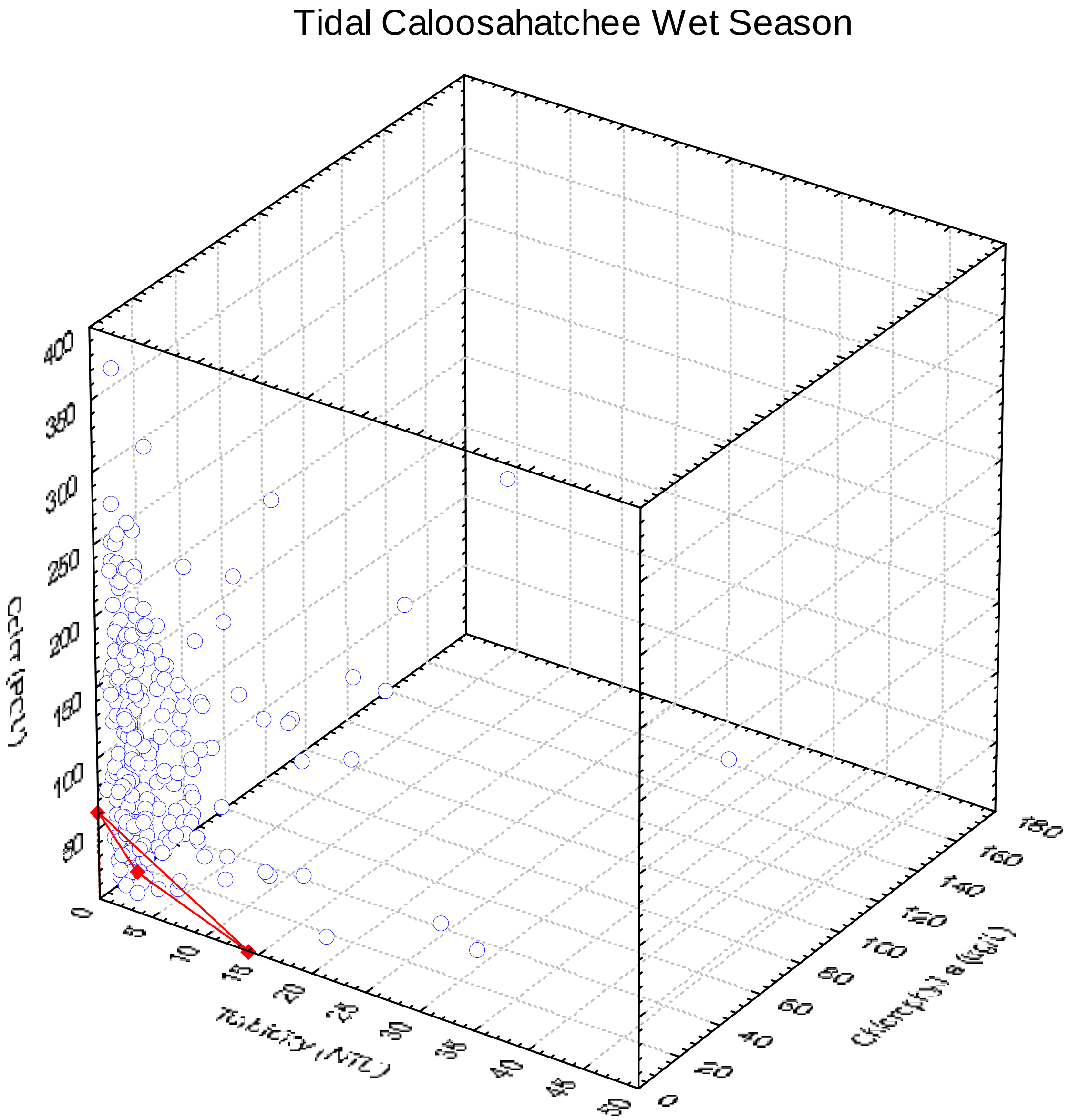

Estero Bay Dry Season
Color (PCU)
160
140
120
100
80
60
40
20
0
Turbidity (NTU)
0
5
10
15
20
25
30
35
40
Chlorophyll a (ug/L)
0
20
40
60
80
100
120

Estero Bay Wet Season

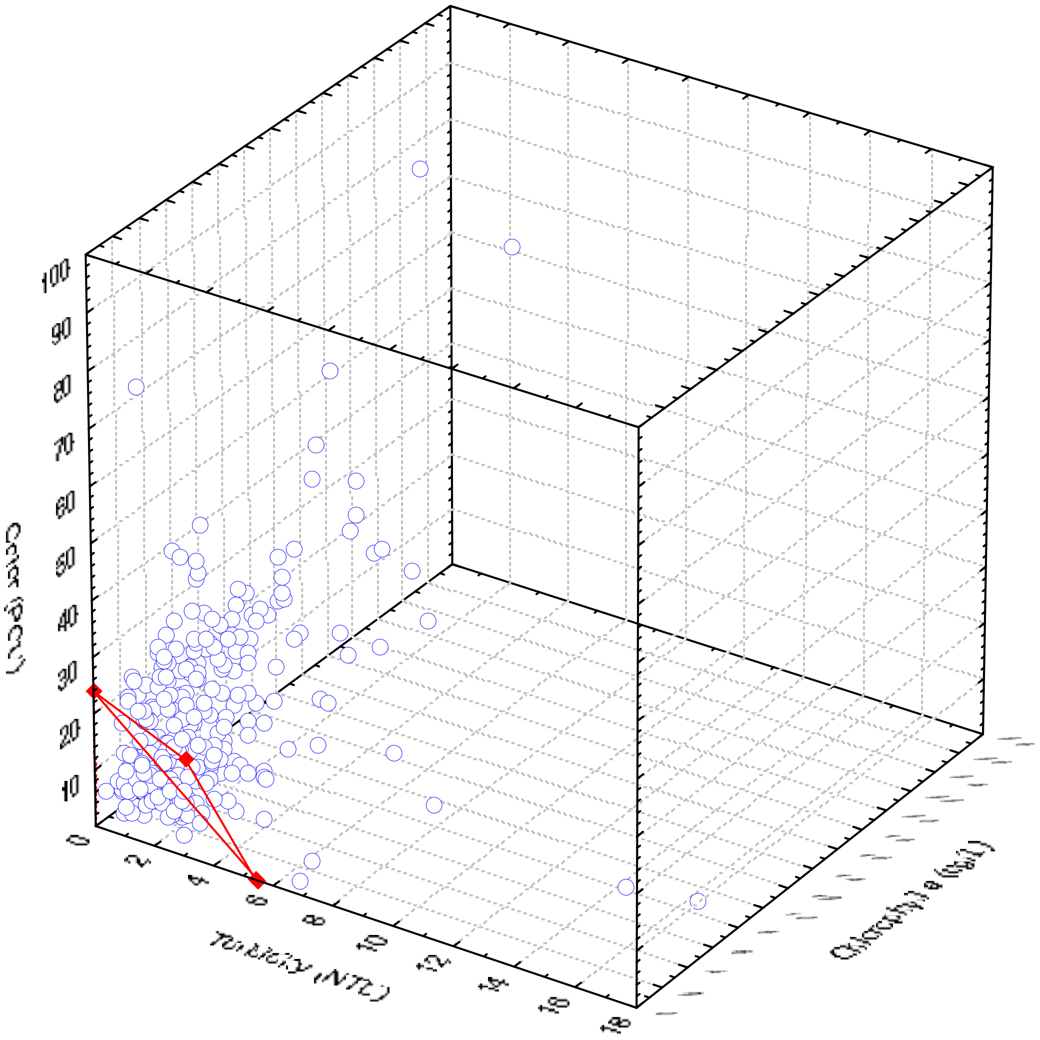




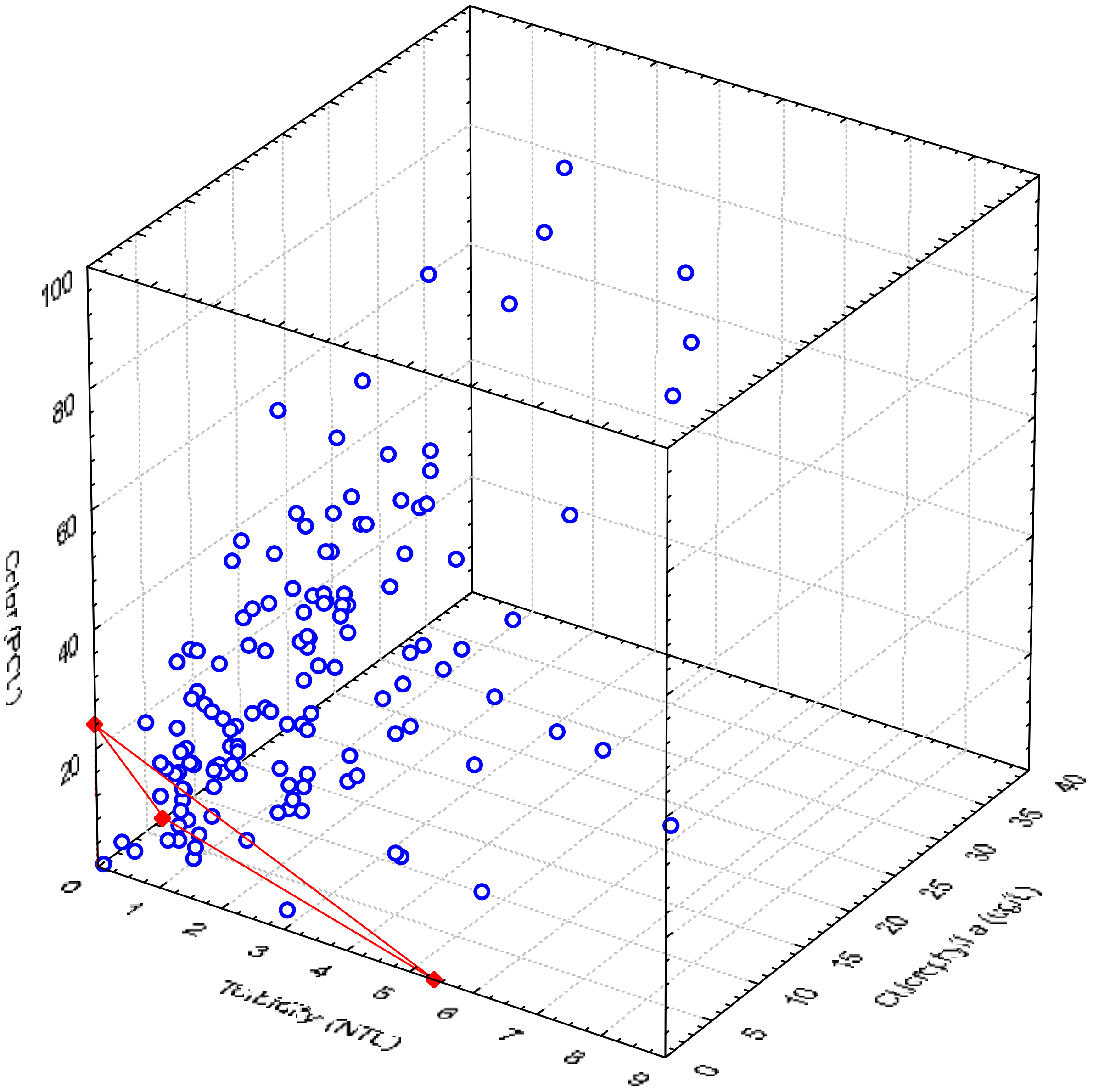
Tidal Caloosahatchee Dry Season


Tidal Caloosahatchee Wet Season
Color (PCU)
0
50
100
150
200
250
300
350
400
Turbidity (NTU)
0
5
10
15
20
25
30
35
40
45
50
Chlorophyll a (ug/l)
0
20
40
60
80
100
120
140
160
180

