Spatial and temporal trends in long-term seagrass coverage in Palm Beach County, Florida

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Introduction

- Coastal marine ecosystems are among the most productive and biodiverse globally[1].
- Seagrass beds are declining globally, with an average loss of 1.5% of seagrass coverage per year from 1879 to 2006[2].
- Diminished water quality and light availability are some of the largest threats to seagrasses[3].
- In Lake Worth Lagoon (LWL), seagrass decline has been observed between 2007 and 2018 (Figure 1). While seagrasses acreage increased in the North region, moderate-highly dense seagrass beds mapped in 2013 had sparse coverage by 2018[4].
- To better understand the potential drivers of seagrass loss in LWL, we need to better understand the spatiotemporal patterns in light availability to seagrasses.

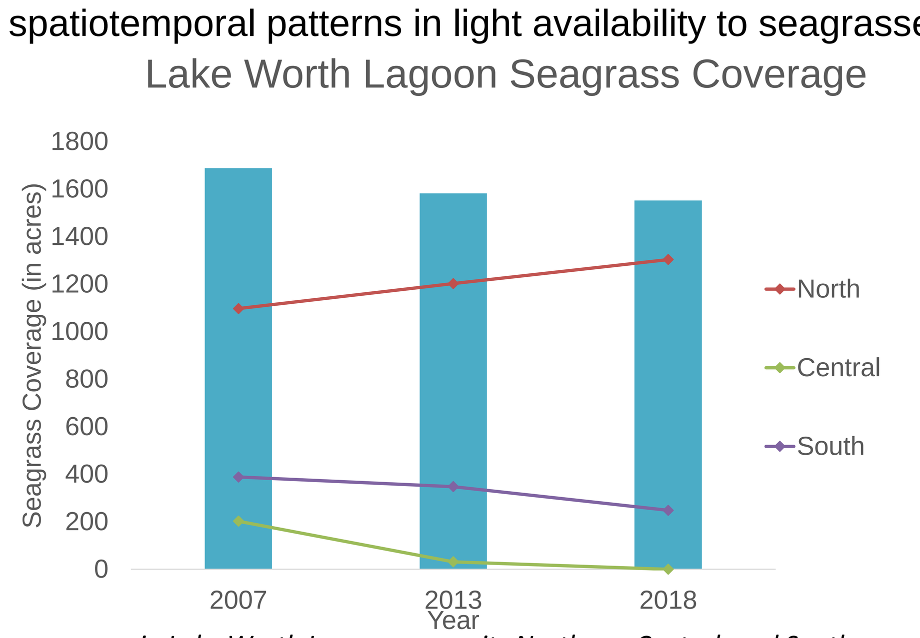

Figure 1. Total seagrass coverage in Lake Worth Lagoon across its Northern, Central, and Southern regions

Objective

Our goals in this research were as follows:

1. Is there a spatio-temporal difference in light availability across LWL system?
2. Is there a relationship between light availability and seagrass cover LWL?
3. How does water clarity and quality influence the relationship between light and seagrass cover in LWL?

Field Collection

Palm Beach County Department of Environmental Resources Management (PBC-ERM) began a lagoon-wide seagrass monitoring program in 2000. This monitoring program has allowed PBC-ERM to assess long-term trends in seagrass distribution and abundance across seagrass species prevailing in LWL[5]. PBC-ERM measured seagrass abundance using the Braun-Blanquet scale. PBC-ERM also collected photosynthetic active radiation (PAR) to quantify how much light reaches the seagrass. Additionally, LWL water quality data from the South Florida Water Management District was used to assess water quality parameters not measured by PBC-ERM.

Figure 2 below maps LWL, the location of PBC-ERM's 10 transects (different seagrass monitoring sites), and seagrass abundance. Each transect has 3 or 4 stations where seagrasses and water quality parameters are monitored.

