NEAR-SHORE WATER QUALITY AND SEAGRASS DEPTH LIMITS IN UPPER TAMPA BAY, FLORIDA

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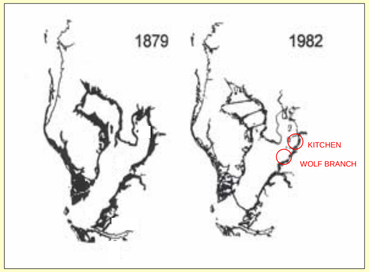
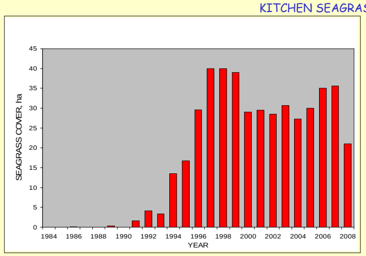
Tampa Bay, and specifically the upper bay segments, has undergone major changes in water quality over the last half century. Water quality became severely degraded during the 1960s and 1970s, but has greatly improved during the last two decades as a result of nutrient discharge reductions. The Tampa Bay seagrass trends are reflected in the water quality record. It has been estimated that about a hundred years ago, the entire shallow shelf around Tampa Bay was covered by submerged seagrass. The seagrass meadows are shown as the black areas in this picture. Large seagrass losses, primarily in the upper bay segments, occurred during the degraded water quality period. By the early 1980s, perhaps as much as 70 percent of the historical Tampa Bay seagrass coverage had been lost.

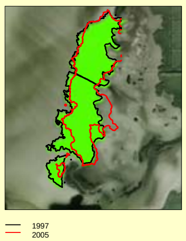
The discussion in this poster will focus on two areas on the eastern shore of the bay, the Kitchen and Wolf Branch areas. Both areas are fringed by extensive mangrove forests and salt-marshes.

SEAGRASS COVERAGE IN TAMPA BAY



KITCHEN SEAGRASS COVER





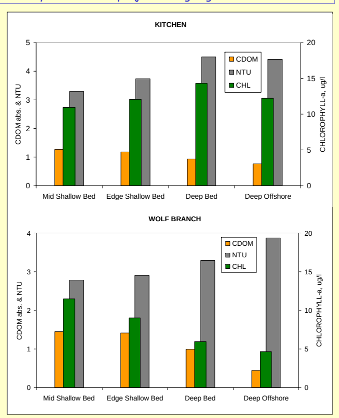
Following the water quality improvements in the early 1980s, primarily *Halodule wrightii* initially expanded rapidly in several shallow areas in the upper bay. Specifically in the Kitchen area, coverage increased from near zero in the mid 1980s to near 40ha in the 1997 to 1999 period. However, over the last decade there has been no sustained increase of the Kitchen meadow.

One striking feature of the near-shore Kitchen and Wolf Branch meadows, as well as of other upper bay *H. wrightii* meadows, is the recent stability of the deep edge. The shallow meadows have not extended into deeper waters over the last decade. However, deeper *H. wrightii* meadows, located further offshore, are temporarily established during extended dry periods.

The enduring lack of expansion of shallow seagrass meadows, and the periodic colonization of the offshore areas during improved water quality periods, suggests that seagrass expansion in the upper bay portions may have reached the upper limit that can be supported by current water quality conditions. Herein we report information from the Kitchen and Wolf Branch areas that examine seagrass distribution and water quality parameters that affect the underwater light climate. The results presented are preliminary because the project is ongoing.

Intensive sampling of the Kitchen during 2005 through 2009 shows that CDOM absorbance was consistently higher in waters above the near-shore seagrass bed compared to areas further offshore. It appears that the source of the CDOM is local, i.e. runoff from nearby mangrove forests and salt-marshes, and/or from the seagrass meadows themselves. Turbidity exhibits an increasing trend with distance from shore. Alternatively, chlorophyll values, do not vary much from the inshore to the offshore areas.