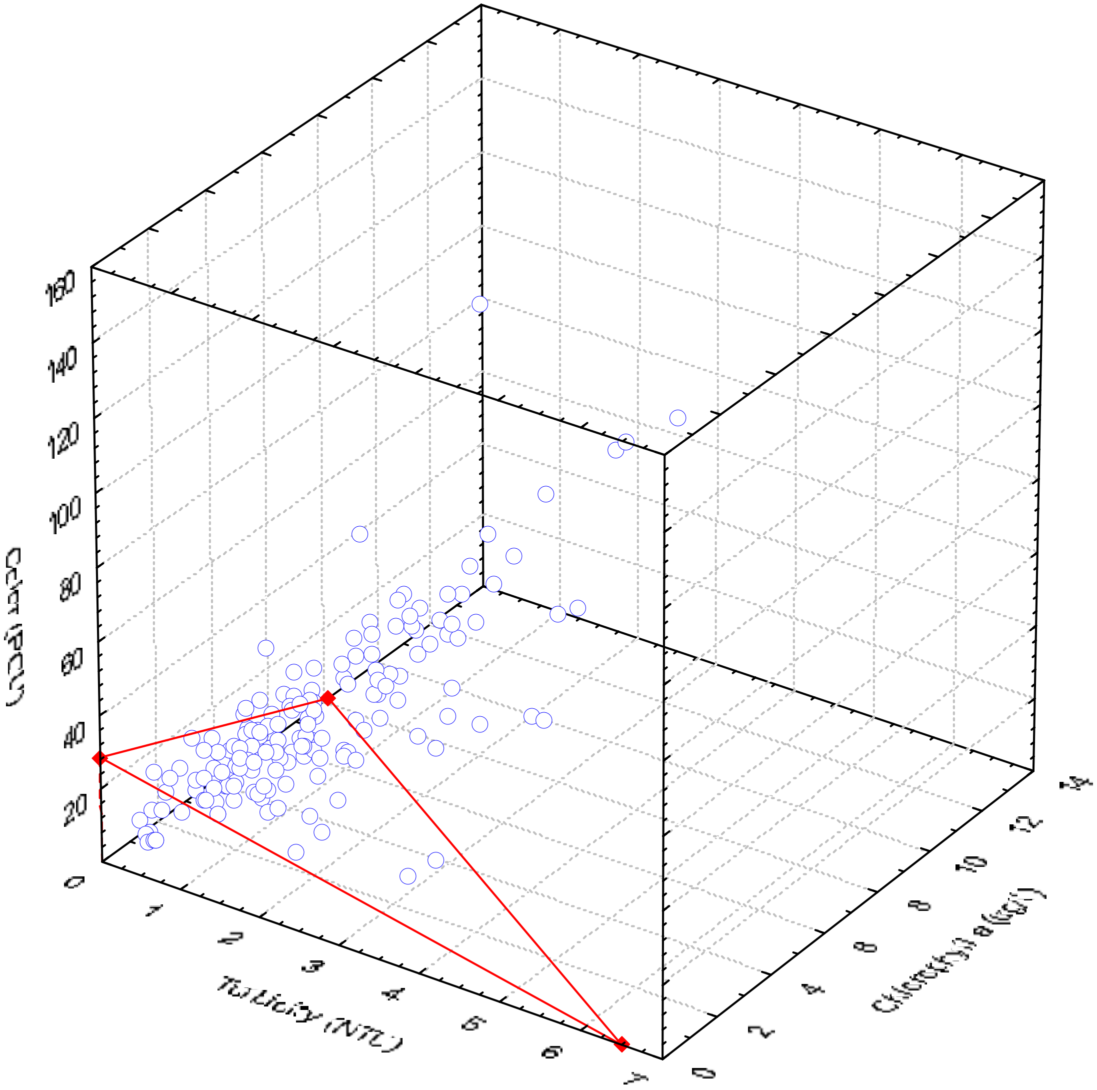
Pine Island Sound Dry Season

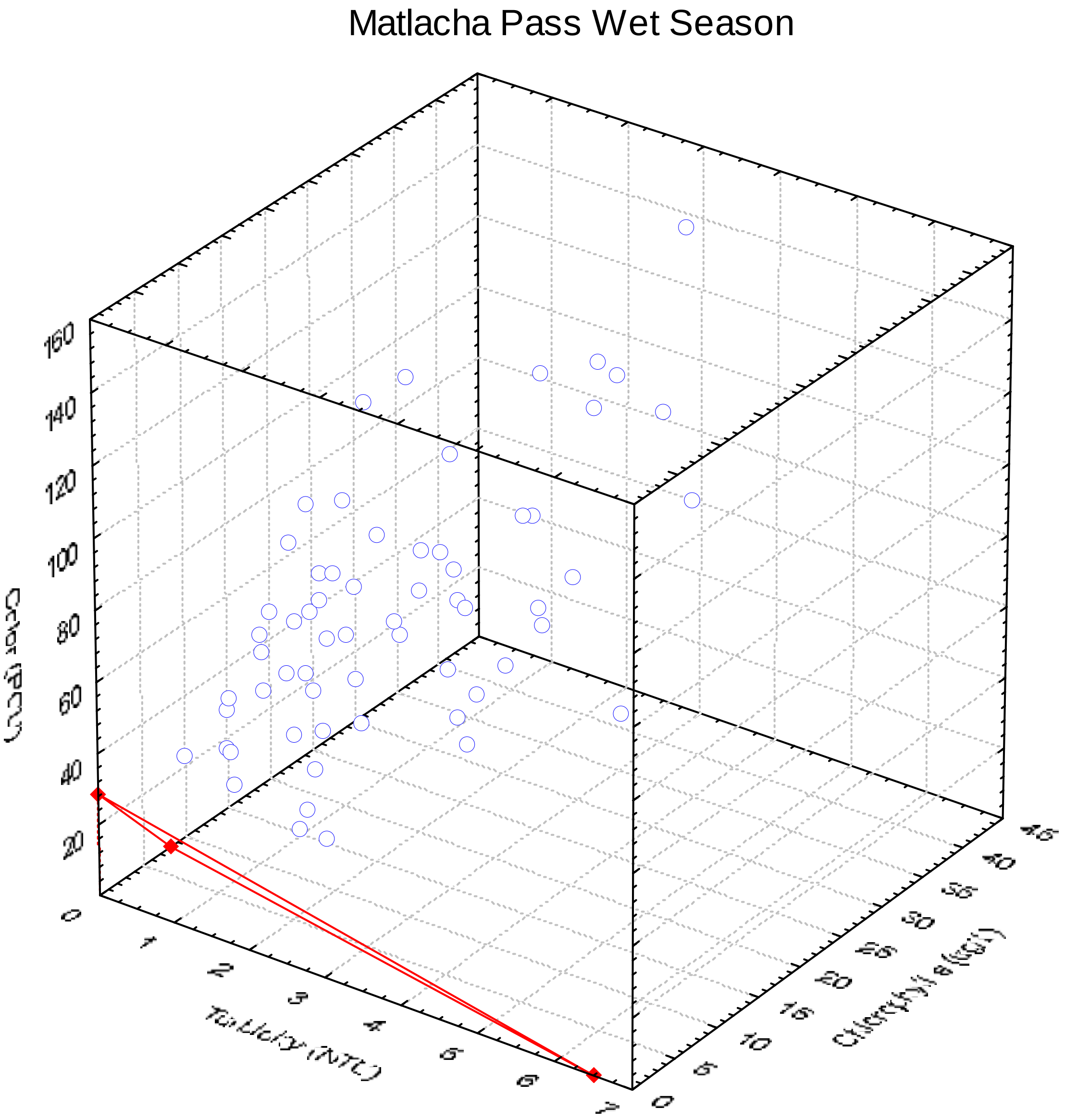


Pine Island Sound Wet Season

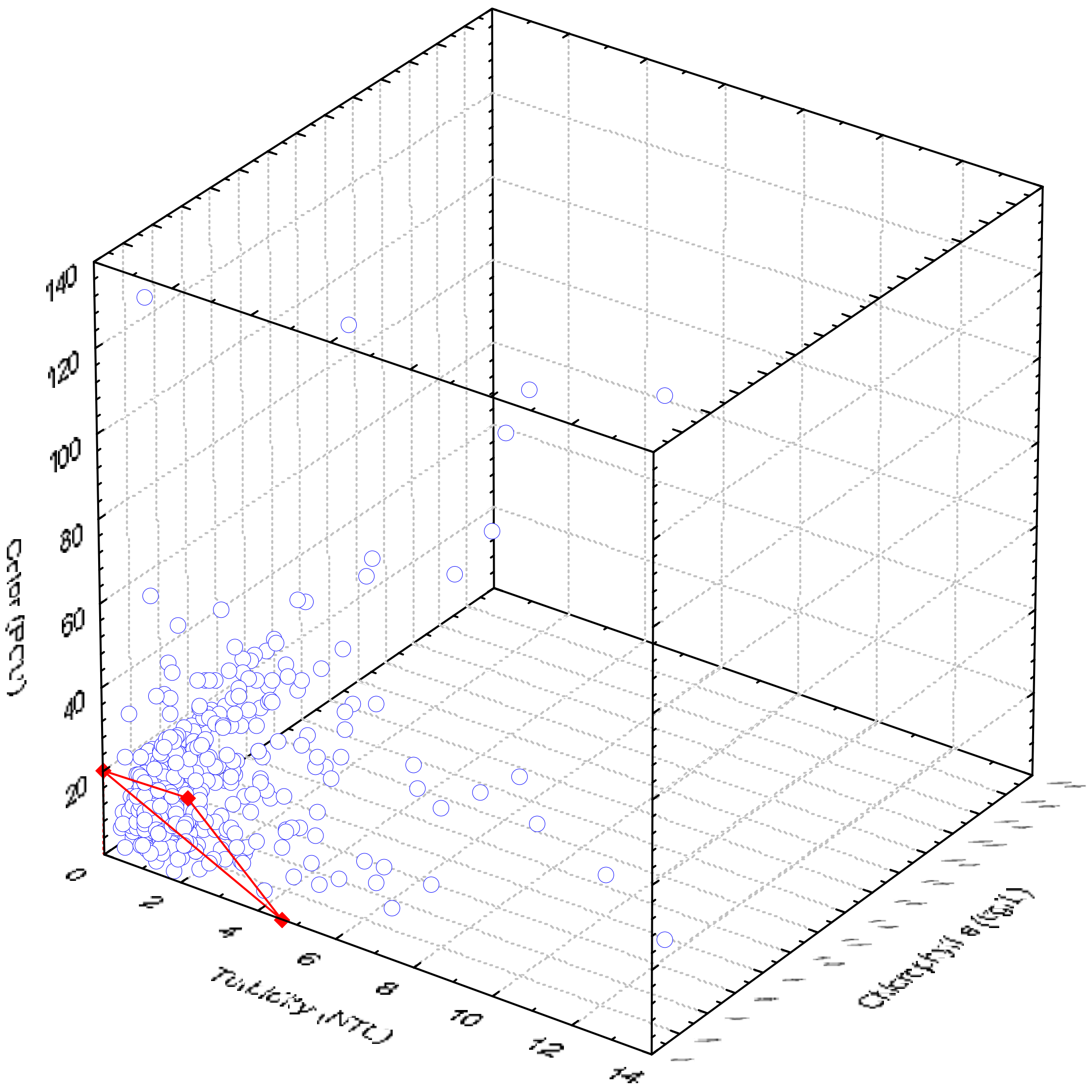


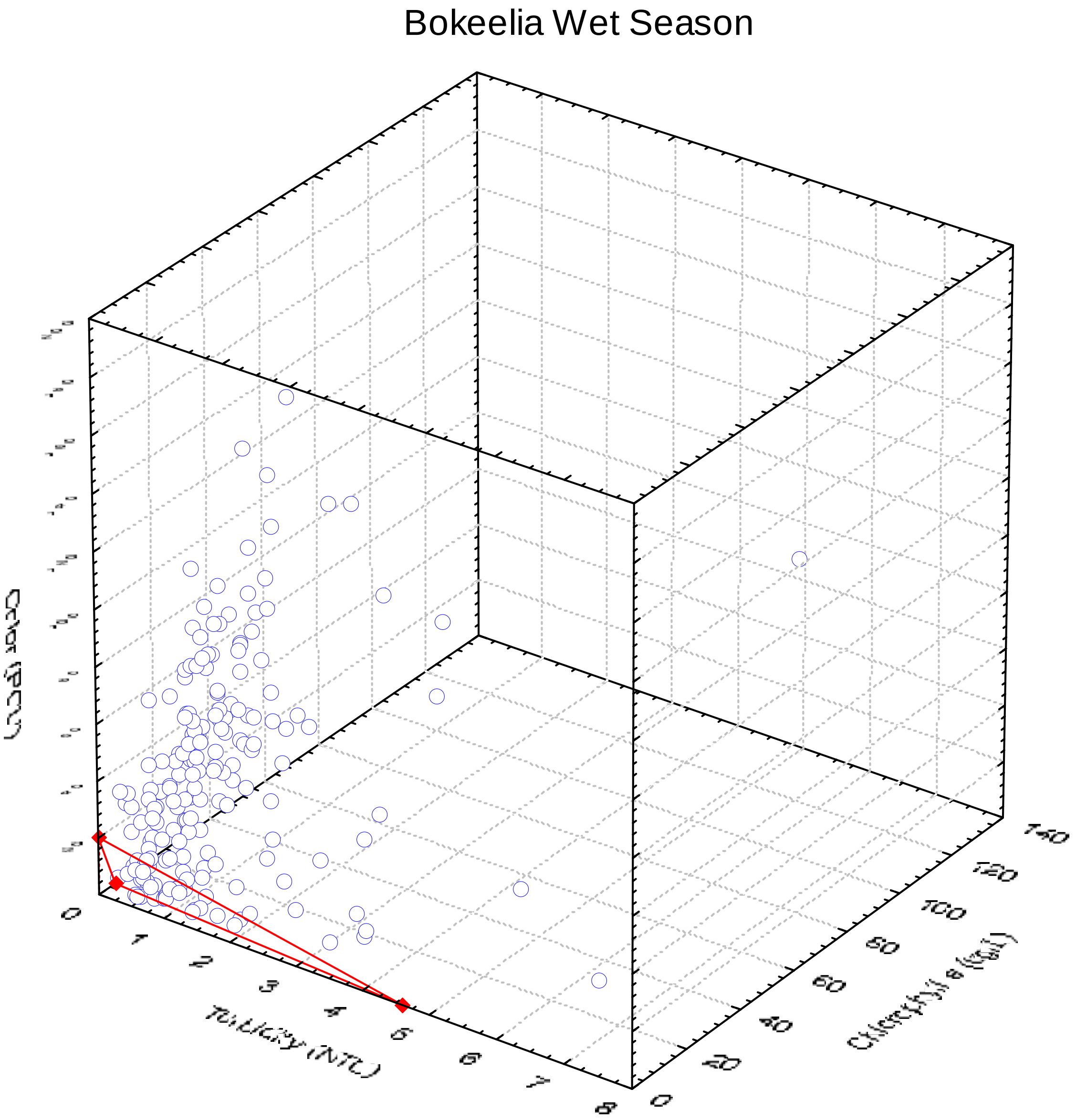
Matlacha Pass Dry Season

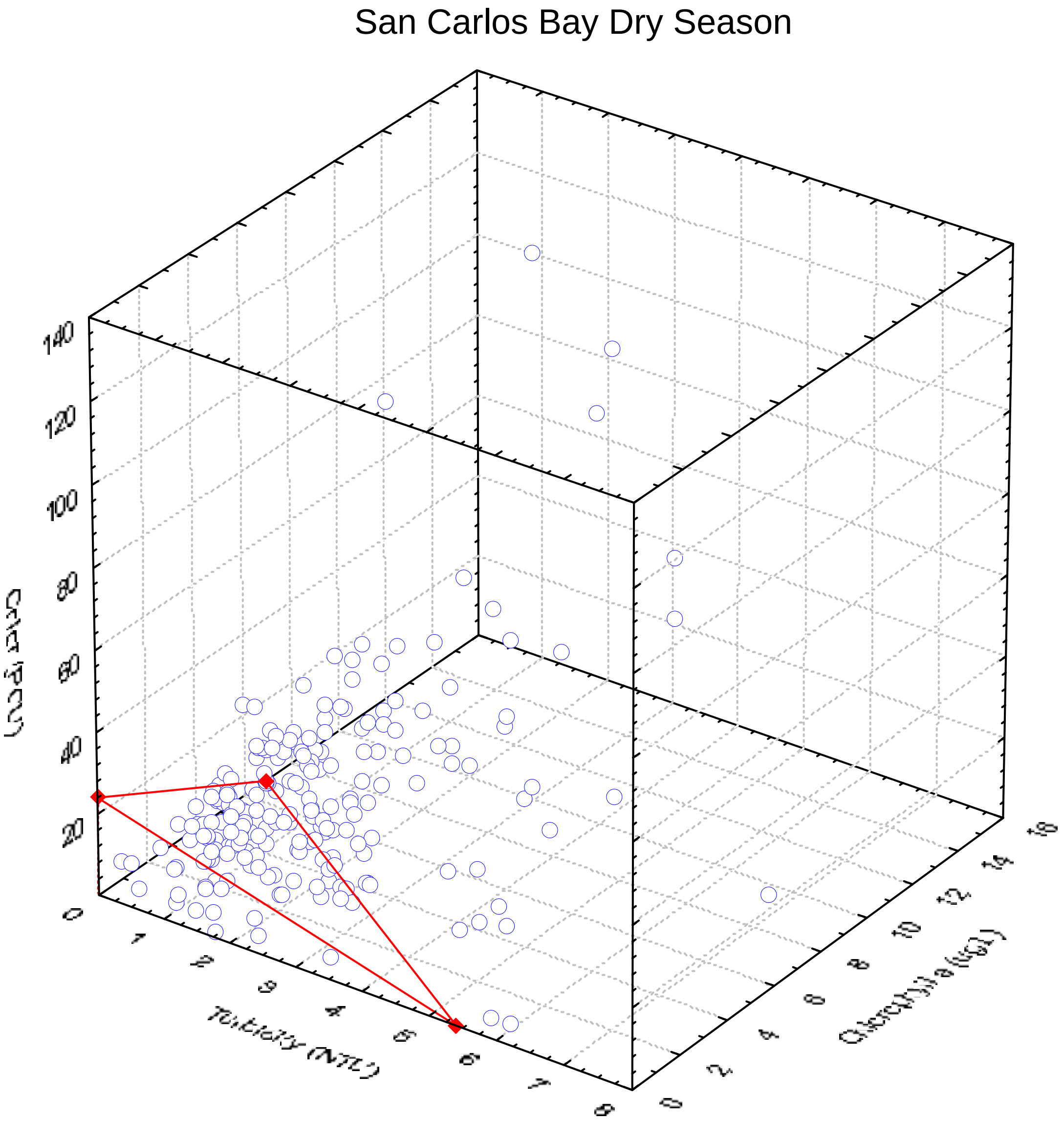



Matlacha Pass Wet Season
Color (PCU)