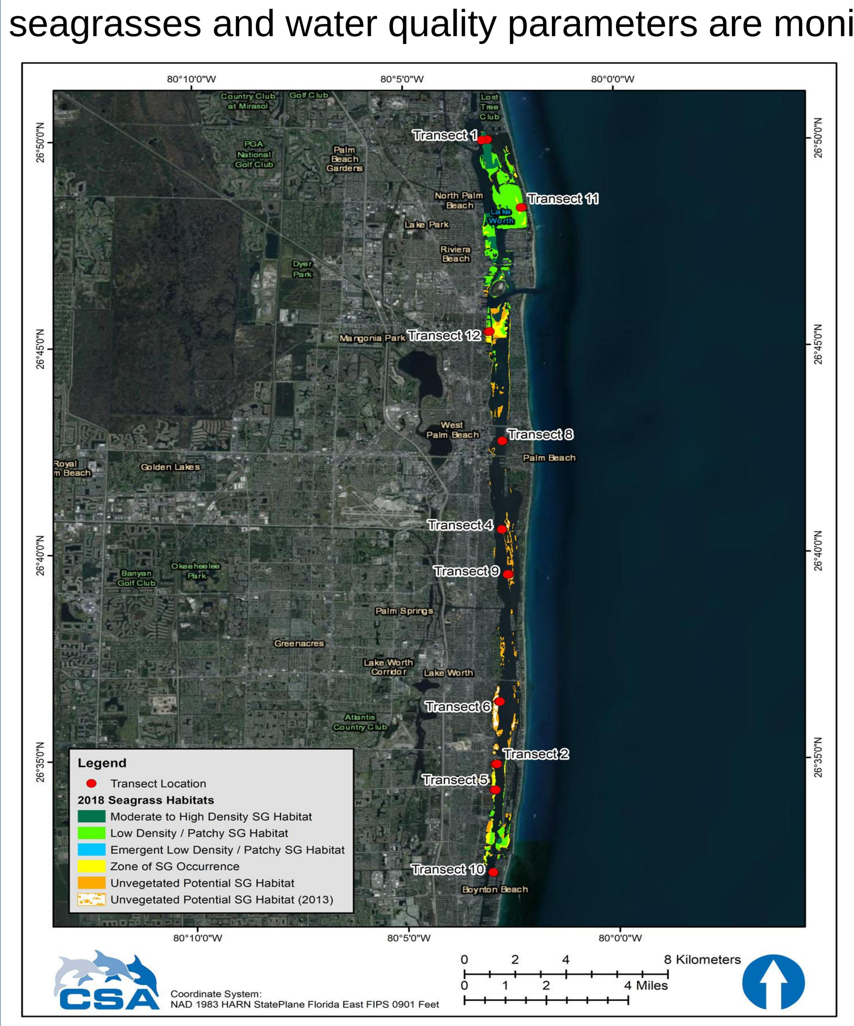

Figure 2. Map of LWL, the location of PBC-ERM's 10 transects, and seagrass abundance