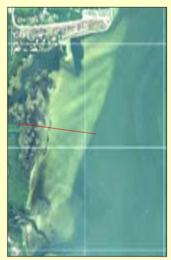
Water quality information from Wolf Branch is sparser, however, the available information indicates a similar spatial pattern for CDOM absorbance and turbidity, but chlorophyll shows a pronounced decreasing trend with distance from shore.

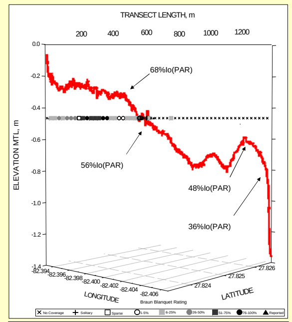


Abstract

Periodic setbacks occur in Tampa Bay seagrass coverage following periods of prolonged rainfall. The setbacks are not unexpected because the increased rainfall causes high tributary discharges of dissolved and particulate matter that affect the light climate of bay waters. However, several near-shore and shallow *Halodule wrightii* meadows in the upper areas of the bay, many bordering mangrove and salt marshes, have been stagnant or shown very limited expansion for a decade or longer; a time which has included both dry and wet periods. Light availability at the deep edge of these near-shore *H. wrightii* meadows, estimated from an optical model, appears to average about 50 to 60% of surface incident (Io) photosynthetically available radiation (PAR). This light level would appear sufficient for the meadows to grow and expand into deeper waters. In contrast, deep edges of *H. wrightii* meadows that are temporarily established during extended dry periods, which are located near the offshore edge of the estuarine shelf, receive lower average light levels of about 30 to 40%Io. A four year and still ongoing study of shallow water quality in southeastern Hillsborough Bay shows that CDOM absorbance is consistently higher in waters above the near-shore seagrass bed than in waters above the offshore meadows. Turbidity shows an increasing trend with distance from shore. Results from the study suggest that reductions of important light energy in the shallow area from relatively high CDOM absorbance, in addition to losses caused by phytoplankton, other particulate matter, and epiphytes may limit the near-shore meadows to the shallow depths they currently inhabit. We also plan to explore, through field measurements and bio-optical modeling, if light availability expressed as photosynthetically usable radiation (PUR), which accounts for spectrum weighted energy requirements of the seagrass, will help us better understand why the near-shore *H. wrightii* meadows are stagnant.

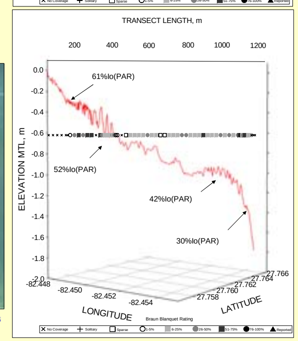
KITCHEN





WOLF BRANCH

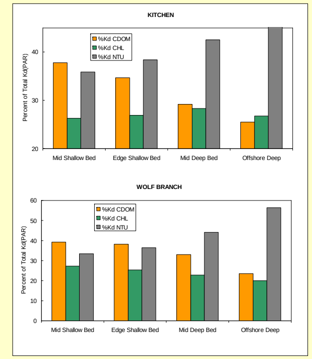
Photos by Tampa Bay Water, October 2008



We used an optical model developed by Dr. Charles Gallegos at the Smithsonian ERC to estimate PAR light attenuation from the three measured water quality parameters in both areas. From those results, we estimated percent PAR light availability (%Io) at the deep edges of the near-shore and offshore meadows. Depths were measured using high resolution DGPS.

In the Kitchen, the shallow meadow deep edge receives about 56% of Io and the deep meadow deep edge receives about 36% Io. At Wolf Branch, the respective values are 52% and about 30%. Light availability at the shallow meadow edge is slightly higher than the 45% requirement recently suggested by Duarte (Estuaries and Coasts 2007) for seagrass growing in shallow and turbid areas, but much higher than the established 20.5% seagrass light target for Tampa Bay.

Relative Contribution of Chlorophyll-a, Turbidity, and CDOM to Total Kd(PAR) 2005-2009



We also used the Gallegos optical model to estimate the relative contribution of each water quality parameter to the total Kd(PAR) for both the Kitchen and Wolf Branch information.