0
20
40
60
80
100
120
140
160
Turbidity (NTU)
0
1
2
3
4
5
6
7
Chlorophyll a (ug/l)
0
5
10
15
20
25
30
35
40
45

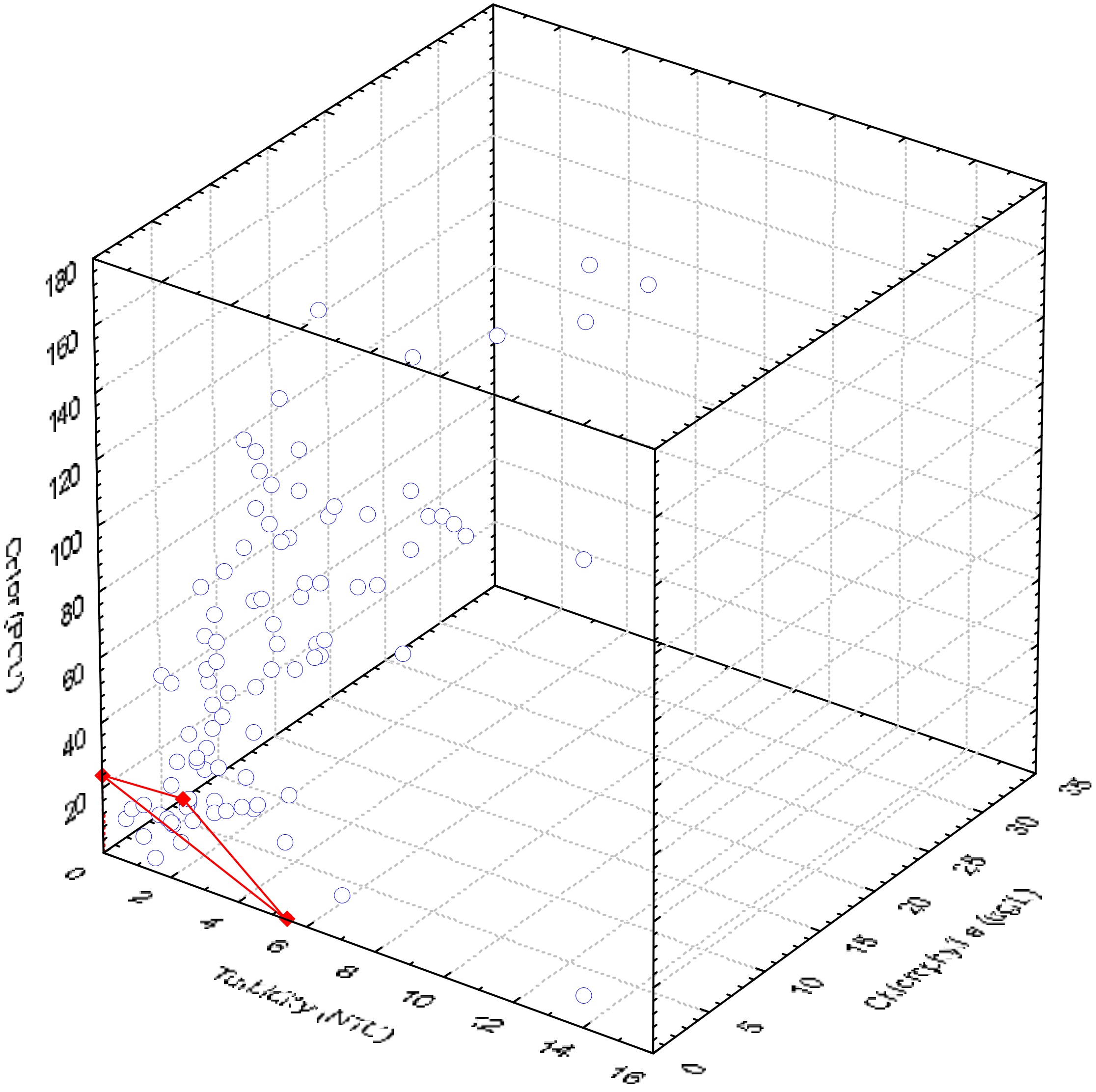
Bokeelia Dry Season



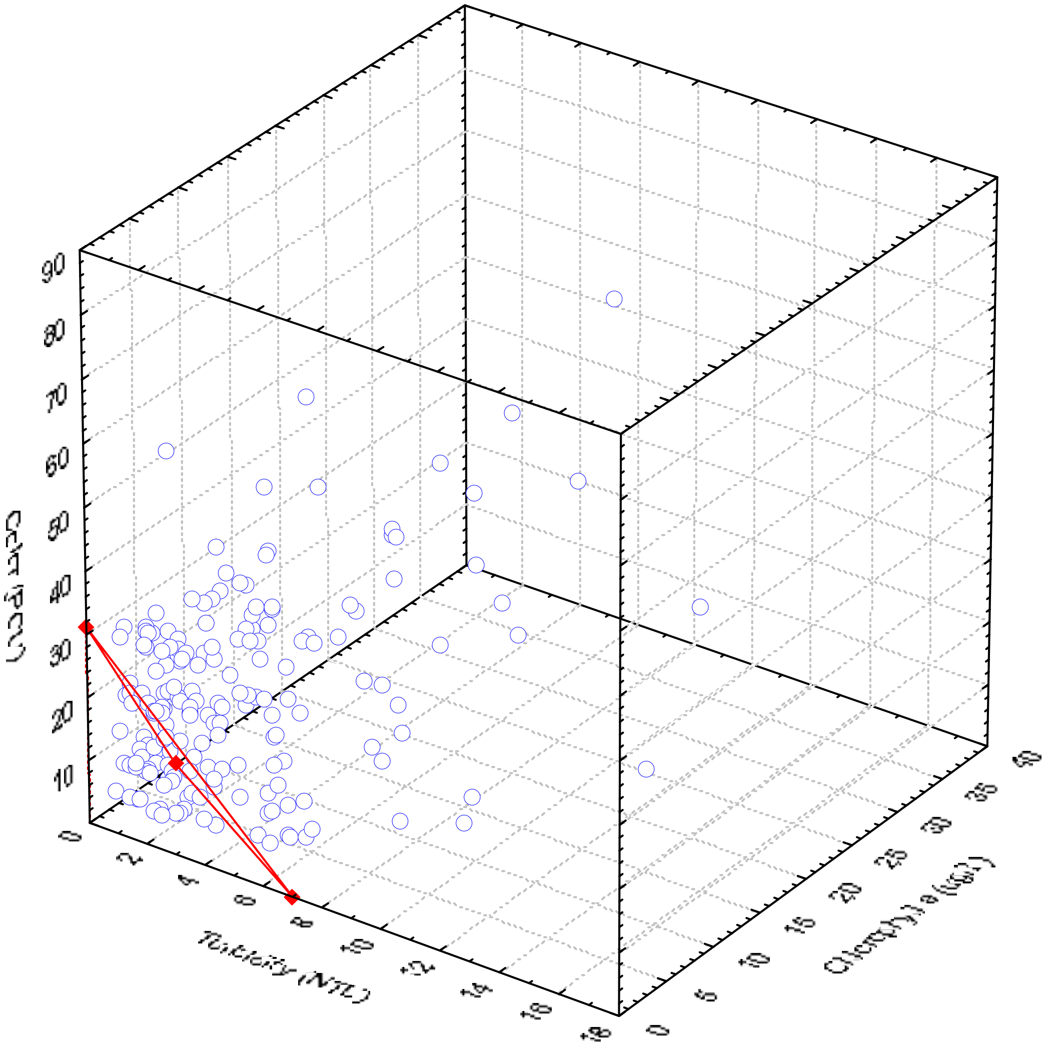

Bokeelia Wet Season
Color (PCU)
0
1
2
3
4
5
6
7
8
Turbidity (NTU)
0
20
40
60
80
100
120
140
Chlorophyll a (ug/L)