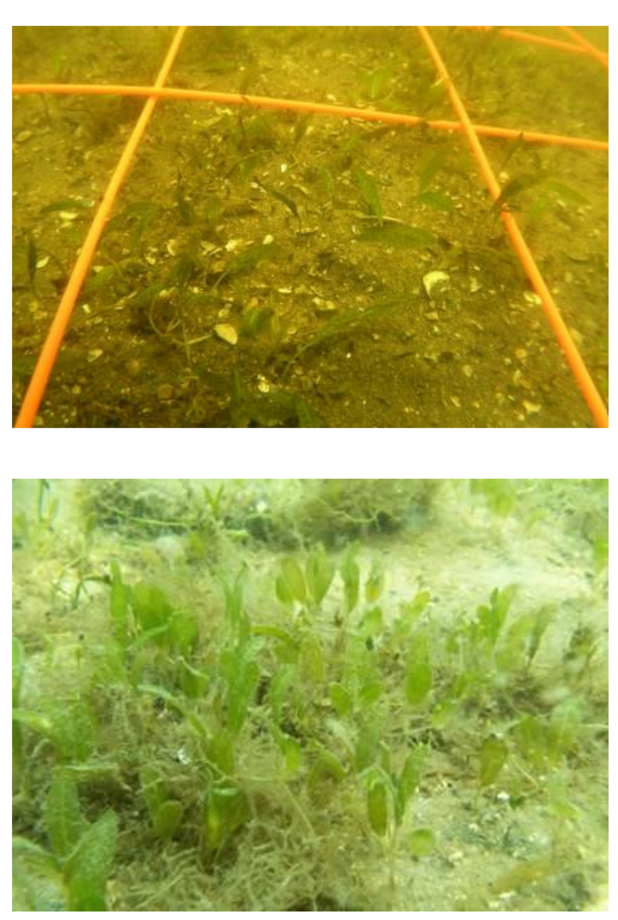

Figure 3. Seagrass monitoring station at Transect 4 (top) and Halophila decipiens

Methods

Narrative Nutrient Criterion (NNCs)

NNCs represent the uppermost acceptable levels for nutrient concentrations. LWL has NNCs for Chlorophyll-a, Total Nitrogen, and Total Phosphorus as shown in Figure 3. Each criteria is expressed as an annual geometric mean (AGM) except for the NNC for Central region's Chl-*a* (shown in bold below). For NNCs expressed as an AGM, the values shall not exceed the NNC more than once during a three-year period. For Central region's Chl-*a* NNC, the values should not exceed 10% of the NNC.

Parameter	North LWL NNC	Central LWL NNC	South LWL NNC	Units
Chlorophyll-*a* (LC)	2.9	**10.2**	5.7	ug/L
Total Nitrogen	0.54	0.66	0.59	mg/L
Total Phosphorus	0.044	0.049	0.05	mg/L

Figure 4. LWL NNCs for Chlorophyll-a, Total Nitrogen, and Total Phosphorus

Light Availability

PAR data was collected at the surface, middle, and bottom depths for each station. The following steps were used to convert those values into % Light Available:

1. Compute average PAR at surface, middle, and bottom depths for each transect
2. Compute light attenuation coefficients (K_d) for each transect

$$K_d = \frac{\Delta \ln(PAR\ Readings)}{\Delta\ (Depths)}$$

3. Convert K_d into % Light Available for each transect ($\%\ Light = e^{(Depth * K_d)} * 100$)

Results

- In SPSS (V. 28), we ran 2-way ANOVA evaluating the interaction between time (season) and geographic region (transect) on water clarity and quality parameters. We ran Pearson bivariate correlations between seagrass cover and water quality parameters.
- We found no difference in light availability across transects ($F_{1,9}$: 0.9, P =0.5), but there was a difference in light availability between Fall 2021 and Spring 2022 ($F_{1,1}$: 7.4, P =0.02). Also, there was no interaction between transect and time ($F_{1,8}$: 1.95, P = 0.08).
- We found no relationship between seagrass cover and light availability (N = 58, r = -0.01, P =0.93) nor was there a significant relationship between seagrass cover of individual seagrass species and light availability.
- There is a difference in seagrass cover across the LWL (F_9= 4.2, P <0.001) and differences in all aquatic vegetation parameters across transects
- Chlorophyll-*a*, Total Nitrogen (TN), and Total Phosphorus (TP) exceed NNCs in multiple instances between January 2020 and July 2022 (Figure 5). However, there were no substantial relationships between Chl-*a*, TN, and TP and light availability and seagrass cover.