CDOM appears to be the most important parameter affecting PAR light attenuation near the deep edges, of the near-shore *H. wrightii* meadows at both Kitchen and Wolf Branch. Further, the importance of CDOM decreases with distance from shore. The importance of turbidity generally increases with distance from shore and has the greatest impact on total Kd(PAR) at the offshore deep meadows at both locations. The relative contribution of chlorophyll is least important at most locations and does not have a pronounced spatial pattern.

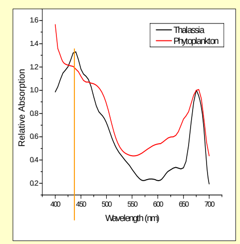
CDOM is a strong absorber of light in the blue region of the visible spectrum and the high energy blue light is very important for photosynthesis. The high CDOM levels found over the shallow seagrass meadows at both Kitchen and Wolf Branch, may reduce the amount of high energy light reaching the seagrass. To compensate for these light losses and additional light losses from relatively high concentrations of turbidity and chlorophyll, the seagrasses appear to require high levels of broad-band PAR light availability for sustained growth.

It is not only important to understand the optical properties of the water column, but also to comprehend the specific light energy requirements of the seagrasses themselves. The black line in the figure below on the left shows the absorbance spectrum for the seagrass *Thalassia testudinum*. *T. testudinum* has two important peaks of light absorption in the PAR spectrum, the highest peak near 440nm in the blue region and the second peak near 675nm in the red region. Similar information for *H. wrightii* has not been located.

The figures below on the right show the PAR absorption spectra estimated from the Gallegos model for two water quality scenarios based on the shallow Kitchen data. In both scenarios chlorophyll and turbidity were set constant as medians for the shallow stations. The CDOM concentration, however, was varied. We used CDOM expressed as PCU and compared absorbencies at 5PCU and 20PCU. These levels approximate minimum and maximum levels during the study. The relatively small increase in CDOM from 5 to 20PCU (CDOM may reach 80PCU or higher in Hillsborough Bay during prolonged wet periods) causes a near 2.5 times increase in the total absorption coefficient at 440nm.

How the reduction of blue light availability due to CDOM absorbance specifically affects the shallow *H. wrightii* meadows in the study areas is unclear at present. It appears reasonable, however, that losses of important light energy in the shallows due to phytoplankton, other particulate matter, epiphyte loads, and the relatively high CDOM absorbance may limit the expansion of the near-shore meadows to deeper areas.

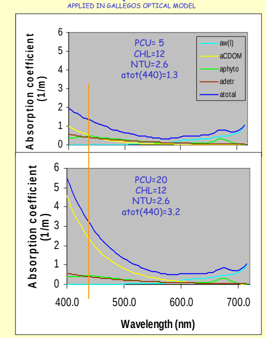
THALASSIA AND PHYTOPLANKTON



Gallegos 2007

KITCHEN WATER QUALITY PARAMETERS

APPLIED IN GALLEGOS OPTICAL MODEL



CONCLUSIONS

The near-shore and offshore *H. wrightii* meadows in the upper portions of Tampa Bay appear to be affected by different light quality due to spatial differences in water quality. As a result, near-shore and offshore seagrass meadows may require different management actions for protection and restoration.

Seagrass light requirements based on photosynthetically usable radiation (PUR), which take into account spectrum weighted energy requirements of the grass may provide better comparisons of light availability than broad-band PAR estimates, specifically for areas such as Tampa Bay which have large spatial and temporal variations in water quality.

NEXT STEPS

Programs have been initiated to increase water quality monitoring of optically important parameters in shallow areas of Tampa Bay. Studies are underway, and some have been completed, to improve the understanding of inherent optical properties of Tampa Bay waters and to determine specific seagrass light quality requirements.

This information will be used to advance the optical model development and to eventually evaluate seagrass light availability and requirements in different environs of Tampa Bay in terms of PUR, in addition to broad-band PAR light availability.