San Carlos Bay Dry Season

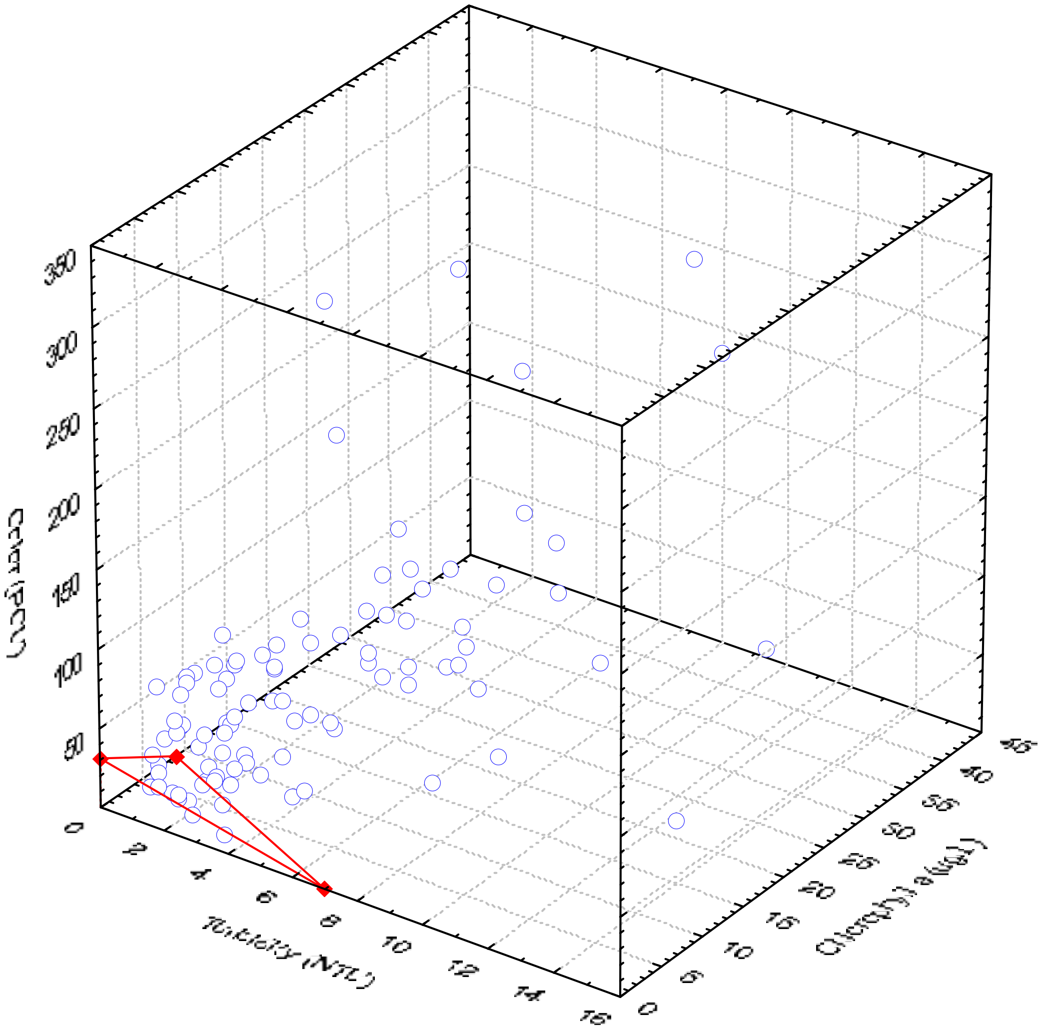
San Carlos Bay Wet Season

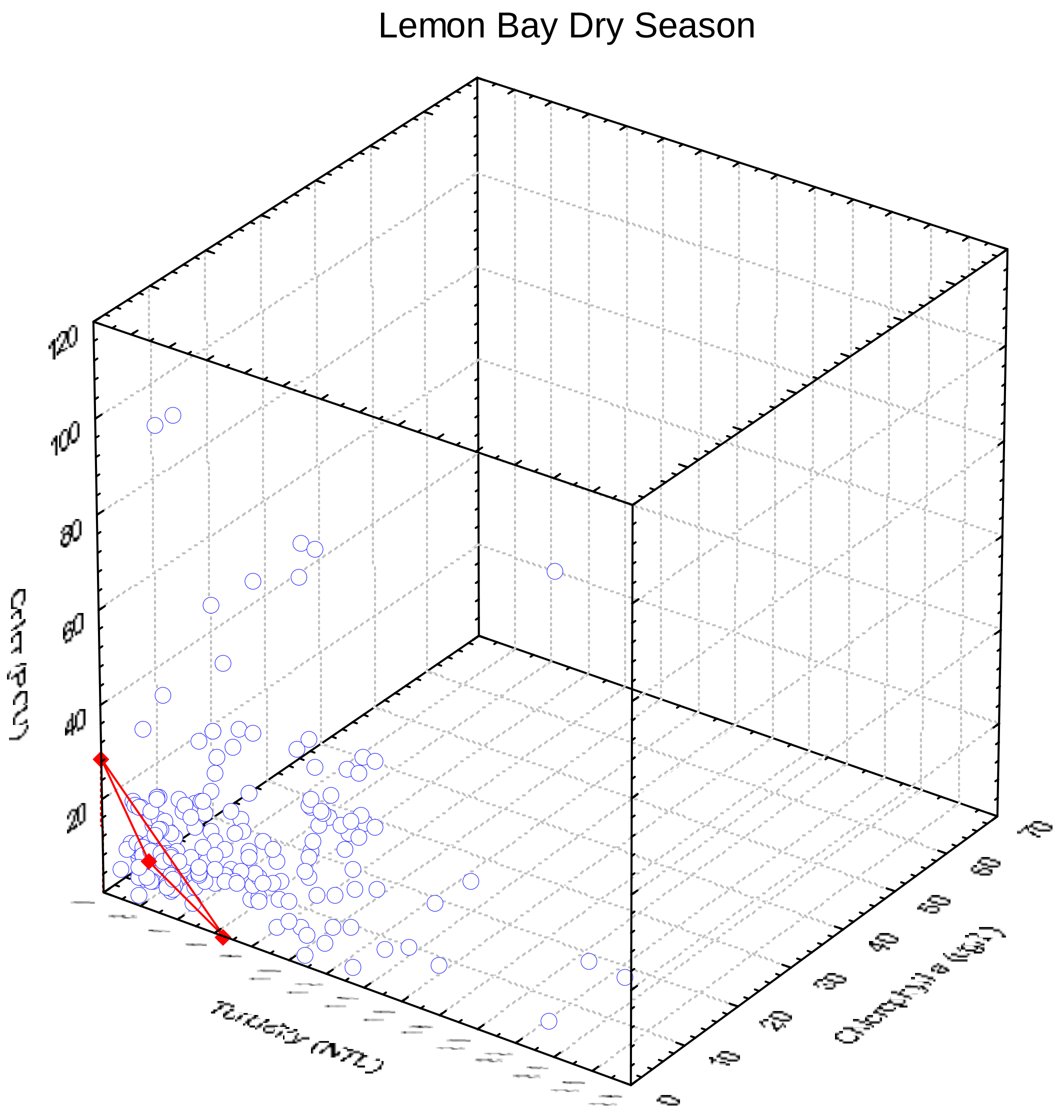


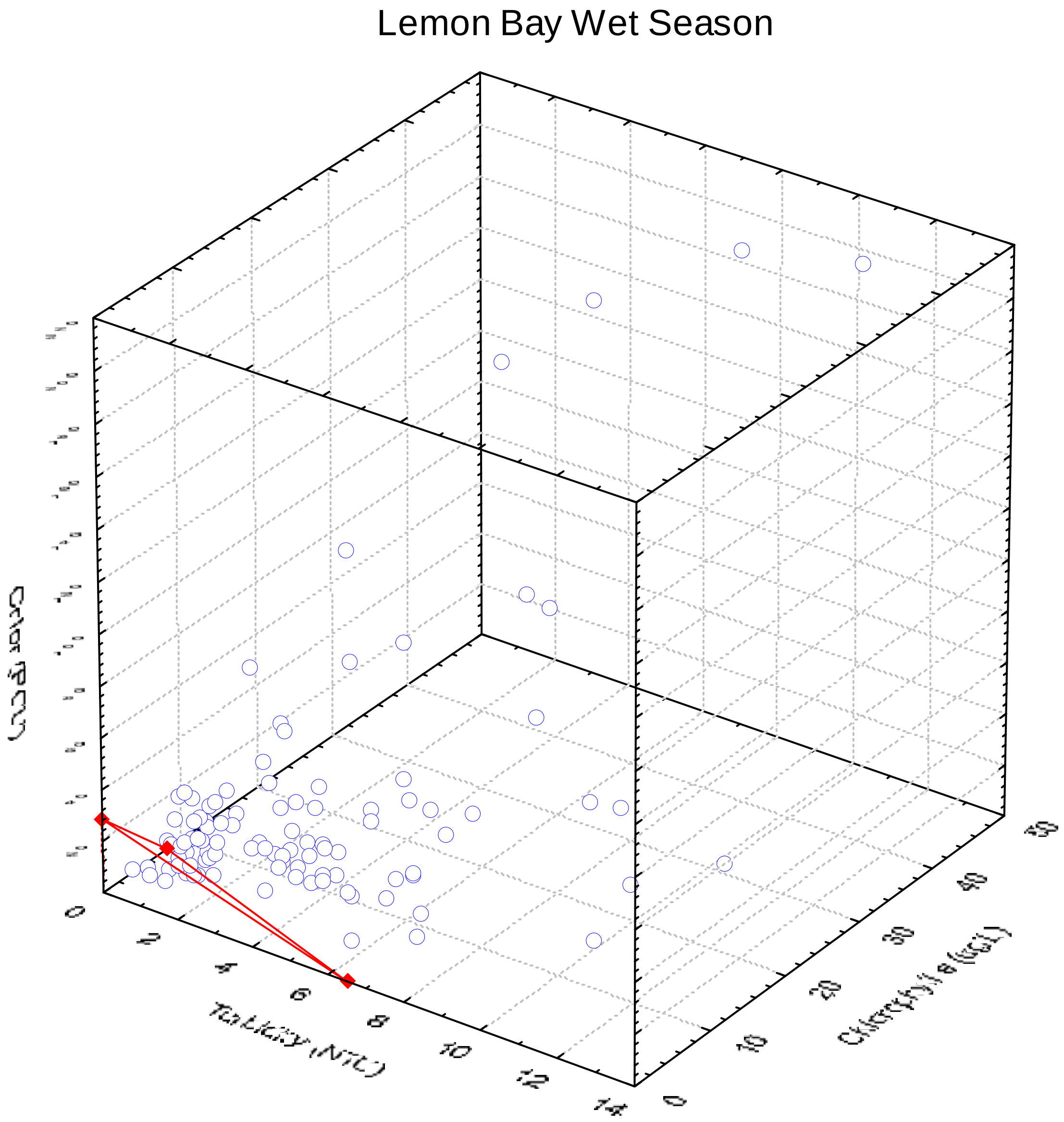
Gasparilla/Cape Haze Dry Season

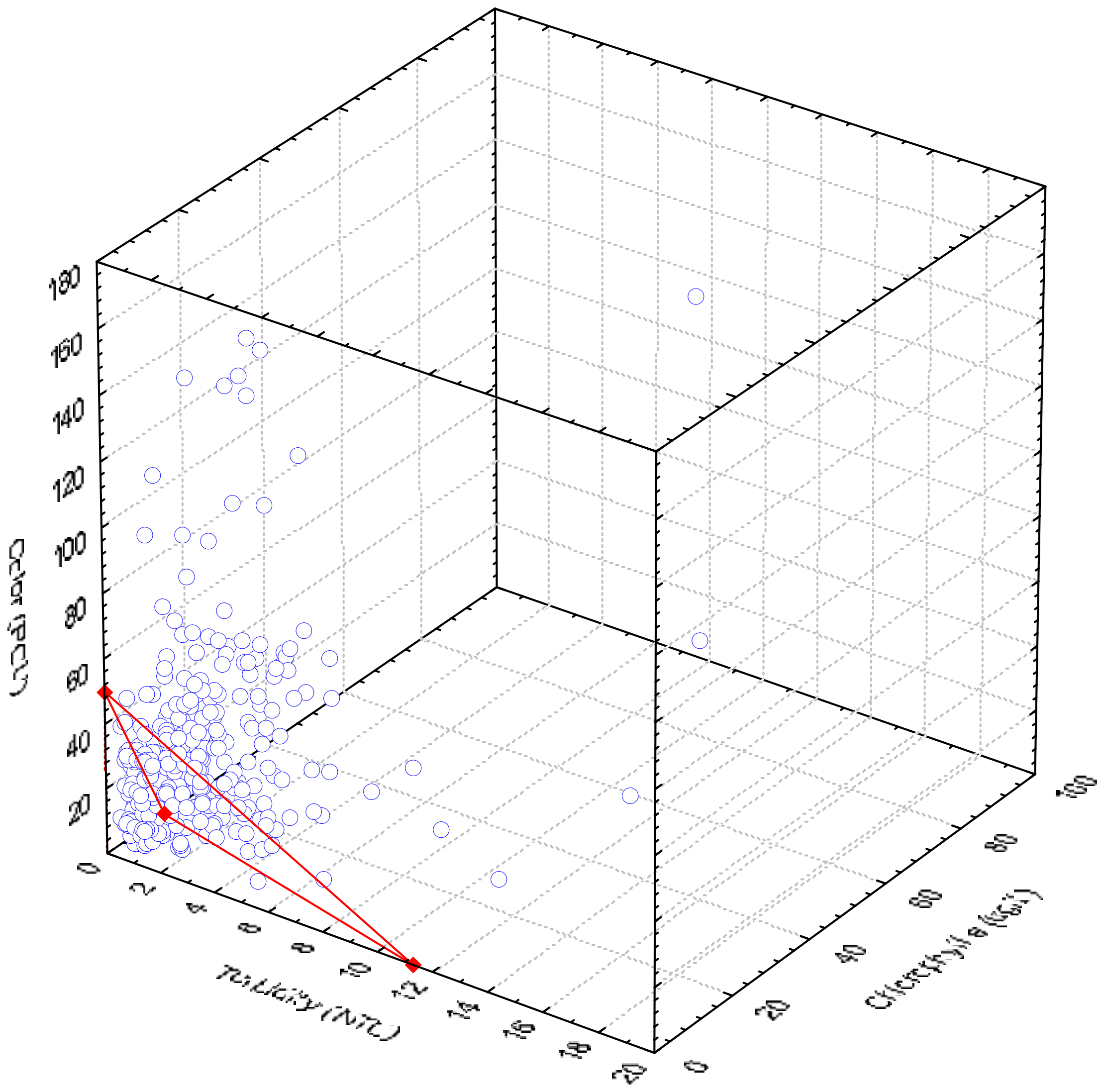


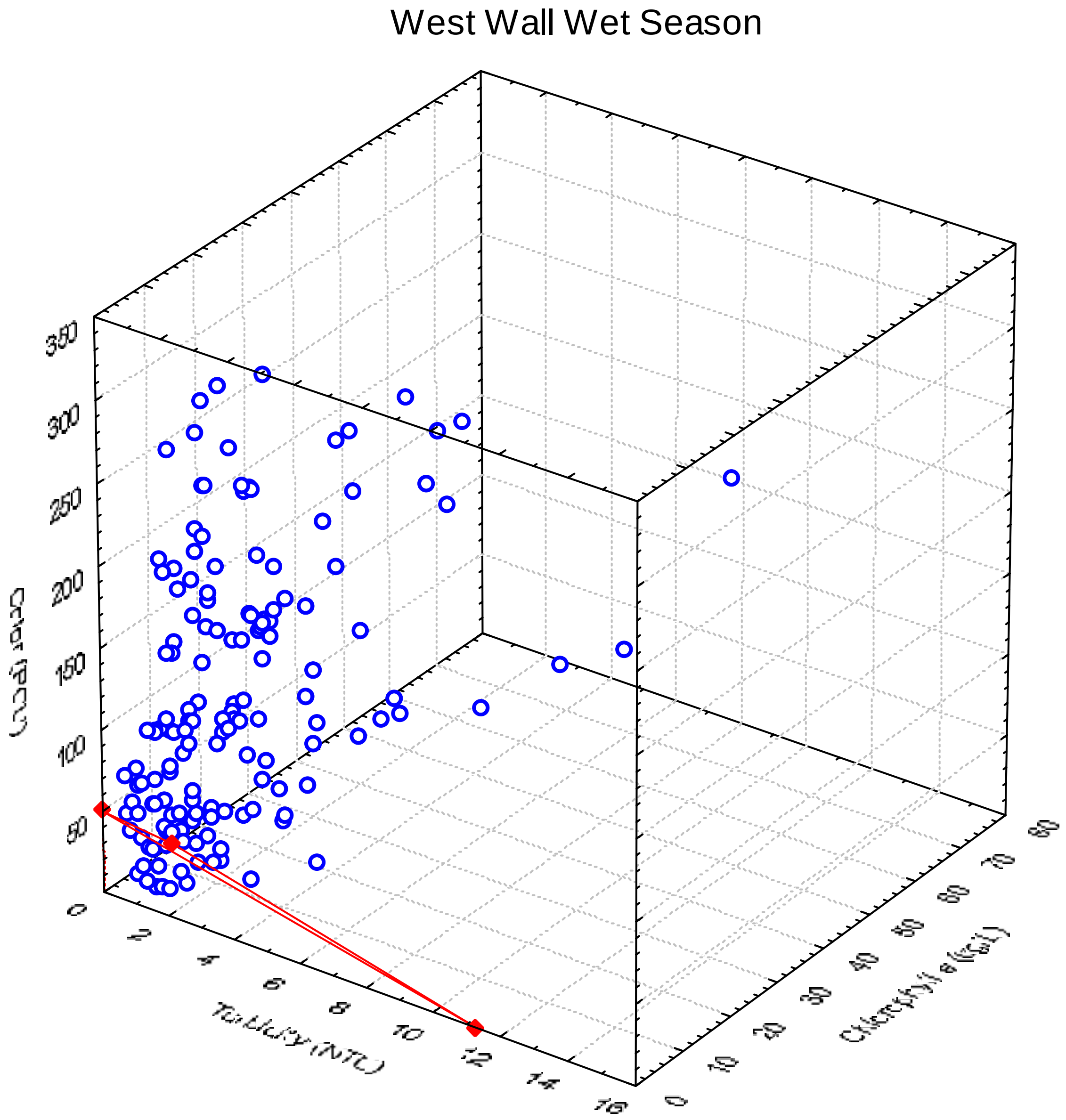
Gasparilla/Cape Haze Wet Season



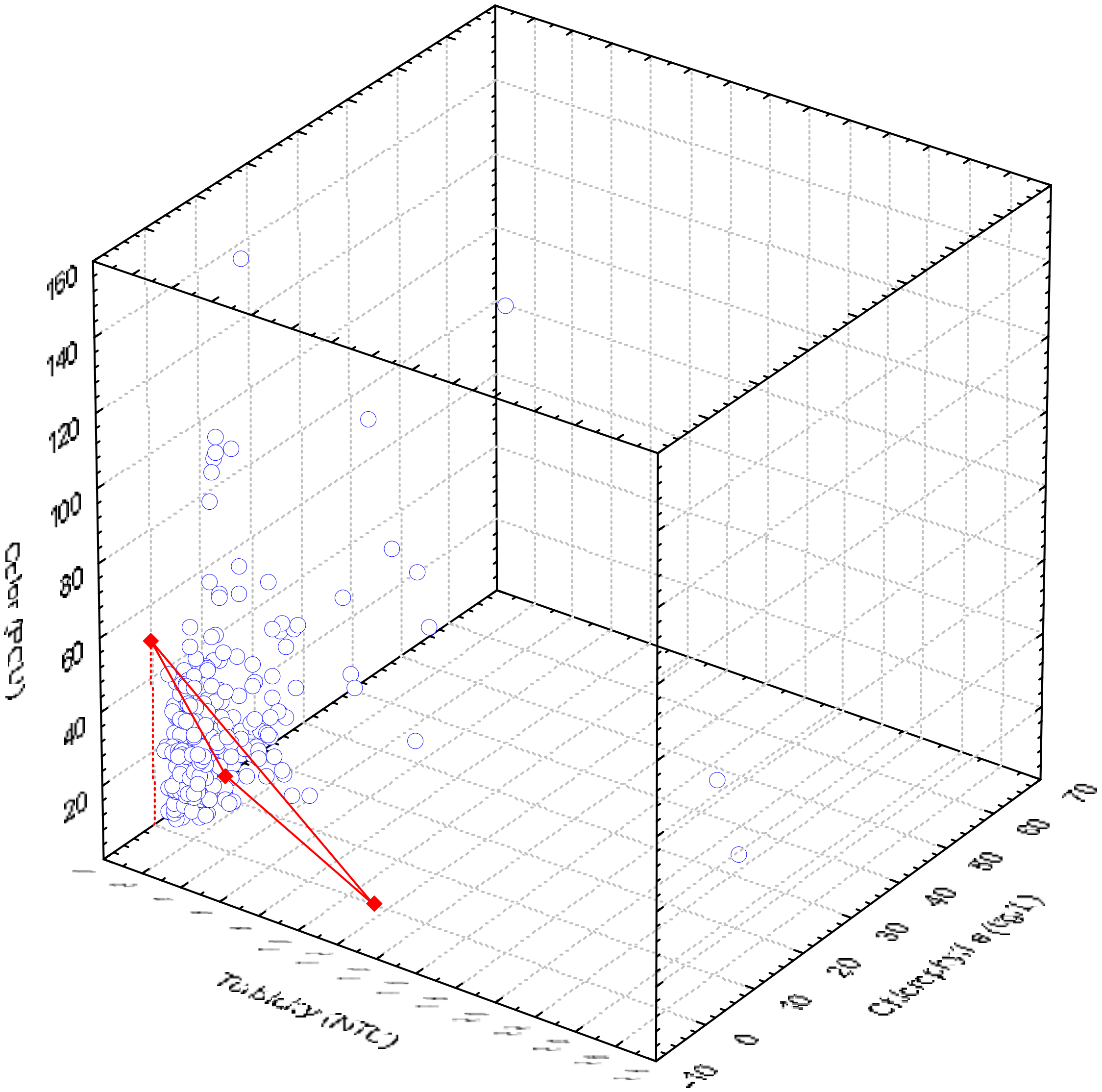

Lemon Bay Dry Season