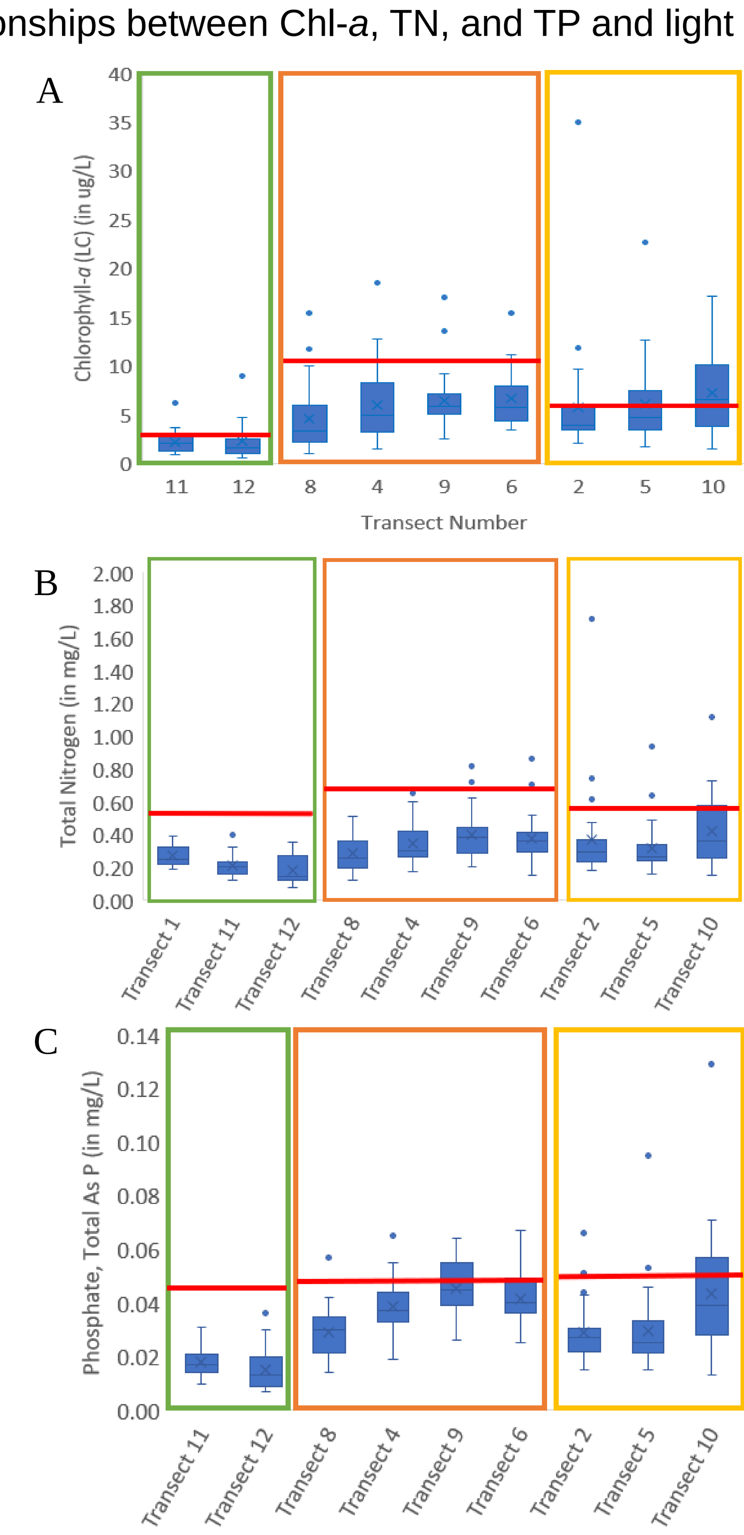

Figure 5. Distributions of Chlorophyll-a (A), Total Nitrogen (B), and Total Phosphorus (C) from January 2020 through July 2022. The red lines on the boxplots represent the NNC for each parameter. Boxplots are ordered from north to south.

Discussion

- While we found that there was no difference in light availability across transects, there appears to be insufficient light to support most seagrass species (Figure 6).
- Seasonality should be further analyzed given the significant difference in light availability observed in Fall 2021 versus Spring 2022.
- There are significant differences in all submerged aquatic vegetation parameters across transects, indicating that other drivers (abiotic or biotic) may be responsible for SAV distribution and density.
- There are no differences in bottom dissolved oxygen, bottom temperature, or bottom salinity across transects, so those are not likely the drivers of differences in seagrass cover.
- Further investigation on potential stressors to seagrasses, including likely interactions between stressors, could provide better understanding on why seagrasses are declining in LWL.

