Retrospective Analysis of Estero Bay Seagrass Cover and Water Quality Trends

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Introduction

- Seagrasses play a variety of critical ecological roles and are known as foundation species or ecosystem engineers [1,2,3]
- Seagrasses are highly vulnerable to changes in the environment, particularly to decreases in water quality, which have been implicated in global seagrass declines [4,5]
- Though the waters of Estero Bay have been protected from development since 1966 as part of the Estero Bay Aquatic Preserve (EBAP), the Bay is experiencing increasing pressures from human encroachment [6]
- A major consequence of these anthropogenic stressors may be reduced light availability in the Bay; Light is the primary influence for seagrass growth and survival [7,8]
- Anecdotal reports suggest that seagrass coverage has seriously declined in the Bay concurrently with the increased watershed development of recent decades
- However, previous quantitative analyses of seagrass trends have had equivocal results [9]

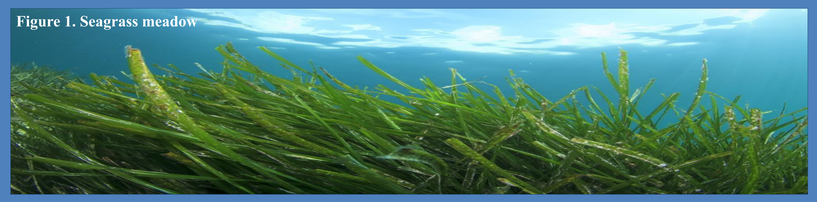

Figure 1. Seagrass meadow

Objectives

1. To update and integrate all available seagrass data for Estero Bay to make a comprehensive assessment of seagrass health trends
2. To conduct an exploratory analysis of environmental factors that might drive seagrass trends in the Bay including optical water quality

Methods

- Analyze all available seagrass data for Estero Bay
  - SFWMD Aerial photography data
    Acquired every 2 years, typically done in winter, from photointerpretation
  - EBAP Transect Monitoring data
    Five seagrass transect sites have been surveyed 2x/year from 2002 – present
- Combine with continuous water quality data
  Three datasondes located throughout the Bay recording every 15 min. from 2004 – present
- 2017-18 Bay-wide seagrass/optical water quality surveys
  50 sites selected[10], Seagrass is surveyed once/season (4x/year)
  Light attenuation is surveyed every 3 weeks for one year using paired light readings LI-193 Spherical PAR sensors for Quantum Scalar Irradiance with water quality using an YSI Professional Series[10]

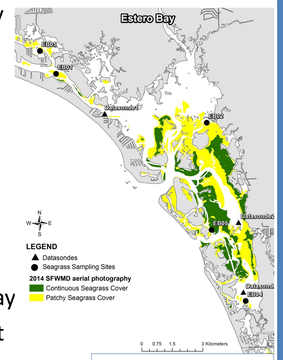

Figure 2. Map of Estero Bay

Results

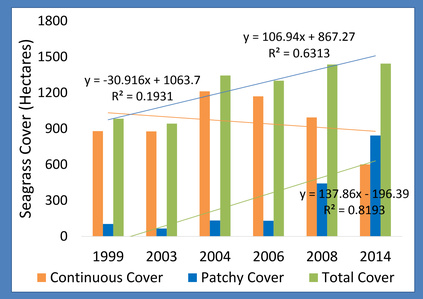

Figure 3. Estimates of seagrass cover (hectares) in Estero Bay for 1999, 2003, 2004, 2006, 2008, and 2014 by SFWMD aerial photography grouped by seagrass coverage type (continuous, patchy, total).

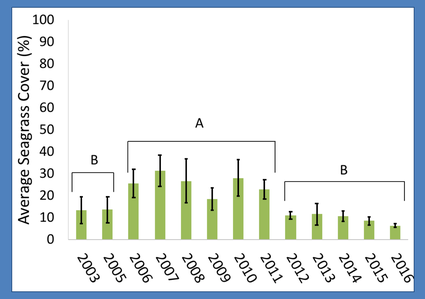

Figure 4. Average percent cover of seagrass in Estero Bay from 2003-2016 (2004 excluded) by EBAP transect surveys. Letters indicate significantly different groups.

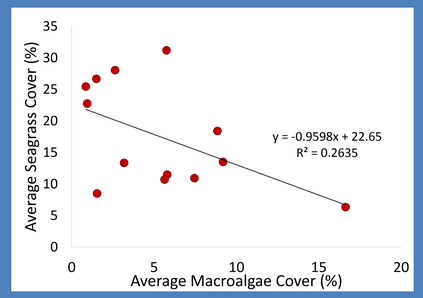

Figure 5. Correlation analysis for average seagrass cover and average macroalgae cover in Estero Bay from 2003-2016 (2004 excluded) from EBAP transect surveys.

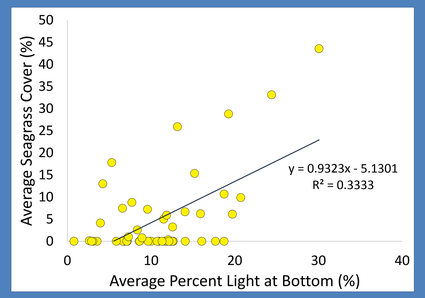

Figure 6. Correlation analysis for average seagrass cover and average percent light at bottom in Estero Bay from 2017 Bay-wide seagrass/optical water quality surveys.

