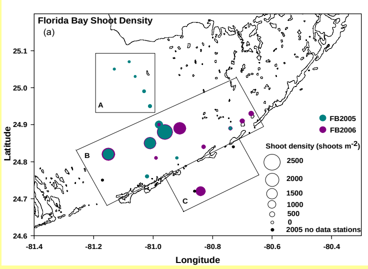
The Optical Properties of Florida Bay: Impacts for Seagrass Abundance

Meredith McPherson[1], Victoria Hill[1], Richard C. Zimmerman[1], Margaret Stoughton[1] Heidi M. Dierssen[2],
[1]Department of Ocean, Earth and Atmospheric Sciences, Old Dominion University, Norfolk, Virginia, USA
[2]Department of Marine Sciences, University of Connecticut, Groton, CT, USA

Abstract:

This project studied the relationship between seagrass productivity and water column optical properties in Florida Bay. The region adjacent to the Everglades National Park encompassed areas of high seagrass density close to the Keys, with little seagrass further north towards Cape Sable. The vertical attenuation coefficient K_{dPAR} was low in the south and increased towards Cape Sable. Approximately 50% of variance in K_{dPAR} was explained by absorption and there was no coherent relationship between scattering and $K_{d(440)}$. Along the Keys, phytoplankton contributed 9% to total absorption compared to 84% by colored dissolved organic material. The average cosine of the submarine light field was 0.7 to 0.9 in the south. Towards Cape Sable values decreased to 0.6 due to higher suspended material, indicating a more diffuse light field. Seagrasses absent from high turbidity areas where incident irradiance reaching the plants was less than 10% of surface irradiance. High suspended sediment loads, not algal abundance, were primarily responsible for light attenuation, which can limit seagrass abundance. Therefore, nutrient load reductions may be necessary, but insufficient to promote seagrass growth in North Florida Bay.



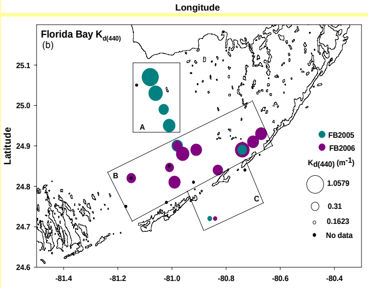


Figure 1. (a) Densities of seagrass measured throughout Florida Bay for the summers of 2005 and 2006. Density is proportional to symbol size. (b) Magnitude of $K_{d(440)}$ for stations in Florida Bay occupied during the summers of 2005 and 2006. Attenuation is proportional to symbol size. Three distinct regions were identified based on the spatial variability of shoot density and attenuation:
-Region A: Located in the northern half of Florida Bay. $K_{d(440)}$ values in these case two waters ranged from 0.68 - 1.1 m^{-1}. Seagrasses were virtually absent from every station.
-Region B: Located in the southern half of Florida Bay. $K_{d(440)}$ values were lower than Region A stations and ranged from 0.54 - 0.91 m^{-1}. Seagrass were present at all stations, but densities varied within the region.
-Region C: Located outside Florida Bay. $K_{d(440)}$ values in these case one waters were ~50% less than Regions A and B. Seagrass density was lower and less variable than Region B.

References:

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- Stoughton, M.. in prep. A bio-optical model for *Syringodium filiforme* Canopies. Masters Thesis. Department of Ocean, Earth, and Atmospheric Sciences, Old Dominion University.

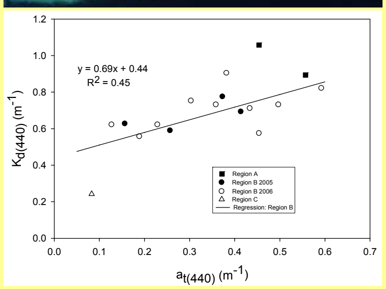


Figure 2. Downwelling diffuse attenuation at 440 nm [$K_{d(440)}$] plotted as a function of total absorption [$a_{t(440)} = a_{pg}$ (particulate + soluble) + a_w (water)]. Total absorption was a strong driver of $K_{d(440)}$ in Region B. IOPs from Region A and C represented the turbid and clear endmembers, respectively, of the IOP gradient across Florida Bay.