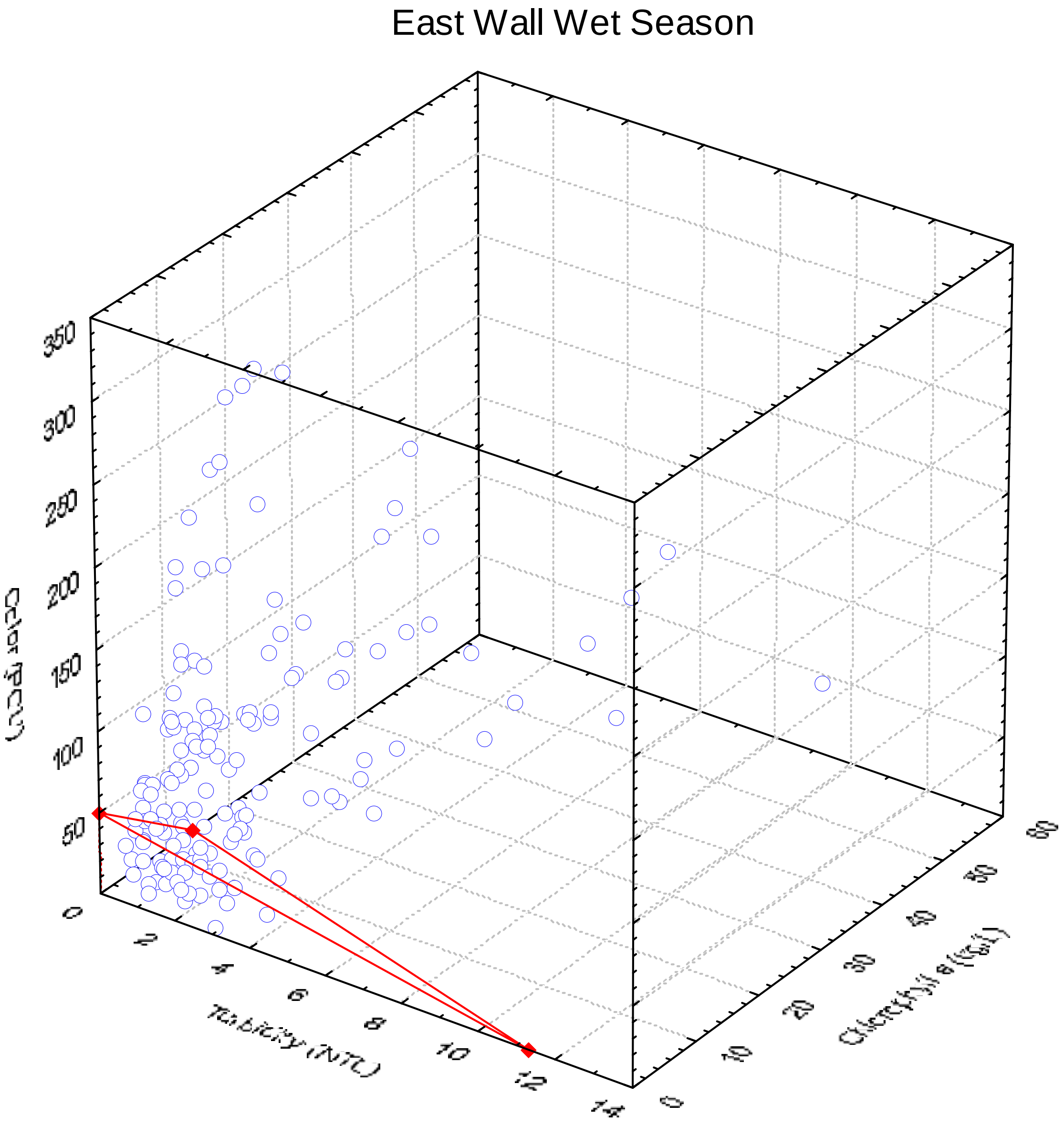

Lemon Bay Wet Season
Color (PCU)
0
20
40
60
80
100
120
140
160
180
200
220
Turbidity (NTU)
0
2
4
6
8
10
12
14
Chlorophyll a (ug/L)
0
10
20
30
40
50


West Wall Dry Season

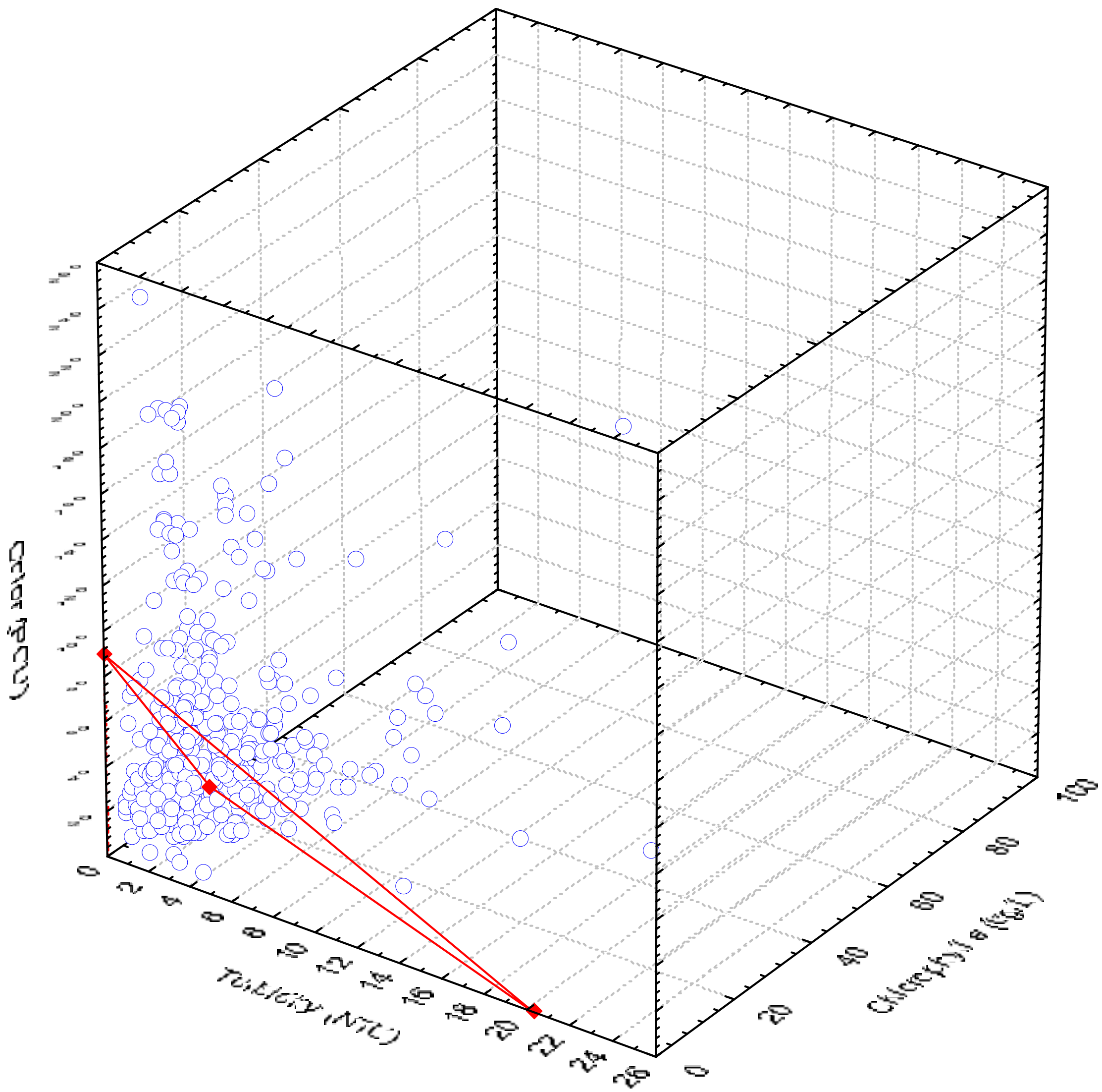

West Wall Wet Season
Color (PCU)
350
300
250
200
150
100
50
0
Turbidity (NTU)
2
4
6
8
10
12
14
16
Chlorophyll a (ug/L)
0
10
20
30
40
50
60
70
80

