Nutrient Over-enrichment & Light Limitation of Seagrass Communities in the Indian River Lagoon

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INTRODUCTION

- The Indian River Lagoon (IRL) is an estuary of national significance that is experiencing anthropogenic eutrophication related to high nutrient loading (Fig. 1).
- Widespread seagrass losses occurred in the IRL since 2010 following unprecedented harmful algal blooms (HABs), including persistent brown tides (*Aureoumbra lagunensis*).
- Little is known about how biochemical factors of seagrasses in the IRL, such as the elemental composition (C:N:P) & stable isotope signatures ($\delta^{13}C$, $\delta^{15}N$) relate to decline.

OBJECTIVE

- To assess the status of nutrient enrichment & light limitation of seagrass communities in the IRL during a critical die-off period.

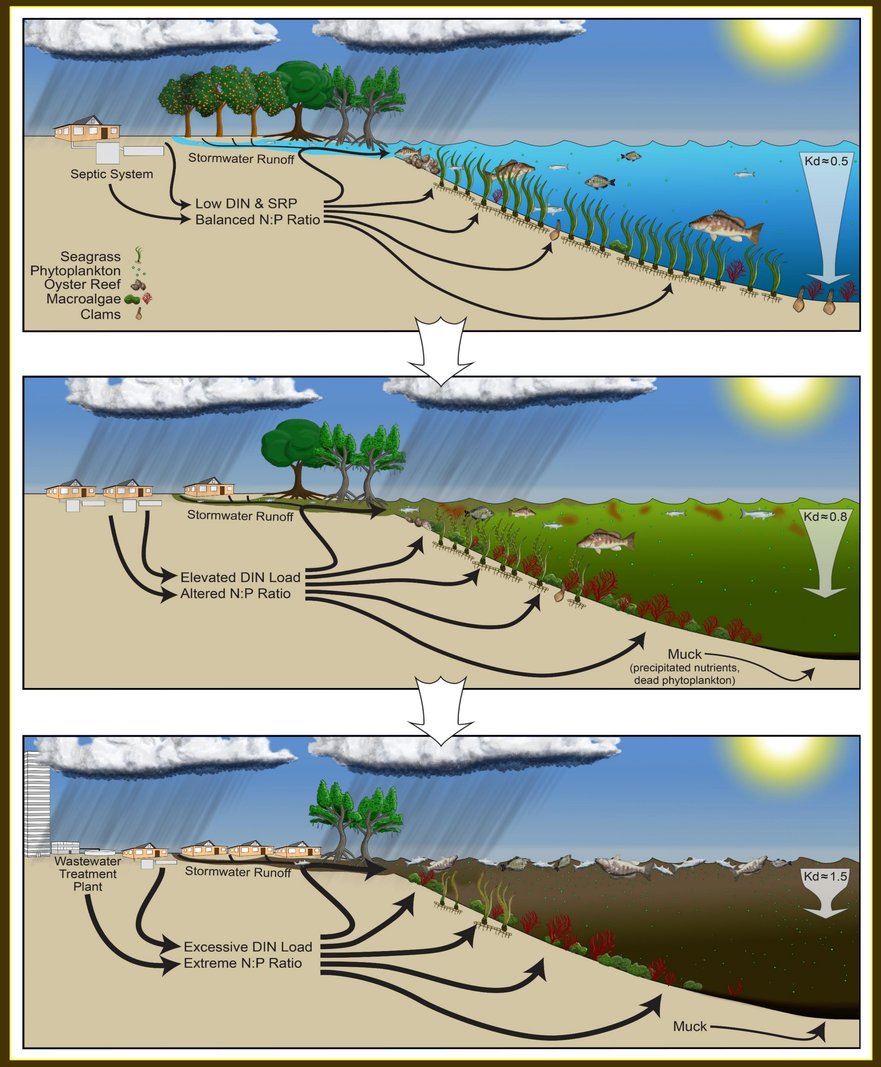

Fig. 1 Cartoon showing the progression of anthropogenic nutrient enrichment and eutrophication that has occurred in the Indian River Lagoon, FL.

