Shifting Baselines: Effects of seagrass loss on fish communities in Southwest Florida tidal creeks

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Introduction

- Ecosystem phase shifts from one steady state (e.g., clear water, seagrass) to another (e.g., phytoplankton blooms, bare substrate) are being documented across the globe[6].
- In Florida's Charlotte Harbor estuary, Coral Creek is a large, seagrass associated tidal system that has incurred substantial development (Fig.1). Recent declines in seagrass cover within the system have coincided with recurring filamentous green algae blooms, indicative of nutrient loading and altered hydrology[3,5]; this trend is especially prevalent in Coral Creek's east branch (Fig.2).
- The goals of this study were: 1) examine environmental conditions driving fish assemblage structure in Coral Creek and two adjacent, reference creeks with less development and 2) identify changes in Coral Creek fish assemblages attributable to loss of seagrass.

Figure 1. Map of study area (left) and example of a 21.3 m seine net deployment (right) in Coral Creek

Methods

Study Area and Field Sampling

- Study period: July 2014 – June 2022
- Coral Creek parsed into 3 "creeks" (East, West, Lower) = study creeks (Fig. 1)
- Catfish and Whidden creeks = reference creeks (Fig. 1)
- Stratified random sampling design (1-5 sites for each creek * month^{-1} year^{-1})
- 21.3 m center bag seine set from back of mullet skiff pulled along shoreline
- Habitat characteristics (e.g., seagrass cover, depth) were assessed and water quality parameters (salinity, temperature, DO) recorded at each site
- All fish and select invertebrates (Blue Crab *Callinectes sapidus* and Pink Shrimp *Farfantepenaeus duorarum*) were identified to lowest possible taxonomic level and enumerated

Data Analysis

- 'Sampling Year' (Yr) was assigned where Yr.1 = July 2014 – June 2015.
- Distanced based linear models and redundancy analysis were conducted to examine relationship between environmental parameters and nekton communities.
- Seagrass die-off stages (pre, transition, post) were assigned *a priori* based on mean seagrass cover per Yr in East Coral Creek.

Yr.1-Yr.2 = *PRE*
Yr.3-Yr.5 = *TRANSITION*
Yr.6-Yr.8 = *POST*

- PERMANOVA was used to test for differences in assemblage structure between creeks and seagrass die-off stages.
- Canonical analysis of principle coordinates (CAP) was used to examine the relationship between seagrass cover (%) and nekton community structure.
- Similarity percentage analysis (SIMPER) was used to identify taxa driving differences between pre- and post seagrass die-off groups in East Coral Creek.

Phase shifts in tidal creek fish communities related to seagrass loss may be a harbinger for estuary wide change

Results

Table 1. PERMANOVA results between creeks and the Coral Creek seagrass die-off stages. Terms denoted with * indicate a fixed factor in the model design, all others were treated as random. Df = degrees of freedom, Sqrt var = square root component of variation, % var = percent variation, and bolded % variation indicates high explanatory variables.

Source	Df	SS	Pseudo-F	P	Sqrt var	% var
Creek (Cr)	4	115370	16.14	0.0001	18.120	**19.33%**
CC Seagrass Die-Off (CC) *	2	16325	2.79	0.0132	6.101	6.51%
Cr x CC	8	23380	1.64	0.0003	6.346	**6.77%**
Residuals	425	759320	-		42.269	45.10%
Total	439	914395	-		72.836	100.00%

