2007-2018 Changes in Seagrass Presence and Composition in the Loxahatchee River Estuary

Jerry L. Metz, Rachel J. Harris, Kenneth "Bud" Howard, and D. Albrey Arrington

Loxahatchee River District, WildPine Ecological Laboratory, Jupiter, FL, USA,

Introduction

Seagrass meadows are a valued component of an ecosystem mosaic that fulfill key ecological functions in coastal and estuarine environments (Orth et al, 2006). For example, they provide food for grazers like manatees (Lefebvre et al., 2017), green sea turtles (Bjorndal, 1980), and herbivorous fishes (McGlathery, 1995). Seagrasses also serve as nursery habitats that provide refuge from predation for numerous economically and ecologically important species (Hunt, 1994; Beck et al., 2001). Seagrasses also perform a role as ecosystem engineers, capable of stabilizing sediments and mitigating wave energy (Jones et al., 1994 ; DeBoer, 2007).

Despite the many valuable ecosystem functions that seagrasses provide, seagrasses face many threats largely attributable to anthropogenic activities that can affect salinity and light availability (Orth *et al*., 2006; Waycott *et al*., 2009). Considering the valuable ecosystem functions seagrasses provide and the many threats seagrasses face (Orth et al., 2006; Waycott et al., 2009; Grech et al., 2012), assessing long-term changes in seagrass presence and community composition is vital to understanding the broader ecological health of estuaries and coastal ecosystems. Seagrasses are increasingly used by researchers as a general biological sentinel of water quality and ecosystem health (Fourquarean and Robblee, 1999; Lirman and Cropper, 2003; Madden et al., 2009). Here, we examine seagrass presence and community composition and present an overview of how it has changed from 2007 to 2018.

Methods

- The framework for the summer 2018 seagrass assessment was based on an estuary-wide mapping study conducted during summer of 2007.
- During the 2007 study: Weighted marker buoys were haphazardly deployed into regions of the estuary known to support seagrass.
- Seagrass presence data were collected at each buoy using a collapsible $9m^2$ quadrat referred to in text as "quadzilla".
  - Seagrass presence was scored 0-9 based on the number of 1 meter squares inside the quadzilla that each seagrass species occupied.
- The location of each sample site was recorded using sub-meter capable GPS and seagrass presence data associated with each sample site was entered into the GPS in the field.
  - The 2007 study resulted in a total of 1,076 sample sites covering full expanse of the estuary.
- For the 2018 seagrass assessment: Study area was divided into five river segments (Figure 1), with a goal of re-sampling 25% of sites assessed in 2007.
- To minimize sampling bias, resampled sites were selected based on a random stratified design where sites were stratified based on river segment and 2007 seagrass score.
  - The goal was to resample a full complement of sites in each river segment, i.e., sites that, in 2007, had continuous seagrass cover as well as bare sites.
- Selected sample sites were loaded onto a sub-meter accurate GPS.
- Staff in the field use GPS to navigate to each selected sample site (Figure 2) and deploy a quadzilla to record seagrass presence data; i.e. 0-9 score (Figure 3).
- For comparison between sample years, the 0-9 seagrass scores were assigned to abundance categories:
  - 0 = Absent; 1 – 3 = Sparse; 4 – 6 = Patchy; 7 – 9 = Continuous
  - Sample points which had no seagrass present in either year were omitted from analysis since the objective of this study was to examine changes in seagrass presence.
- Seagrass change between 2007 to 2018 was described as "Gain", "Loss", or "No Change".
  - For example, a sample site going from Continuous in 2007 to Sparse in 2018 is "Gain".

Seagrass Composition

- We examined changes in seagrass species composition between 2007 and 2018.
- For both 2007 and 2018, we only examined sample sites that had seagrass present.
  - i.e. sample sites that had no seagrass present were ignored for this analysis.
- Evaluated each species' composition throughout the estuary as the percent frequency of occurrence among sample sites.

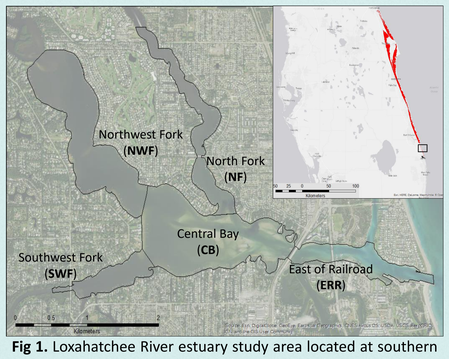


Fig 1. Loxahatchee River estuary study area located at southern end of the Indian River Lagoon (shown in red). Shown are the five river segments discussed throughout study.