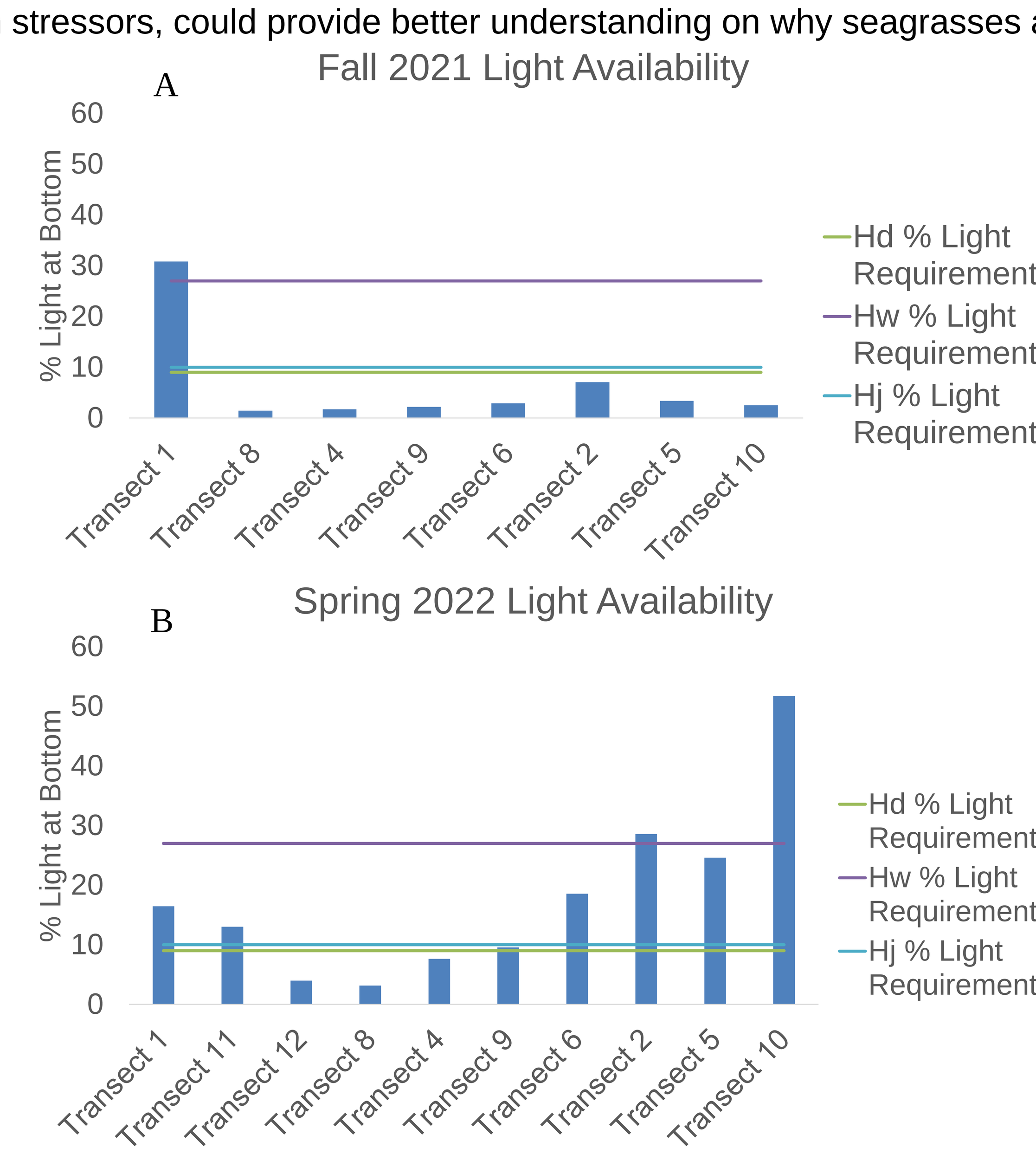

Figure 6. A) Light availability at bottom depths at Fall 2021, B) Light availability at bottom depths at Spring 2022 (Choice et al, 2014, York et al, 2015, National Marine Fisheries Service, 2002). Light requirement for Halophila decipiens (Hd), Halodule wrightii (Hw), and Halophila johnsonii (Hj) are shown on each chart.

Figure 7. Images of S-155 letting stormwater and accompanying nutrients into LWL (left) and a muck sample collect in the Central region of LWL (right) (Courtesy of PBC-ERM)

References and Acknowledgements

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