METHODS

- IRL-wide sampling of 20 sites sampled between Ponce and Jupiter inlets from 2013 – 2015 during wet & dry seasons that included:
  - Seagrass community composition surveys
  - Measurement of light attenuation (K_d)
  - Quantification of chlorophyll *a* concentrations
  - Analysis of seawater for dissolved nutrient concentrations
  - Determination of seagrass stable isotope values ($\delta^{13}C$, $\delta^{15}N$) & elemental composition (%C, %N, %P)
- Data were compared by location & season

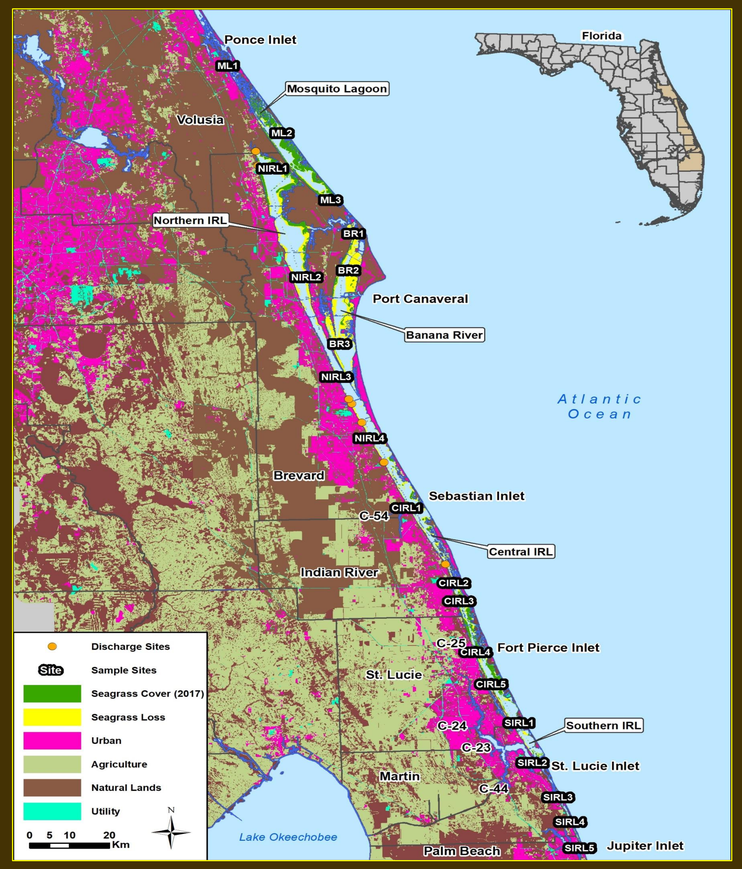

Fig. 2 Indian River Lagoon, Florida showing the 20 sampling sites labeled by segment. Seagrass cover and land-use data for Volusia, Brevard, and Indian River counties from St. Johns Water Management District & land-use data for St. Lucie, Martin, and Palm Beach counties from South Florida Water Management District.

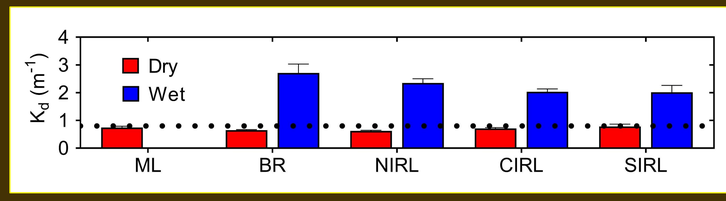

Fig. 3 K_d values (mean ± SE m^{-1}) by season (wet / dry 2015) for segments of the Indian River Lagoon, FL; the dashed line indicates the maximum K_d threshold (0.8 m^{-1}) required for seagrass survival in restoration (Dennison et al. 1993).

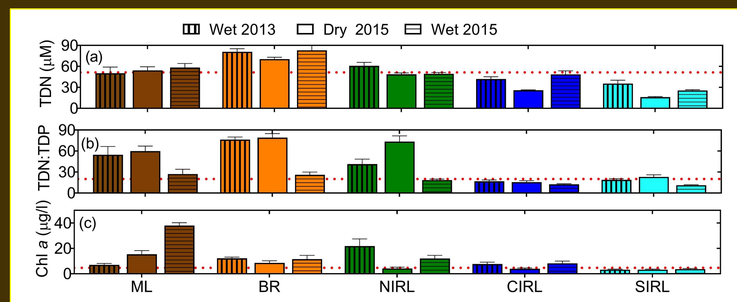

Fig. 4 Dissolved nutrients by Indian River Lagoon segment & season; showing concentrations of a) Total Dissolved Nitrogen (TDN), b) the ratios of TDN to Total Dissolved Phosphorus (TDP), and c) chlorophyll *a* (Chl *a*).