East Wall Dry Season

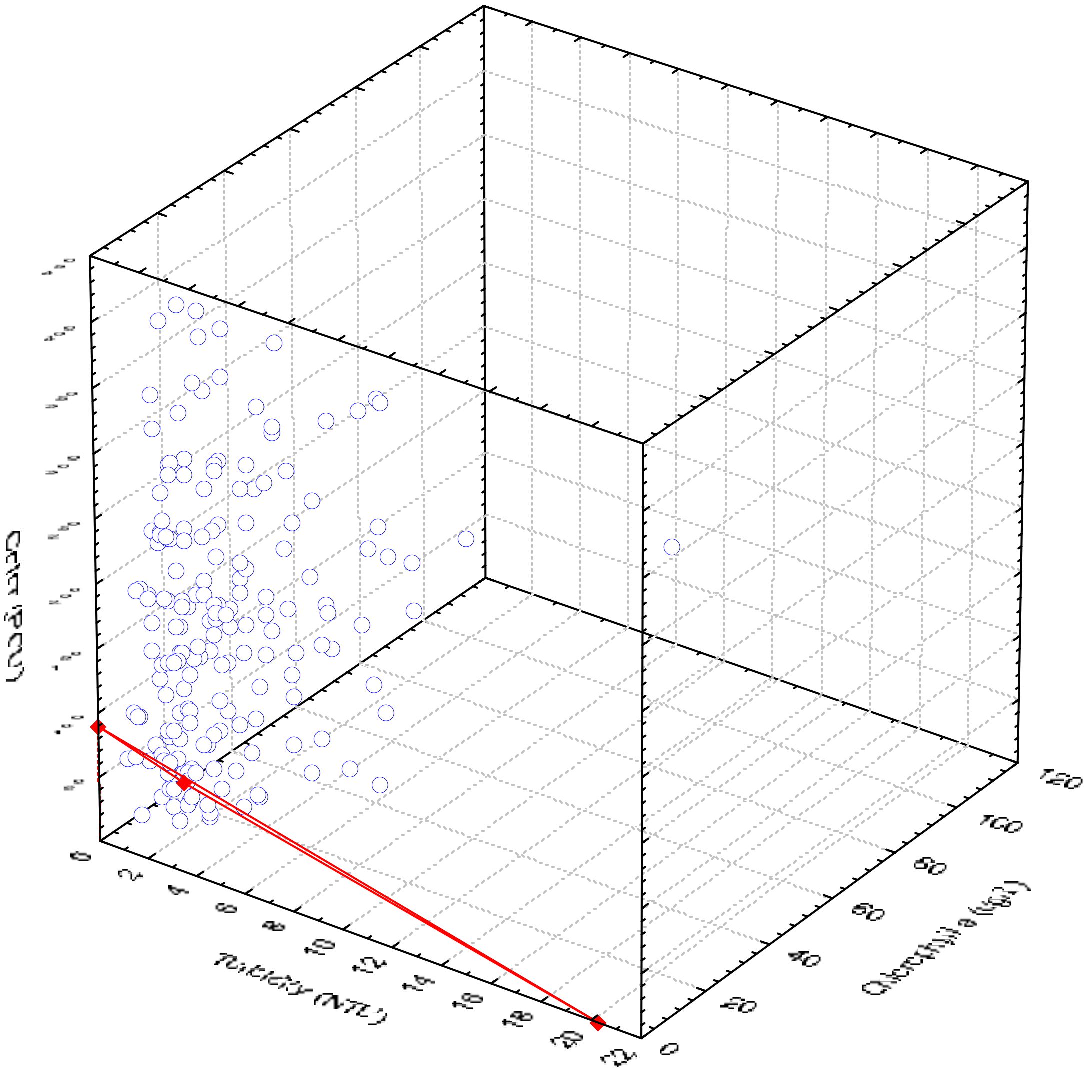



East Wall Wet Season
Color (PCU)
0
50
100
150
200
250
300
350
Turbidity (NTU)
2
4
6
8
10
12
14
Chlorophyll a (ug/L)
0
10
20
30
40
50
60

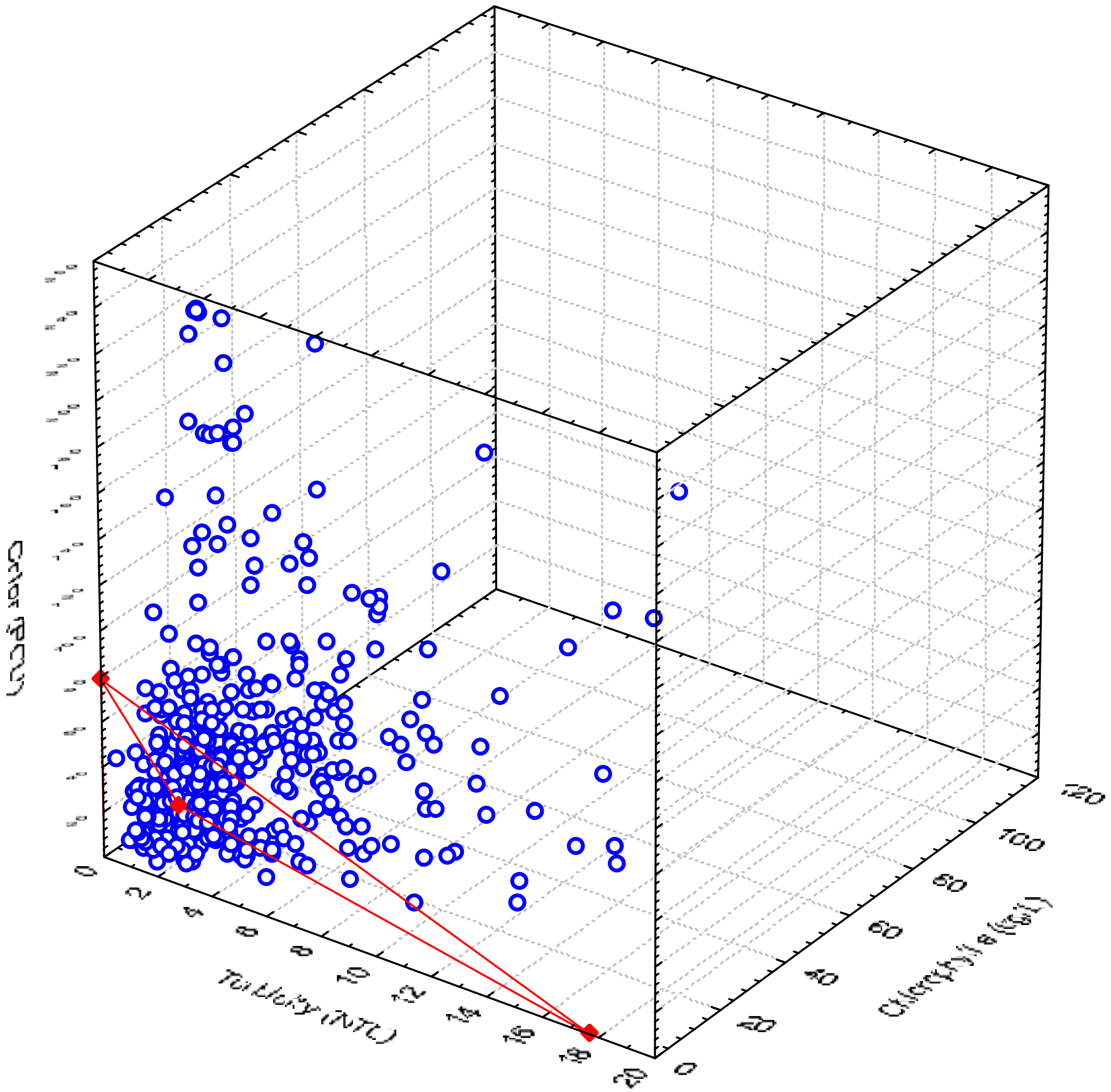
Tidal Myakka Dry Season

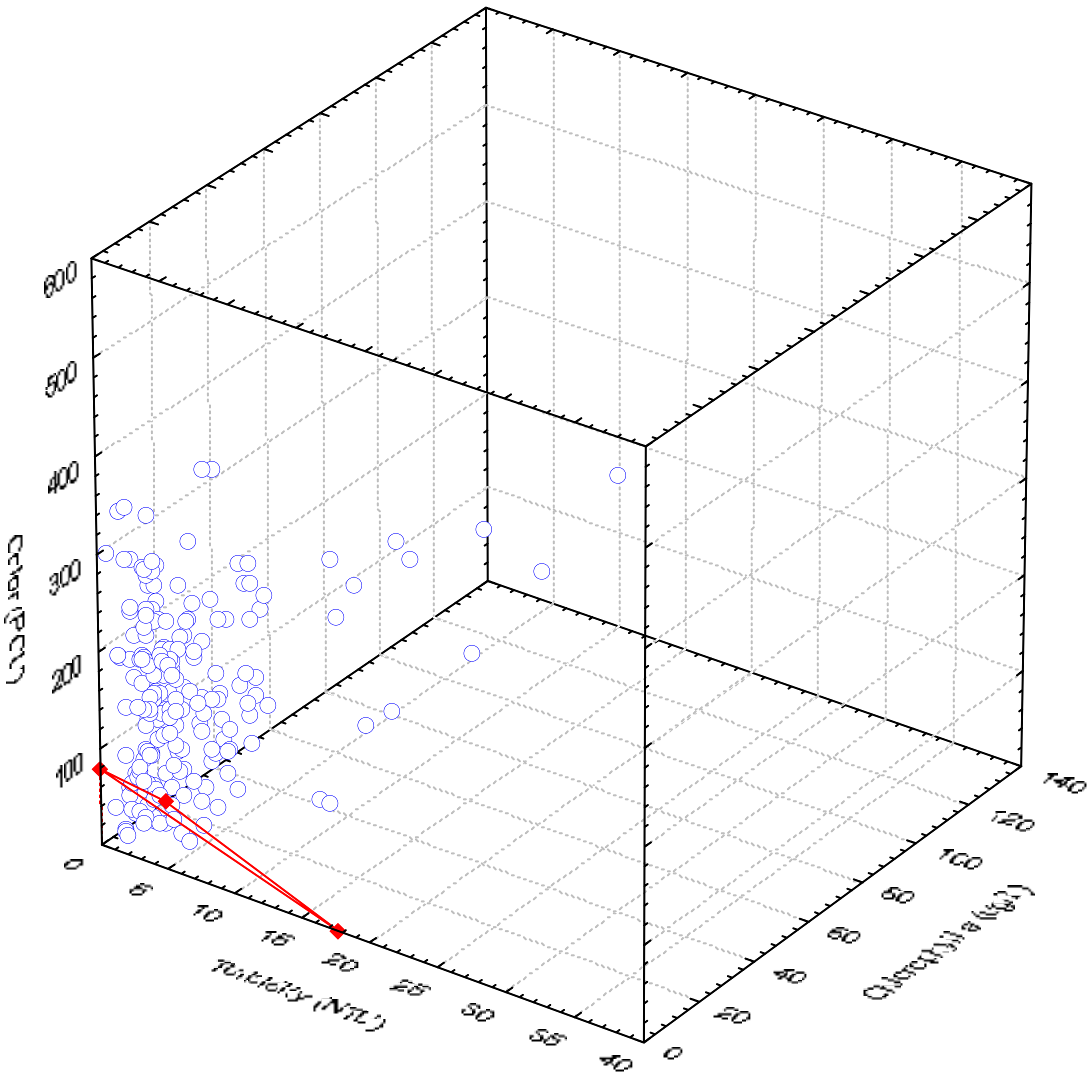


Tidal Myakka Wet Season



Tidal Peace Dry Season




Tidal Peace Wet Season

Appendix C

DEP Transect Data

Segment	Site	Year	Species	BB Abundance	Depth (m)	Deepest Mean Depth
Bokeelia	PIS01	1999	Thalassia	3.0	0.7	
Bokeelia	PIS01	1999	Halodule	2.0	0.7	
Bokeelia	PIS02	1999	Thalassia	2.0	1.2	
Bokeelia	PIS03	1999	Thalassia	0.1	2.0	
Bokeelia	PIS06	1999	Thalassia	1.0	1.6	
Mean (4)					**1.4**	
Standard Deviation					0.5	
Bokeelia	PIS01	2000	Halodule	2.0	0.6	
Bokeelia	PIS02	2000	Halodule	1.0	1.0	
Bokeelia	PIS03	2000	Halodule	1.0	1.8	
Bokeelia	PIS06	2000	Thalassia	1.0	1.3	
Bokeelia	PIS07	2000	Halodule	0.5	2.3	
Mean (5)					**1.4**	
Standard Deviation					0.7	
Bokeelia	PIS01	2001	Halodule	0.5	0.4	
Bokeelia	PIS02	2001	Halodule	1.0	1.0	
Bokeelia	PIS03	2001	Halodule	0.5	1.4	
Bokeelia	PIS06	2001	Thalassia	3.0	0.5	
Bokeelia	PIS06	2001	Halodule	3.0	0.5	
Bokeelia	PIS07	2001	Halodule	0.5	2.1	
Mean (5)					**1.1**	
Standard Deviation					0.7	
Bokeelia	PIS02	2002	Thalassia	1.0	1.1	
Bokeelia	PIS03	2002	Halodule	0.1	1.5	
Bokeelia	PIS06	2002	Thalassia	2.0	0.5	
Mean (3)					**1.0**	
Standard Deviation					0.5	
Bokeelia	PIS01	2003	Thalassia		0.5	
Bokeelia	PIS01	2003	Halodule	1.0	0.5	
Bokeelia	PIS02	2003	Halodule	0.1	0.8	
Bokeelia	PIS03	2003	Halodule	0.1	1.7	
Bokeelia	PIS06	2003	Halodule	0.5	0.8	
Bokeelia	PIS07	2003	Halodule	0.1	2.3	
Mean (5)					**1.2**	
Standard Deviation					0.7	
Bokeelia	PIS01	2004	Halodule	0.1	0.5	
Bokeelia	PIS02	2004	Halodule	0.1	1.0	
Bokeelia	PIS03	2004	Halodule	0.1	2.0	
Bokeelia	PIS06	2004	Halodule	1.0	0.7	
Bokeelia	PIS07	2004	Halodule		2.3	
Mean (5)					**1.3**	
Standard Deviation					0.8	
Bokeelia	PIS01	2005	Thalassia	2.0	0.9	
Bokeelia	PIS02	2005	Halodule	0.1	1.3	
Bokeelia	PIS03	2005	Halodule	0.1	1.9	
Bokeelia	PIS06	2005	Halodule	0.5	0.9	
Bokeelia	PIS07	2005	Halodule	0.1	2.5	
Mean (5)					**1.5**	**1.5**
Standard Deviation					0.7	
East Wall	MC03	2000	Halodule	1.0	**1.2**	
East Wall	MC02	2001	Halodule	0.5	0.7	
East Wall	MC03	2001	Halodule	0.1	1.2	
Mean					**1.0**	
Standard Deviation					0.4	
East Wall	MC03	2002	Halodule	0.5	1.3	
East Wall	MC02	2002	Halodule	0.1	1.2	
Mean					**1.2**	
Standard Deviation					0.0	
East Wall	MC02	2003	Halodule	0.1	1.5	
East Wall	MC03	2003	Halodule	0.1	1.1	
Mean					**1.3**	
Standard Deviation					0.3	
East Wall	MC03	2004	Halodule	0.1	1.3	
East Wall	MC02	2004	Halodule	0.1	1.3	
Mean					**1.3**	
Standard Deviation					0.0	
East Wall	MC03	2005	Halodule		1.3	
East Wall	MC02	2005	Halodule	0.1	1.6	
Mean					**1.4**	**1.4**
Standard Deviation					0.2	
Gasparilla Sound	GAS02	1999	Thalassia	2.0	1.3	
Gasparilla Sound	GAS02	1999	Halodule	2.0	1.3	
Gasparilla Sound	GAS03	1999	Syringodium	2.0	1.6	
Gasparilla Sound	GAS04	1999	Halodule	1.0	1.9	
Gasparilla Sound	GAS05	1999	Thalassia	1.0	1.5	
Gasparilla Sound	GAS05	1999	Halodule	1.0	1.5	
Gasparilla Sound	PIS08	1999	Thalassia	0.5	1.3	