Fig 2. Field staff using sub-meter accurate GPS to locate sample site and deploy marker buoy (orange float) by kayak. A total of 279 sample sites were deployed during summer 2018, each associated with seagrass presence data from 2007 assessment.

Fig 3. A $9m^2$ collapsible sampling quadrat, referred to in text as "quadzilla", centered on weighted marker buoy. The smaller $1m^2$ quadrat is shown for scale. Seagrass score was based on the number of 1 meter squares within the quadzilla in which seagrass was present.

2007-2018 Results

- A total of 279 sample sites were selected for the 2018 assessment.
  - 234 sample sites had seagrass present in either 2007, 2018, or both and were the only points used for the comparison between years.
- 67% of the sample sites show a seagrass decline across all segments of the estuary (Figure 4).
- Seagrass had completely disappeared from 52% of the sample points across all segments between the 2007 and 2018 surveys (black line in Figure 4, red crosses in Figure 6).
- The SWF segment experienced complete seagrass loss between 2007 and 2018 (Figure 4); this was the only river segment where complete seagrass loss was observed (compare Figures 7a and 7b).
- *Halodule* wrightii and Halophila *johnsonii* were the most frequently encountered seagrasses throughout the estuary during both sample years (Figure 5).
  - *Syringodium filiforme, Halophila decipiens, and Thalassia testudinum* were observed much less frequently.
- During 2007, these two species composed 63% and 89% respectively (n=228) while during 2018, the observed prevalence of these two species changed to 78% and 67% respectively (n=113); *S. filiforme, H. decipiens, and T. testudinum were also observed at much lower frequency.*
- *H.* wrightii and H. *johnsonii* were most frequently observed co-occurring within the same sample point during both 2007 (42%) and 2018 (50%).

Changes in Seagrass Presence

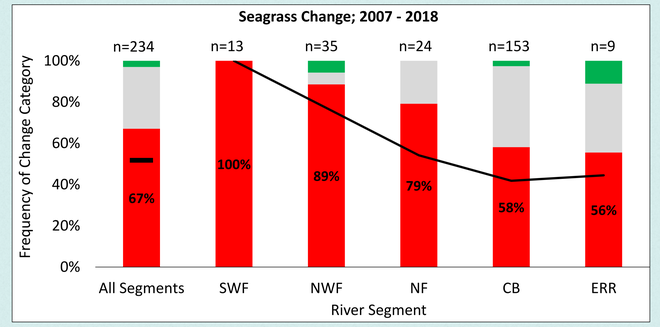
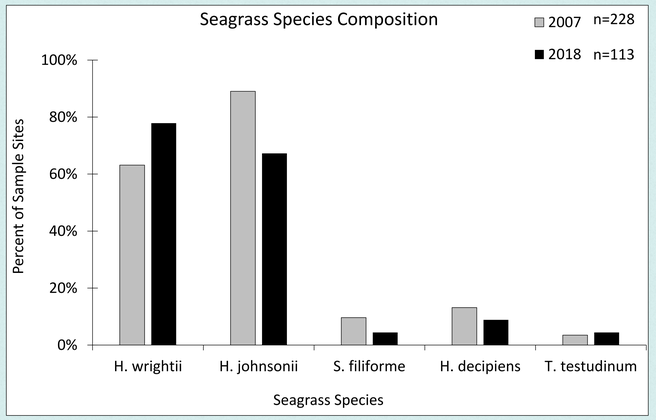


Fig 4. Stacked bar graph showing change in seagrass presence between 2007 to 2018 by river segment. Bars are arranged in approximate distance from inlet. Change indicated as Gain (green), No Change (gray), or Loss (red). Black line is a subset of the data that indicates percentage of sample points that experienced complete seagrass loss between 2007 and 2018.

Seagrass Community Composition



Figures 5 Graphs show seagrass species composition for 2007 (gray bars) and 2018 (black bars) as percent frequency of $9m^2$ sample sites.

Seagrass Presence and Decline Between 2007 - 2018

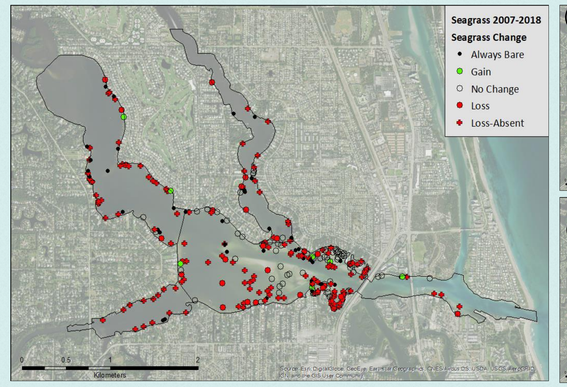


Fig 6. Map showing locations of 2018 sample sites and their corresponding seagrass change between 2007 and 2018. Categories defined as a change in seagrass presence: Gain (green dots), Loss (red dots) or No Change between sample years (uncolored rings). A subset of the data looked at sample sites where seagrass completely disappeared between years and indicated as Loss to Absent (red crosses). Black dots indicate where seagrass was absent during both years and are not used in the comparison.