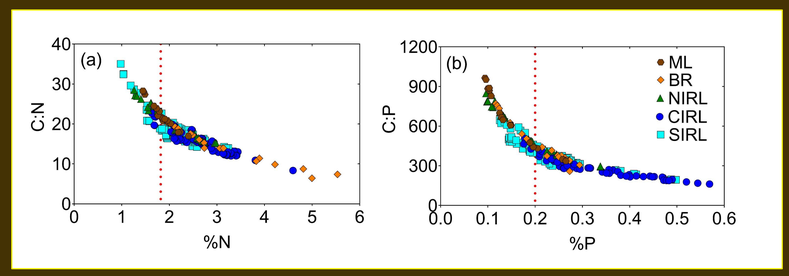

Fig. 5 Elemental composition & molar ratios of seagrass (*Halodule wrightii*, *Syringodium filiforme*, & *Thalassia testudinum*) tissue samples by segment for a) C:N and b) C:P, showing critical median values of %N and %P indicating eutrophic conditions (Duarte 1990).

RESULTS

- *Halodule wrightii* was collected in all segments; *Syringodium filiforme* in the NIRL, CIRL, and SIRL; and *Thalassia testudinum* in the CIRL and SIRL.
- IRL-wide mean K_d was 1.32 ± 0.1 m^{-1} (Fig. 3). Critical K_d values were approached RL-wide in the dry season & exceeded in the wet.
- TDN was elevated lagoon-wide & mean concentrations exceeded an IRL-target of ~51 µM in the three northern lagoon segments (Fig. 4a)
- TDN:TDP exceeded the Redfield ratio (16:1) within ML (48.1), BR (60.5), the NIRL (44.5), & SIRL (17.7; Fig. 4b).
- An IRL chlorophyll *a* target (4.7 µg/l) was exceeded in many segments, including ML (18.8 ± 2.7 µg/l), BR (10.7 ± 1.2 µg/l), and NIRL (12.7 ± 2.4 µg/l; Fig. 4a). SIRL was the only seagrass segment with consistently low chlorophyll *a* (3.39 ± 0.3 µg/l; Fig. 4a).
- For tissue C:N, 163 out of 201 individual samples (81%) exceeded the %N threshold value of 1.8 proposed by Duarte (1990; Fig. 5a).
- The relationship of C:P to %P also varied spatially, with 131 individual samples (65%) in exceedance of the 0.2 threshold (Duarte 1990; Fig. 5b).

DISCUSSION

- Seagrass species composition varied by location.
- Nutrient enrichment drives seagrass loss in the IRL through light limitation.
- K_d measurements showed the importance of light limitation from algal blooms.
- Light limitation is most severe in the poorly-flushed and highly urbanized northern IRL segments.
- Human wastewater is the primary N source fueling eutrophication in the IRL.
- Some segments of the IRL have undergone nutrient-mediated, biotic phase-shifts resulting in alterations of primary producer biomass (Fig. 6).

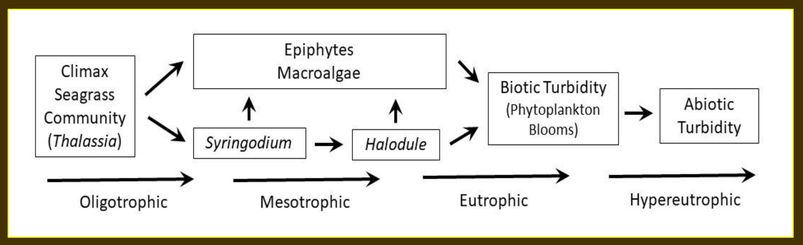

Fig. 6 Nutrient-mediated, biotic phase shift model for the Indian River Lagoon (adapted from Lapointe et al. 2002; see Lapointe et al. 2020).

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