Segment	Site	Year	Species	BB Abundance	Depth (m)	Deepest Mean Depth
Mean (5)					**1.5**	
Standard Deviation					0.3	
Gasparilla Sound	GAS02	2000	Halodule	3.0	1.5	
Gasparilla Sound	GAS02	2000	Thalassia	1.0	1.5	
Gasparilla Sound	GAS03	2000	Syringodium	3.0	1.4	
Gasparilla Sound	GAS04	2000	Halodule	1.0	1.8	
Gasparilla Sound	GAS05	2000	Halodule	1.0	2.1	
Mean (4)					**1.7**	
Standard Deviation					0.3	
Gasparilla Sound	GAS02	2001	Thalassia	1.0	1.6	
Gasparilla Sound	GAS02	2001	Halodule	1.0	1.6	
Gasparilla Sound	GAS03	2001	Halodule	2.0	1.9	
Gasparilla Sound	GAS04	2001	Halodule	2.0	1.8	
Gasparilla Sound	GAS05	2001	Halodule	0.5	2.1	
Gasparilla Sound	PIS08	2001	Thalassia	0.5	0.7	
Gasparilla Sound	PIS08	2001	Halodule	2.0	0.7	
Mean (5)					**1.6**	
Standard Deviation					0.6	
Gasparilla Sound	PIS08	2002	Halodule	1.0	1.1	
Gasparilla Sound	GAS05	2002	Halodule	0.5	2.8	
Gasparilla Sound	GAS03	2002	Syringodium	2.0	1.8	
Gasparilla Sound	GAS02	2002	Thalassia	0.1	1.5	
Gasparilla Sound	GAS04	2002	Halodule	1.0	1.8	
Mean (5)					**1.8**	
Standard Deviation					0.6	
Gasparilla Sound	GAS05	2003	Halodule	0.1	1.8	
Gasparilla Sound	PIS08	2003	Thalassia	0.1	0.8	
Gasparilla Sound	GAS02	2003	Thalassia	1.0	1.5	
Gasparilla Sound	GAS03	2003	Halodule	2.0	1.9	
Gasparilla Sound	GAS04	2003	Halodule	0.5	2.0	
Mean (5)					**1.6**	
Standard Deviation					0.5	
Gasparilla Sound	GAS05	2004	Halodule	0.5	2.0	
Gasparilla Sound	GAS02	2004	Thalassia	0.1	1.6	
Gasparilla Sound	GAS03	2004	Halodule	0.5	1.9	
Gasparilla Sound	GAS04	2004	Halodule		2.0	
Mean (4)					**1.9**	
Standard Deviation					0.2	
Gasparilla Sound	GAS02	2005	Thalassia	0.1	1.7	
Gasparilla Sound	GAS04	2005	Halodule	0.5	2.2	
Gasparilla Sound	GAS05	2005	Halodule	1.0	1.9	
Gasparilla Sound	GAS03	2005	Halodule	1.0	1.6	
Mean (4)					**1.9**	**1.9**
Standard Deviation					0.3	
Lemon Bay	GAS01	1999	Halodule	1.0	1.4	
Lemon Bay	ICW01	1999	Halodule	0.5	1.3	
Lemon Bay	ICW02	1999	Thalassia	0.1	1.8	
Lemon Bay	ICW03	1999	Halodule	0.5	1.6	
Mean (4)					**1.5**	
Standard Deviation					0.2	
Lemon Bay	ICW01	2000	Halodule	1.0	1.4	
Lemon Bay	ICW03	2000	Halodule	1.0	1.7	
Lemon Bay	ICW04	2000	Syringodium	5.0	1.2	
Lemon Bay	GAS01	2000	Halodule	3.0	1.5	
Lemon Bay	ICW05	2000	Syringodium		1.8	
Mean (5)					**1.5**	
Standard Deviation					0.2	
Lemon Bay	ICW01	2001	Halodule	0.5	1.2	
Lemon Bay	ICW04	2001	Syringodium	5.0	1.0	
Lemon Bay	GAS01	2001	Halodule	1.0	1.5	
Lemon Bay	ICW02	2001	Thalassia	0.1	1.8	
Lemon Bay	ICW03	2001	Halodule	0.5	1.6	
Lemon Bay	ICW05	2001	Thalassia	2.0	2.1	
Mean (6)					**1.5**	
Standard Deviation					0.4	
Lemon Bay	ICW02	2002	Halodule	0.5	1.7	
Lemon Bay	ICW02	2002	Thalassia	0.5	1.7	
Lemon Bay	ICW01	2002	Halodule	1.0	1.2	
Lemon Bay	GAS01	2002	Halodule	2.0	1.1	
Lemon Bay	ICW03	2002	Halodule	1.0	1.7	
Lemon Bay	ICW04	2002	Syringodium		1.4	
Lemon Bay	ICW05	2002	Thalassia	1.0	2.0	
Mean (6)					**1.5**	
Standard Deviation					0.3	
Lemon Bay	ICW01	2003	Halodule	0.1	1.4	
Lemon Bay	ICW02	2003	Halodule	0.1	1.8	
Lemon Bay	GAS01	2003	Halodule	0.1	1.5	
Lemon Bay	ICW05	2003	Thalassia	1.0	2.0	

Segment	Site	Year	Species	BB Abundance	Depth (m)	Deepest Mean Depth
Mean (4)					**1.7**	
Standard Deviation					0.3	
Lemon Bay	ICW04	2004	Halodule	0.1	1.0	
Lemon Bay	ICW04	2004	Syringodium	0.1	1.0	
Lemon Bay	GAS01	2004	Syringodium	0.5	1.4	
Lemon Bay	ICW05	2004	Thalassia	0.5	2.1	
Lemon Bay	ICW01	2004	Halodule	0.1	1.3	
Lemon Bay	ICW02	2004	Halodule	0.5	2.0	
Lemon Bay	ICW03	2004	Halodule	0.1	1.9	
Mean (6)					**1.6**	
Standard Deviation					0.5	
Lemon Bay	ICW01	2005	Halodule	0.5	1.2	
Lemon Bay	ICW02	2005	Halodule		1.6	
Lemon Bay	ICW03	2005	Halodule	0.1	2.1	
Lemon Bay	ICW04	2005	Halodule	0.5	1.0	
Lemon Bay	ICW05	2005	Halodule	0.1	2.5	
Lemon Bay	GAS01	2005	Syringodium	1.0	1.9	**1.7**
Mean (6)					**1.7**	
Standard Deviation					0.6	
Matlacha Pass	MP02	1999	Halodule	1.0	1.0	
Matlacha Pass	MP01	1999	Halodule	0.5	0.8	
Mean (2)					**0.9**	
Standard Deviation					0.1	
Matlacha Pass	MP01	2000	Halodule	0.5	1.1	
Matlacha Pass	MP02	2000	Halodule	1.0	1.3	
Matlacha Pass	MP03	2000	Halodule	3.0	1.5	
Matlacha Pass	MP04	2000	Halodule	0.5	2.0	
Matlacha Pass	MP04	2000	Halophila	0.5	2.0	
Mean (4)					**1.5**	
Standard Deviation					0.4	
Matlacha Pass	MP02		Halodule	2.0	1.1	
Matlacha Pass	MP04		Halodule	1.0	1.5	
Matlacha Pass	MP01		Halodule	0.1	1.0	
Mean (3)					**1.2**	
Standard Deviation					0.3	
Matlacha Pass	MP02		Halodule	0.5	1.2	
Matlacha Pass	MP04		Halodule	0.5	1.6	
Matlacha Pass	MP03		Halodule	0.5	1.3	
Matlacha Pass	MP01		Thalassia	0.5	1.2	
Mean (4)					**1.3**	
Standard Deviation					0.2	
Matlacha Pass	MP03		Halodule	0.5	1.1	
Matlacha Pass	MP04		Halodule	0.5	1.2	
Matlacha Pass	MP02		Halodule	1.0	0.9	
Matlacha Pass	MP01		Thalassia	0.5	1.3	
Mean (4)					**1.1**	
Standard Deviation					0.1	
Matlacha Pass	MP01		Thalassia	0.1	1.3	
Matlacha Pass	MP02		Halodule	1.0	1.1	
Matlacha Pass	MP03		Halodule	1.0	1.5	
Matlacha Pass	MP04		Halodule	0.5	1.5	
Mean (4)					**1.3**	
Standard Deviation					0.2	
Matlacha Pass	MP01		Halodule	1.0	1.2	
Matlacha Pass	MP02		Halodule	0.5	1.2	
Matlacha Pass	MP03		Halodule	0.1	1.6	
Matlacha Pass	MP04		Halodule	1.0	0.9	**1.5**
Mean (4)					**1.2**	
Standard Deviation					0.3	
Myakka River	MYR01	2000	Ruppia	0.1	0.5	
Myakka River	MYR02	2000	Halodule	0.1	1.0	
Myakka River	MYR03	2000	Halodule	0.1	0.9	
Myakka River	MYR04	2000	Halodule	0.1	1.1	
Mean (4)					**0.8**	
Standard Deviation					0.2	
Myakka River	MYR01	2001	Ruppia	0.5	0.2	
Myakka River	MYR05	2001	Halodule	1.0	0.7	
Myakka River	MYR04	2001	Halodule	2.0	0.7	
Mean (3)					**0.5**	
Standard Deviation					0.3	
Myakka River	MYR01	2002	Halodule	0.5	0.6	
Myakka River	MYR02	2002	Halodule	0.1	0.8	
Myakka River	MYR05	2002	Halodule	1.0	1.0	
Myakka River	MYR03	2002	Halodule	0.5	1.0	
Myakka River	MYR04	2002	Halodule	1.0	0.8	
Mean (5)					**0.8**	
Standard Deviation					0.2	

Segment	Site	Year	Species	BB Abundance	Depth (m)	Deepest Mean Depth
Myakka River	MYR02	2003	Halodule	0.5	0.5	
Myakka River	MYR03	2003	Halodule	0.1	0.7	
Myakka River	MYR04	2003	Halodule	0.1	0.8	
Myakka River	MYR05	2003	Halodule	0.1	0.9	
Mean (4)					**0.7**	
Standard Deviation					0.2	
Myakka River	MYR02	2004	Halodule	0.1	0.6	
Myakka River	MYR03	2004	Halodule	0.1	0.8	
Myakka River	MYR04	2004	Halodule	0.1	0.7	
Myakka River	MYR05	2004	Halodule	0.1	1.0	
Mean (4)					**0.8**	
Standard Deviation					0.2	
Myakka River	MYR05	2005	Halodule	0.5	1.0	
Myakka River	MYR01	2005	Halodule	0.5	0.2	
Myakka River	MYR02	2005	Halodule	0.5	0.3	
Myakka River	MYR03	2005	Halodule	0.1	1.0	
Myakka River	MYR04	2005	Halodule	0.5	0.6	**0.8**
Mean (5)					**0.6**	
Standard Deviation					0.4	
Peace River	PR02	1999	Halodule	1.0	0.7	
Peace River	PR03	1999	Halodule	0.1	1.1	
Peace River	PR04	1999	Halodule	0.5	0.8	
Peace River	MC08	1999	Halodule	0.1	1.1	
Mean (4)					**0.9**	
Standard Deviation					0.2	
Peace River	PR03	2000	Halodule	0.5	0.7	
Peace River	MC08	2000	Halodule	0.1	1.1	
Mean (2)					**0.9**	
Standard Deviation					0.3	
Peace River	MC08	2001	Halodule	0.1	0.9	
Peace River	PR03	2001	Halodule	0.1	0.9	
Peace River	PR04	2001	Halodule	0.1	0.8	
Mean (3)					**0.8**	
Standard Deviation					0.1	
Peace River	PR03	2002	Halodule	0.5	1.0	
Peace River	MC08	2002	Halodule	0.1	0.9	
Peace River	PR04	2002	Halodule	0.5	0.8	
Mean (3)					**0.9**	
Standard Deviation					0.1	
Peace River	PR02	2003	Halodule	0.5	0.9	
Peace River	PR03	2003	Halodule	0.5	1.1	
Peace River	PR04	2003	Halodule	0.1	1.0	
Mean (3)					**1.0**	
Standard Deviation					0.1	
Peace River	PR03	2004	Halodule	0.5	0.7	
Peace River	PR04	2004	Halodule	0.1	0.9	
Peace River	MC08	2004	Halodule	0.5	0.6	
Mean (3)					**0.7**	
Standard Deviation					0.1	
Peace River	PR03	2005	Halodule	0.5	0.9	
Peace River	MC08	2005	Halodule	0.5	0.9	
Peace River	PR02	2005	Halodule	0.5	0.8	
Peace River	PR04	2005	Halodule	0.1	0.9	**1.0**
Mean (4)					**0.9**	
Standard Deviation					0.0	
Pine Island Sound	PI08	1999	Thalassia	0.5	1.8	
Pine Island Sound	PI08	1999	Halodule	0.1	1.8	
Pine Island Sound	PI09	1999	Halodule	0.5	2.0	
Pine Island Sound	PI01	1999	Syringodium	2.0	2.3	
Pine Island Sound	PI02	1999	Halodule	0.5	1.6	
Pine Island Sound	PI04	1999	Thalassia	1.0	1.1	
Pine Island Sound	PI06	1999	Halodule	5.0	1.2	
Pine Island Sound	PI07	1999	Thalassia	0.5	1.6	
Pine Island Sound	PIS05	1999	Thalassia	0.5	1.5	
Mean (8)					**1.6**	
Standard Deviation					0.4	
Pine Island Sound	PI08	2000	Halodule	1.0	1.9	
Pine Island Sound	PI02	2000	Halodule	1.0	1.5	
Pine Island Sound	PI04	2000	Thalassia	1.0	1.0	
Pine Island Sound	PIS05	2000	Thalassia	1.0	1.4	
Pine Island Sound	PI03	2000	Thalassia	2.0	2.3	
Pine Island Sound	PI06	2000	Halodule	4.0	1.2	
Pine Island Sound	PI07	2000	Thalassia	1.0	1.3	
Pine Island Sound	PI09	2000	Halodule	1.0	2.0	
Mean (8)					**1.6**	
Standard Deviation					0.5	
Pine Island Sound	PI03	2001	Thalassia	1.0	2.3	