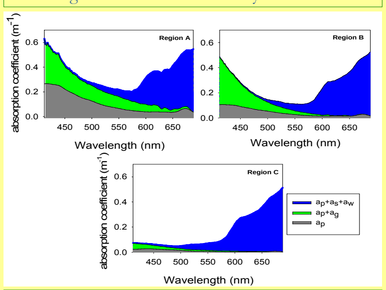


Figure 3. Mean cumulative absorption spectra for all three regions. Absorption by dissolved material was approximately four times greater than absorption by particulate material in Region B. Both particulate and dissolved material contributed equally to the total absorption in Regions A and C. Region C $a_{t(440)}$ was only 16% of the values found in Regions A and B.

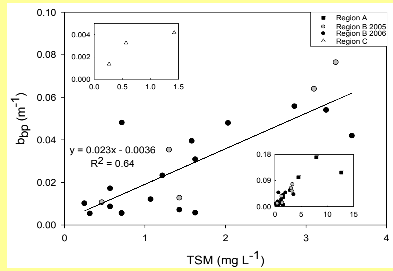


Figure 4 (left). Total backscattering (b_{bp}) plotted as a function of total suspended material (TSM). Region A was characterized by high concentrations of TSM and large coefficients of backscattering (insert bottom). TSM was a strong driver of backscattering in Region B. TSM and backscattering values were much lower in Region C than Region A or B (insert top).

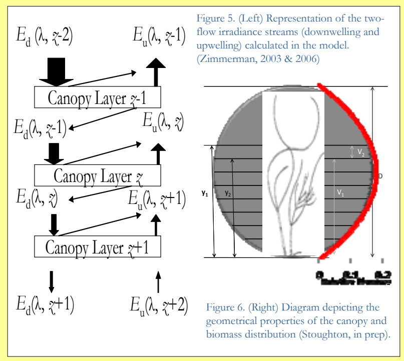
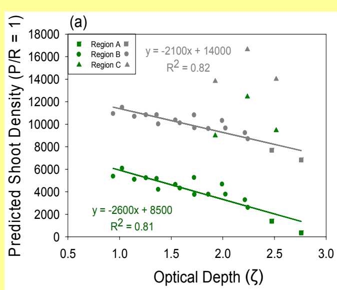


Figure 5. (Left) Representation of the two-flow irradiance streams (downwelling and upwelling) calculated in the model. (Zimmerman, 2003 & 2006)

Figure 6. (Right) Diagram depicting the geometrical properties of the canopy and biomass distribution (Stoughton, in prep).

S. filiforme bio-optical model: (Stoughton, in prep)

- Radiative-Transfer based; two-flow (Fig. 5).
- Incorporation of the spherical geometry and biomass distribution of the canopy (Fig. 6).
- Predicts:
  - Submerged aquatic light environment within the canopy
  - Canopy Photosynthesis
  - Whole plant metabolic carbon balance (P/R)



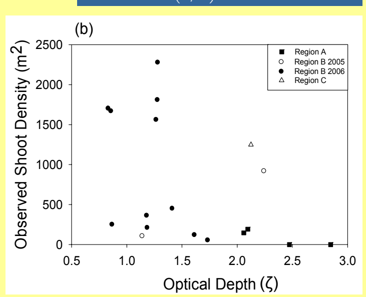


Figure 7. (a) Predicted shoot density where P/R = 1 with increasing optical depth ($\zeta = K_{dPAR} * z$) for *S. filiforme*. Grey and green symbols represent modeled PAR or PUR irradiances respectively for photosynthetic calculations. OD was a strong driver of shoot density in modeled PAR and PUR, respectively. PUR and PAR differed in both absolute shoot density and OD at which light limits seagrass growth. (b) Observed shoot density plotted as a function of OD for the stations shown in Fig. 1. The modeled shoot densities in 8(a) were consistently greater than maximum observed shoot densities in 8(b). The observed and modeled results (using PUR) were consistent in defining the threshold for seagrass growing at OD 2.5 (≈8% surface irradiance).ζ

Conclusion:

TSM was a major attenuating factor in Florida Bay and more important than algae or CDOM in the high turbidity, unvegetated areas of North Florida Bay. The critical OD for seagrass survival in Florida Bay appears to be 2.5 (≈8% surface irradiance). Where seagrass exist in Florida Bay, observed densities are much lower than predicted by the canopy radiative-transfer model, suggesting that other factors (e.g. nutrient limitation, space competition, grazing) may limit seagrass abundance in light replete environments. Predicted shoot densities based on PAR were two times higher and did not accurately predict the OD threshold generated by PUR. This illustrates the importance of light quality, not just quantity, with respect to seagrass habitat requirements. Recovery of seagrass populations in North Florida Bay will require a reduction in TSM, independent of any efforts to improve water quality by reducing nutrient loading.

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