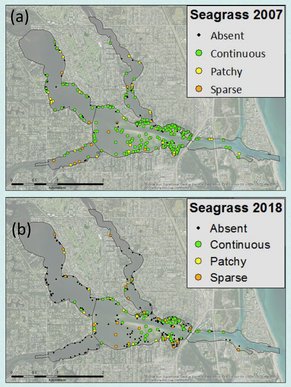


Fig 7 a,b. Maps show location of the sample sites assessed during summer 2018 with associated categorical presence data from 2007 (Figure a) and from 2018 (Figure b). Black dots indicate absence of seagrass.

Conclusions

- This study showed that there was a substantial decline in seagrass presence throughout the estuary (Figure 6).
- The central bay (CB) region of the river supports the most seagrass in terms of abundance and diversity. Conditions appear to be more suitable for seagrasses to establish and persist compared to other segments of the river.
- Seagrass decline was related to proximity to the inlet; loss increased with distance from inlet (Figure 4).
- Seagrasses may have been adversely impacted by a combination of factors such as terrestrial runoff (i.e. salinity, turbidity) and hydrodynamic forcing (i.e. sediment accretion , wave action).
  - Other factors known to impact seagrass such as boating activities and increased development are present near sampling area and may have also contributed to seagrass loss.
- The seagrass community of the Loxahatchee River estuary is composed primarily of H. wrightii and H. johnsonii (Figure 5).
  - The seagrasses S. filiforme, H. decipiens, and T. testudinum were also found, though at much lower frequency (Figure 5).
- Despite substantial loss of seagrass between 2007 and 2018, the seagrass community composition remains mostly unchanged.
  - Observed seagrass loss did not occur to a solitary species.
- We are concerned by the long-term decline of seagrasses in the Loxahatchee River estuary.

References

Beck, M.W., et al 2001. The identification, conservation, and management of estuarine and marine nurseries for fish and invertebrates. BioScience 51: 633–641.

Bell, Susan S., et al. 2006. Seagrass Ecology: New contributions from a landscape prospective. In W.D. Larkum et al (eds) "Seagrasses: Biology, Ecology, and Conservation" (pp. 625-645). Springer, Netherlands.

Bjorndal, K.A. 1980. Nutrition and grazing behavior of the green turtle *Chelonia mydas*. Mar. Bio. 56(2): 147-154.

de Boer, W.F. 2007. Seagrass–sediment interactions, positive feedbacks and critical thresholds for occurrence: a review. Hydrobiologia 591: 5–24.

Duarte C.M. (2002). The future of seagrass meadows. Env. Cons. 29(2): 192-206.

Fourquarean, James W., and Michael B. Robblee. 1999. Florida Bay: A recent history of recent ecological changes. Estuaries. 2b: 345-357.

Grech, A. 2012. A comparison of threats, vulnerabilities and management approaches in global seagrass bioregions. *Environmental Research Letters*, *7*(2), 024006.

Hunt, J. H. 1994. Status of the fishery for Panulirus argus in Florida, p. 158-168. In B. Phillips, S. Cobb, and J. Kittaka (eds.), Spiny Lobster Management. Blackwell Press, Oxford.

Jones, Clive J. *et al* 1994. Organisms as ecosystem engineers. OIKOS 69:373-386.

Kirsch, Kevin D. et al. 2002. Parrotfish grazing on turtlegrass Thalassia testudinum: evidence for the importance of seagrass consumption in food web dynamics of the Florida Keys National Marine Sanctuary. Mar. Eoc. Prog. Ser. 227: 71-85.

Lefebvre, Lynn W. 2017. Manatee grazing impacts on a mixed species seagrass bed. Mar. Eco. Prog. Ser. 564: 29-45.

Lirman, D. and W. P. Cropper Jr. 2003. The influence of Salinity on Seagrass Growth, Survivorship and Distribution within Biscayne Bay, Florida: Field, Experimental and Modeling Studies. *Estuaries* 26:131-141.

McGlathery, Karen J. 1995. Nutrient and grazing influences on a subtropical seagrass community. Mar. Eco. Prog. Ser. 122: 239-252.

Orth, Robert J. 2006. A global crisis for seagrass ecosystems. Bioscience 56(12): 987-996.