Segment	Site	Year	Species	BB Abundance	Depth (m)	Deepest Mean Depth
Pine Island Sound	PI06	2001	Halodule	1.0	1.3	
Pine Island Sound	PI01	2001	Syringodium	2.0	2.1	
Pine Island Sound	PI02	2001	Halodule	0.1	1.4	
Pine Island Sound	PI04	2001	Thalassia	0.5	0.9	
Pine Island Sound	PIS05	2001	Thalassia	1.0	1.0	
Pine Island Sound	PI07	2001	Thalassia	1.0	1.3	
Pine Island Sound	PI09	2001	Halodule	1.0	2.0	
Pine Island Sound	PI08	2001	Halodule	0.5	1.8	
Pine Island Sound	PI08	2001	Thalassia	0.1	1.8	
Mean (9)					**1.6**	
Standard Deviation					0.5	
Pine Island Sound	PI01	2002	Halodule	1.0	2.2	
Pine Island Sound	PI02	2002	Halodule	1.0	1.3	
Pine Island Sound	PI03	2002	Thalassia	0.5	2.4	
Pine Island Sound	PI08	2002	Thalassia	1.0	1.9	
Pine Island Sound	PIS05	2002	Thalassia	0.5	1.1	
Pine Island Sound	PI04	2002	Thalassia	1.0	1.0	
Pine Island Sound	PI06	2002	Halodule	2.0	0.9	
Pine Island Sound	PI07	2002	Thalassia	0.5	1.4	
Pine Island Sound	PI09	2002	Thalassia	0.5	2.3	
Pine Island Sound	PI09	2002	Halodule	1.0	2.3	
Mean (9)					**1.6**	
Standard Deviation					0.6	
Pine Island Sound	PI07	2003	Thalassia	2.0	1.2	
Pine Island Sound	PI07	2003	Halodule	0.5	1.2	
Pine Island Sound	PI08	2003	Halodule	0.1	2.1	
Pine Island Sound	PI09	2003	Thalassia	0.1	2.2	
Pine Island Sound	PI06	2003	Halodule	2.0	1.0	
Pine Island Sound	PI02	2003	Halodule	0.5	1.3	
Pine Island Sound	PI03	2003	Thalassia	0.5	2.5	
Pine Island Sound	PI04	2003	Halodule	0.1	1.5	
Pine Island Sound	PIS05	2003	Thalassia	0.5	1.1	
Pine Island Sound	PI01	2003	Syringodium	1.0	2.2	
Pine Island Sound	PI01	2003	Halodule	0.5	2.2	
Mean (9)					**1.7**	
Standard Deviation					0.6	
Pine Island Sound	PI07	2004	Halodule	0.5	1.6	
Pine Island Sound	PI07	2004	Thalassia	0.1	1.6	
Pine Island Sound	PIS05	2004	Thalassia	0.1	1.3	
Pine Island Sound	PI01	2004	Syringodium	0.5	2.3	
Pine Island Sound	PI03	2004	Thalassia	0.5	2.5	
Pine Island Sound	PI04	2004	Thalassia	0.1	1.6	
Pine Island Sound	PI06	2004	Halodule	2.0	1.1	
Pine Island Sound	PI10	2004	Halodule	0.5	2.5	
Pine Island Sound	PI11	2004	Halodule	0.1	1.6	
Pine Island Sound	PI09	2004	Halodule	0.1	2.5	
Pine Island Sound	PI02	2004	Halodule	0.1	1.4	
Pine Island Sound	PI08	2004	Thalassia	0.1	2.1	
Pine Island Sound	PI08	2004	Halodule	0.5	2.1	
Mean (11)					**1.9**	
Standard Deviation					0.5	
Pine Island Sound	PI08	2005	Thalassia	0.5	1.9	
Pine Island Sound	PI08	2005	Halodule	0.5	1.9	
Pine Island Sound	PI10	2005	Halodule		1.8	
Pine Island Sound	PI11	2005	Halodule	0.1	1.9	
Pine Island Sound	PI01	2005	Syringodium	2.0	2.2	
Pine Island Sound	PI03	2005	Thalassia	1.0	2.3	
Pine Island Sound	PIS05	2005	Thalassia	0.5	1.3	
Pine Island Sound	PI06	2005	Halodule	1.0	1.2	
Pine Island Sound	PI07	2005	Thalassia	0.1	1.6	
Pine Island Sound	PI09	2005	Halodule	0.5	2.2	
Pine Island Sound	PI02	2005	Halodule	0.5	1.5	
Pine Island Sound	PI04	2005	Halodule		1.2	**1.9**
Mean (11)					**1.7**	
Standard Deviation					0.4	
San Carlos Bay	SC01	1999	Thalassia	1.0	1.9	
San Carlos Bay	SC01	1999	Syringodium	3.0	1.9	
San Carlos Bay	SC03	1999	Syringodium	1.0	1.5	
San Carlos Bay	SC02	1999	Syringodium	0.5	1.7	
San Carlos Bay	MP05	1999	Halodule	0.5	1.2	
San Carlos Bay	MP05	1999	Thalassia	0.5	1.2	
San Carlos Bay	MP05	1999	Halophila	0.5	1.2	
Mean (4)					**1.6**	
Standard Deviation					0.3	
San Carlos Bay	SC03	2000	Syringodium	2.0	1.7	
San Carlos Bay	SC03	2000	Thalassia	0.5	1.7	
San Carlos Bay	SC02	2000	Thalassia	0.5	1.8	
San Carlos Bay	MP05	2000	Halodule	2.0	1.2	

Segment	Site	Year	Species	BB Abundance	Depth (m)	Deepest Mean Depth
San Carlos Bay	MP05	2000	Thalassia	2.0	1.2	
Mean (3)					**1.6**	
Standard Deviation					0.3	
San Carlos Bay	MP05	2001	Halodule	1.0	1.6	
San Carlos Bay	SC03	2001	Thalassia	0.1	1.6	
San Carlos Bay	SC02	2001	Syringodium	0.5	1.7	
San Carlos Bay	SC01	2001	Halodule	1.0	1.9	
Mean (4)					**1.7**	
Standard Deviation					0.1	
San Carlos Bay	SC02	2002	Syringodium	0.1	1.9	
San Carlos Bay	SC02	2002	Halodule	0.1	1.9	
San Carlos Bay	SC01	2002	Halodule	0.5	1.9	
San Carlos Bay	MP05	2002	Halodule	0.5	1.5	
San Carlos Bay	SC03	2002	Thalassia	0.5	1.8	
San Carlos Bay	SC03	2002	Syringodium	1.0	1.8	
Mean (4)					**1.8**	
Standard Deviation					0.2	
San Carlos Bay	SC01	2003	Thalassia	0.5	2.0	
San Carlos Bay	SC02	2003	Thalassia	0.5	2.5	
San Carlos Bay	MP05	2003	Halodule	0.1	2.0	
San Carlos Bay	SC03	2003	Thalassia	0.5	1.7	
San Carlos Bay	SC03	2003	Syringodium	0.5	1.7	
Mean (4)					**2.0**	
Standard Deviation					0.3	
San Carlos Bay	SC04	2004	Syringodium	0.1	1.9	
San Carlos Bay	SC05	2004	Thalassia	0.1	1.2	
San Carlos Bay	SC01	2004	Thalassia	0.5	2.3	
San Carlos Bay	MP05	2004	Halodule	1.0	2.0	
San Carlos Bay	SC03	2004	Syringodium	0.1	2.2	
San Carlos Bay	SC02	2004	Thalassia	0.1	2.2	
Mean (6)					**1.9**	
Standard Deviation					0.4	
San Carlos Bay	SC04	2005	Thalassia	0.1	1.8	
San Carlos Bay	SC05	2005	Halodule	1.0	0.6	
San Carlos Bay	MP05	2005	Halodule	0.1	1.9	
San Carlos Bay	SC01	2005	Thalassia	0.1	1.9	
San Carlos Bay	SC03	2005	Thalassia	0.1	1.8	**2.0**
Mean (5)					**1.6**	
Standard Deviation					0.5	
West Wall	MC06	1999	Halodule	1.0	1.0	
West Wall	MC07	1999	Halodule	0.1	1.0	
West Wall	MC04	1999	Halodule	0.1	1.3	
West Wall	MC05	1999	Halodule	0.5	1.8	
Mean (4)					**1.3**	
Standard Deviation					0.4	
West Wall	MC07	2000	Halodule	0.5	1.1	
West Wall	MC05	2000	Halodule	0.5	1.8	
West Wall	MC04	2000	Thalassia	2.0	1.5	
Mean (3)					**1.4**	
Standard Deviation					0.4	
West Wall	MC04	2001	Thalassia	0.1	1.7	
West Wall	MC05	2001	Halodule	0.5	1.4	
West Wall	MC01	2001	Halodule	1.0	0.7	
West Wall	MC06	2001	Halodule	0.5	1.4	
West Wall	MC07	2001	Halodule	0.5	0.7	
Mean (5)					**1.2**	
Standard Deviation					0.4	
West Wall	MC04	2002	Thalassia	0.1	1.1	
West Wall	MC05	2002	Halodule	0.5	1.8	
West Wall	MC01	2002	Halodule	0.1	1.0	
West Wall	MC06	2002	Halodule	0.1	1.3	
West Wall	MC07	2002	Halodule	1.0	0.5	
Mean (5)					**1.2**	
Standard Deviation					0.5	
West Wall	MC04	2003	Halodule	0.1	1.0	
West Wall	MC04	2003	Thalassia	0.1	1.0	
West Wall	MC05	2003	Halodule	0.1	1.2	
West Wall	MC06	2003	Halodule	0.5	1.3	
West Wall	MC01	2003	Halodule	0.1	0.5	
West Wall	MC07	2003	Halodule	0.5	0.6	
Mean (5)					**0.9**	
Standard Deviation					0.4	
West Wall	MC01	2004	Thalassia	0.1	0.7	
West Wall	MC01	2004	Halodule	0.1	0.7	
West Wall	MC07	2004	Halodule	0.5	1.1	
West Wall	MC05	2004	Halodule	0.1	1.6	
West Wall	MC06	2004	Halodule	0.5	1.4	
West Wall	MC04	2004	Halodule	0.5	1.6	

Segment	Site	Year	Species	BB Abundance	Depth (m)	Deepest Mean Depth
Mean (5)					**1.3**	
Standard Deviation					0.4	
West Wall	MC01	2005	Halodule	0.1	0.8	
West Wall	MC07	2005	Halodule	0.1	1.1	
West Wall	MC04	2005	Halodule	0.1	1.5	
West Wall	MC05	2005	Halodule	0.1	1.9	
West Wall	MC06	2005	Halodule	0.5	1.0	**1.4**
Mean (5)					**1.3**	
Standard Deviation					0.4	
Estero Bay	EB01	2002			1.6	
Estero Bay	EB02	2002			0.8	
Estero Bay	EB03	2002			0.7	
Estero Bay	EB04	2002			0.9	
Estero Bay	EB05	2002			1.1	
Mean					**1.0**	
Standard Deviation					0.3	
Estero Bay	EB01	2003			1.0	
Estero Bay	EB02	2003			0.5	
Estero Bay	EB03	2003			1.2	
Estero Bay	EB04	2003			0.9	
Estero Bay	EB05	2003			0.8	
Estero Bay	EB01	2003			1.5	
Estero Bay	EB02	2003			0.9	
Estero Bay	EB03	2003			0.9	
Estero Bay	EB04	2003			1.1	
Estero Bay	EB05	2003			1.6	
Mean					**1.0**	
Standard Deviation					0.3	
Estero Bay	EB01	2004			0.4	
Estero Bay	EB02	2004			0.9	
Estero Bay	EB03	2004			1.4	
Estero Bay	EB04	2004			1.5	
Estero Bay	EB05	2004			1.4	
Estero Bay	EB01	2004			1.3	
Estero Bay	EB02	2004			0.5	
Estero Bay	EB04	2004			1.0	
Estero Bay	EB05	2004			0.7	
Mean					**1.0**	
Standard Deviation					0.4	
Estero Bay	EB01	2005			1.6	
Estero Bay	EB02	2005			0.5	
Estero Bay	EB03	2005			0.6	
Estero Bay	EB04	2005			0.8	
Estero Bay	EB05	2005			0.9	
Estero Bay	EB01	2005			1.4	
Estero Bay	EB02	2005			0.8	
Estero Bay	EB03	2005			0.8	
Estero Bay	EB04	2005			0.9	
Estero Bay	EB05	2005			0.2	**1.0**
Mean					**0.8**	
Standard Deviation					0.4	