Table 1. Results of regression analyses of annual average seagrass cover with abiotic and biotic factors from 2006-2016 in Estero Bay. Corrected Akaike's Information Criterion (AICc) was calculated for each model, and used to calculate the weighted model probability, wi. Models with top 3 wi values are shown.

Response Variable	Predictor Variables and Standardized Coefficients				
	Prev. year Avg. Seagrass % Cover	Nov. - Oct. Avg. Annual Temperature (°C)	Avg. Annual Drift Algae % Cover	Weighted Model Probability (wi)	Adjusted R^2 value
Avg. Annual Seagrass % Cover (2006-2016)	0.495	-9.858		0.29	0.50
	0.699			0.25	0.35
	0.577		-0.708	0.13	0.42

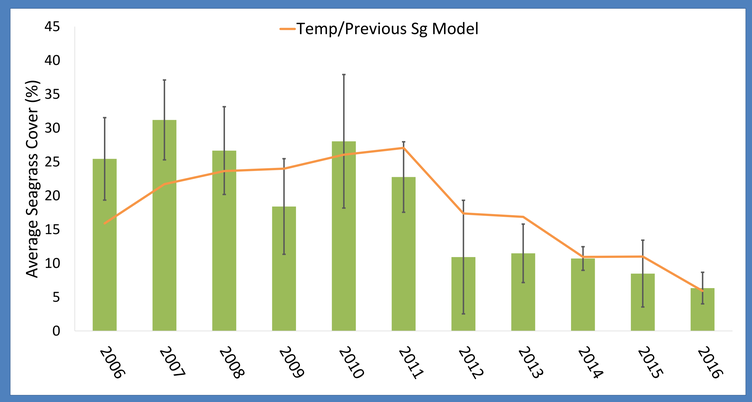

Figure 7. Average percent cover of seagrass in Estero Bay from 2006-2016 with best seagrass coverage predictor model (Nov. - Oct. average temperature (°C) and previous year average seagrass cover (%)).

Discussion

- The amount of seagrass cover measured in Estero Bay in 2016 was the lowest recorded in 14 years of transect monitoring; less than half of the recorded seagrass cover when monitoring began in 2003, and a five-fold decrease from the peak cover observed in 2007
- Aerial photography indicates a decline of continuous seagrass beds from 879 hectares in 1999 to 601 hectares in 2014
- The assessment indicates that, despite a benign period from 2006-2011, a progressive degradation of Estero Bay seagrass habitats is underway
- Regression analyses found a strong negative connection between annual seagrass trends and average annual temperature, meaning seagrass performance was worse during warmer years
  - Potential sulfide poisoning [11]
- A strong negative relationship with macroalgae was found as well, which suggests harmful eutrophication is occurring in the Bay
  - Macroalgae cover exceeded seagrass cover for the first time in 2016, suggesting that the estuary may have crossed a tipping point between seagrass and macroalgae dominance

Figure 8. Examples of macro-algae found in the Bay

- A strong positive correlation was found between 2017 average percent sunlight available at bottom and 2017 average seagrass coverage, suggesting reduced water clarity in the Bay may inhibit seagrass growth
- Restoration should thus focus on areas of the Bay that are well lit and shallow, but do not go intertidal
  - Potential for seagrass to be trampled on and potential for excessive solar light and heat exposure
- Further exploration of available sunlight at bottom as a predictor for seagrass cover in Estero Bay is needed

Acknowledgements

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References

1. Costanza, R., D'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R.G., Sutton, P., Van Den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260.

2. Green, E.P., Short, F., 2003. World atlas of seagrasses, Prepared by the UIMEP World Conservation Monitoring Centre. University of California Press, Berkeley, USA.

3. Larkum, A.W.D., Orth, R.J., Duarte, C.M., 2006. Seagrasses, Seagrasses: Biology, Ecology and Conservation.

4. Robert J. Orth, Tim J. B. Carruthers, William C. Dennison, Carlos M. Duarte, J.W., Fourqurean, Kenneth L. Heck Jr., A. Randall Hughes, Gary A. Kendrick, W.J.K., Suzanne Olyarnik, Frederick T. Short, Michelle Waycott, A.S.L.W., 2006. A Global Crisis for Seagrass Ecosystems. Bioscience 56, 987–996.

5. Waycott, M., Duarte, C.M., Carruthers, T.J.B., Orth, R.J., Dennison, W.C., Olyarnik, S., Calladine, A., Fourqurean, J.W., Heck, K.L., Hughes, A.R., Kendrick, G.A., Kenworthy, W.J., Short, F.T., Williams, S.L., 2009. Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proc. Natl. Acad. Sci. 106, 12377–12381.

6. Estero Bay Aquatic Preserve, 2014. Estero Bay Aquatic Preserve Management Plan.

7. Duarte, C.M., 1991. Seagrass depth limits. Aquat. Bot. 40, 363–377.

8. Dennison, W.C., Orth, R.J., Moore, K.A., Stevenson, J.C., Carter, V., Kollar, S., Bergstrom, P.W., Batiuk, R.A., 1993. Assessing Water Quality with Submersed Aquatic Vegetation. Bioscience 43, 86–94.

9. Yarbro, L.A., Carlson, P., 2016. Seagrass Integrated Mapping and Monitoring for the State of Florida Mapping and Monitoring Report No. 2.

10. Hotaling, A., 2014. Seagrass restoration in a boating environment. University of Florida.

11. Morris, L.J., Virnstein, R.W., 2004. The demise and recovery of seagrass in the northern Indian River Lagoon, Florida. Estuaries 27, 915–922. .