PREDICTED INCREASES IN SEAGRASS HABITAT ASSOCIATED WITH DECREASED WATER COLUMN CHLOROPHYLL LEVELS IN CENTRAL SARASOTA BAY

Introduction

The relationship between the maximum depth of occurrence of perennial species of seagrasses and the light attenuation of the overlying water column has been previously investigated (e.g. Dennison, 1987; Dennison and Alberte, 1982, 1985, 1986; Zimmerman et al., 1989; 1991). Light attenuation of the water column can be used to predict the depth limit of various species of seagrasses, although some situations do not result in a tight correlation (Zimmerman et al., 1991).

In Sarasota Bay, most previous work on light availability underwater has involved secchi disk depths. The relationship between secchi disk depth and light attenuation coefficients degenerates when color is a significant component of light attenuation (Chambers and Prepas, 1988). However, relatively low levels of color in Sarasota Bay (Heyl, 1990) suggest that the close correlation between secchi disk depth and attenuation coefficients found by Kenworthy et al. (1987) in Hobe Sound, Florida might also exist in Sarasota Bay.

Yearly average light attenuation coefficients have been shown to be good predictors of the maximal depth of distribution for perennial species of seagrasses (Dennison, 1987). Thus, if light attenuation coefficients in Sarasota Bay could be averaged over a year, it might be possible to estimate the maximum depth limit for both Thalassia testudinum and Halodule wrightii, the dominant perennial seagrasses in Sarasota Bay.

Further, by partitioning out light attenuation due to chlorophyll a, it would then be possible to project new depth limits for seagrasses based on projected increases or decreases in average water column chlorophyll levels.

Approach

Assumptions:

1- Sarasota Bay, due to relatively low values for color, would have a good correlation between secchi disk depth and light attenuation coefficients (Kenworthy et al., 1987).

2- Yearly averages of light attenuation coefficients can be accurate estimators of the maximum depth of distribution of perennial species of seagrasses (Dennison, 1987).

3- Values for light attenuation of chlorophyll a (Dawes, 1981), and attenuation due to seawater alone (Lorenzen, 1972) can be used to partition the attenuation of photosynthetically useful radiation due to these two variables (McPherson & Miller, 1987).

4- The average slope of the bottom of Sarasota Bay from Whitaker Bayou north to approximately Bowlees Creek can be approximated by current bathymetric maps.

Using Heyl's (1990) average bay-wide secchi disk depth of 1.4 m, and Kenworthy et al.'s (1987) equation:

$$K = -0.22 (D) + 1.03$$

Where, K = light attenuation coefficient
D = secchi disk depth (meters)

The bay-wide attenuation coefficient would be 0.72. This compares nicely with the lagoon-wide average attenuation coefficient of 0.75 for Hobe Sound, Florida (Kenworthy et al., 1991).

Using Dennison's (1987) equation for predicting compensation depths for perennial species of seagrasses:

$$D = 1.62 / K$$

Where, D = maximum depth limit (meters)
K = light attenuation coefficient

The bay-wide average for maximum depth of distribution of seagrasses would be 2.25 meters. This value translates into approximately 7.5 feet, and would be the average for sites with greatly different actual depth limits.

Using an attenuation coefficient for seawater alone of 0.0384 / meter (Lorenzen, 1972), and an attenuation coefficient at 663 nm of 0.84 for 1 ug of Chl a / liter in a 1 cm light path (Dawes, 1981) we can estimate the percent of photosynthetically useful radiation transmitted through the water column by the following formula:

$$\text{Absorbance} = 2 - \log(\%\ \text{transmission})$$

Using two values of chlorophyll a concentration (both representative of segment-wide averages in Sarasota Bay), and taking into account light attenuation due to seawater alone, we get the following:

	Chlorophyll concentration	
	15 ug / l	10 ug / l
Depth (m)	% surface irradiance	
1.0	67	74
2.0	40	51
3.0	19	32

It is stressed that these values take into account only light attenuation due to chlorophyll and seawater. The non-inclusion of attenuation due to turbidity and color results in overestimates for light transmission, as shown below.

Using the formula:

$$K = \ln (Io/Iz) / z$$

Where, K = attenuation coefficient
Io = surface irradiance
Iz = irradiance at depth z
z = depth in meters

The average percent of surface irradiance at 2.25 m, the predicted maximum depth of distribution of seagrasses, would be 20 percent. This value matches very closely data from Kenworthy et al. (1991) and Kenworthy (personal communication).

The following table can then be constructed using information on light attenuation due to chlorophyll. Light attenuation due to seawater, color, and turbidity would constitute the remaining absorbance necessary for 20 % light levels at 2.25 m.

	Chlorophyll concentration	
	15 ug / l	10 ug / l
Percent surface irradiance (2.25 m)	20 %	20 %
Percent light attenuation due to Chl <u>a</u>	41 %	27 %

These values are within reason for areas with high chlorophyll levels and low color, such as segment B-11 of Sarasota Bay (McPherson, personal communication).

If basin-wide management practices reducing nutrient loading could sustain a segment-wide reduction in average chlorophyll <u>a</u> levels from 15 ug / l to 10 ug / l, and assuming that chlorophyll <u>a</u> accounts for 35 % of total light attenuation, the average light attenuation coefficient would decline from 0.72 to 0.62.

This decline in attenuation would result in an increase in depth limits for seagrasses, using Dennison's (1987) formula, from 2.25 m to 2.61 m (7.5 feet to 8.75 feet).

If we use an average bottom slope in Sarasota Bay of 1.0 m of depth per 0.25 miles (middle portion of the bay), the horizontal distance between the 2.25 and 2.61 m isobars would be 153 meters. A representative circular area in central Sarasota Bay with a diameter of 2 miles would then result in a difference in areal extent from 2.25 m of depth to 2.61 m of just over one-half square mile of bay bottom. As data become available from a currently-funded bathymetric survey of Sarasota Bay, more accurate estimates can be made of areal increases in seagrass coverage to be expected with increased depth limits (Sheng, personal communication.

Using horizontal growth rates of 0.40 cm / day for Thalassia testudinum (Tomasko and Lapointe, in press) and 2.23 cm / day for Halodule wrightii (Tomasko, in press), it would take T. testudinum approximately 104 years to extend its depth limit to the deeper level associated with reduced chlorophyll a levels. In contrast, it would take H. wrightii only 19 years to extend its depth limit to the deeper level associated with reduced chlorophyll a levels. Plantings could shorten the time frame for extension to new depth limits.

Positive changes in land use patterns, stormwater retention, and wastewater treatment would be expected to reduce nutrient loading into Sarasota Bay. Reductions in nutrient loading rates would be expected to result in decreased water column chlorophyll a levels. Using the above assumptions and calculations, a sustained 33 % decline in chlorophyll a levels would reduce light attenuation such that there could be a one-half square mile increase in seagrass habitat in the central portion of Sarasota Bay alone in just under two decades.

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