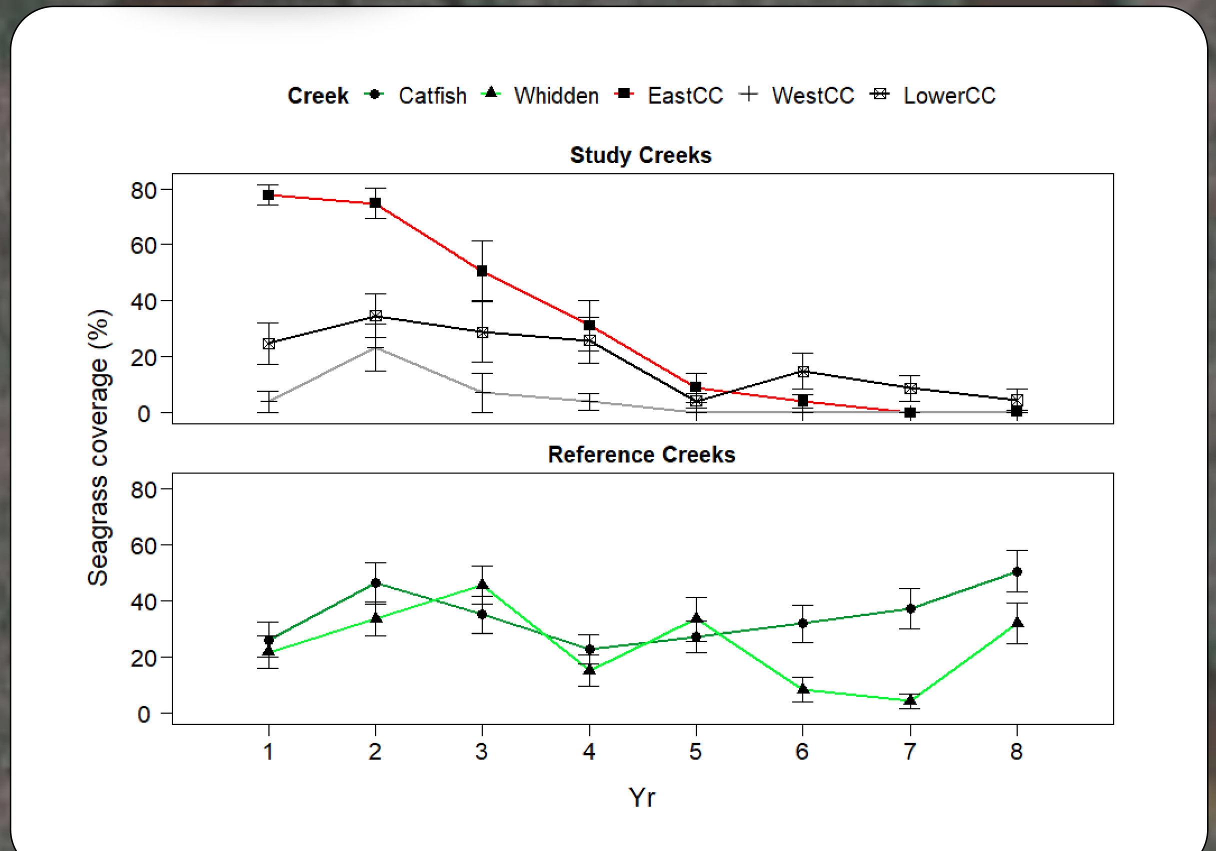


Figure. 2 Seagrass coverage for each creek averaged by sampling year. Error bars depict standard error of the mean. The red line shows rapid decline of seagrass coverage in East Coral Creek.

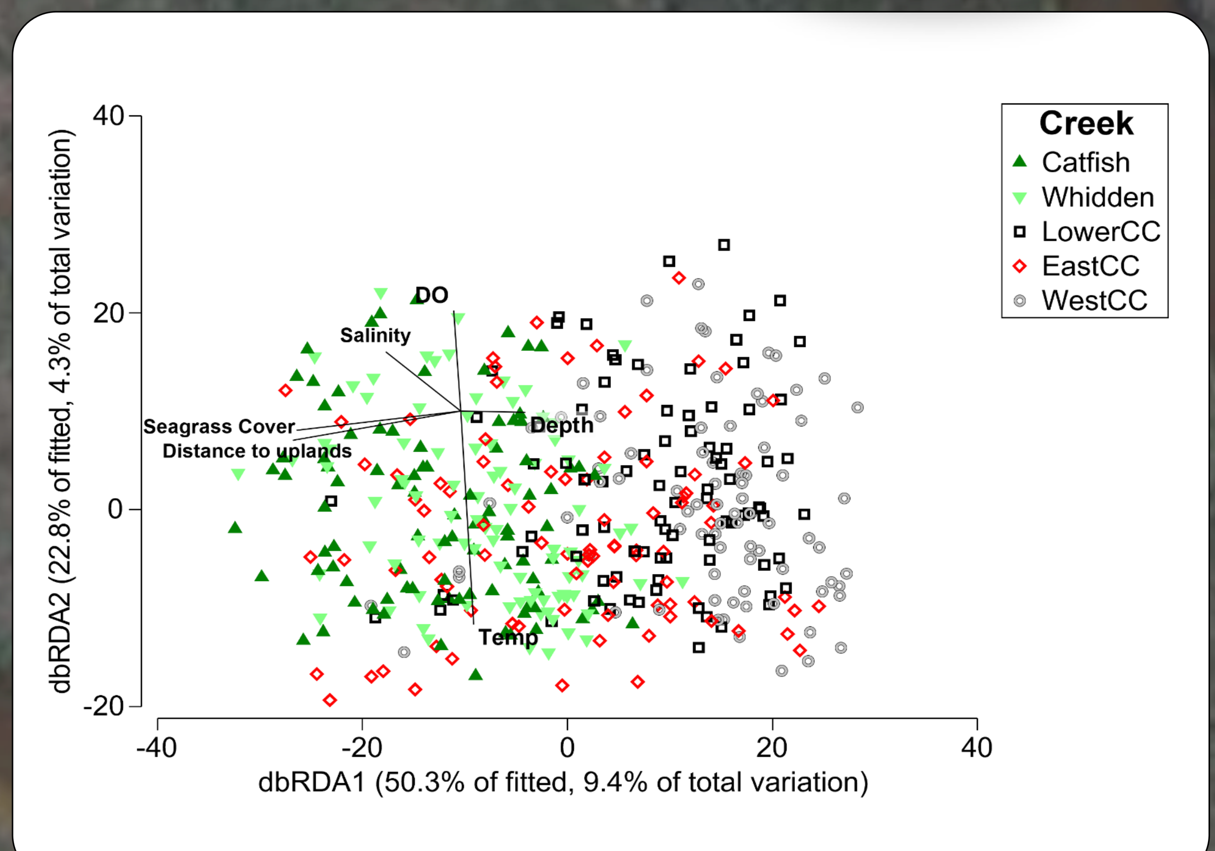


Figure 3. dbRDA ordination plot for environmental parameters assessed during sampling. Percentages signify the proportion of the fitted and total variation in fish communities explained by the canonical axis, respectively. Vector lines and corresponding labels indicate environmental parameters correlated to canonical axes, where line size and direction indicate strength and direction of the relationship, respectively. The more parallel a vector line is to an axis indicates increasing contribution of a variable to the variation explained by the axis.

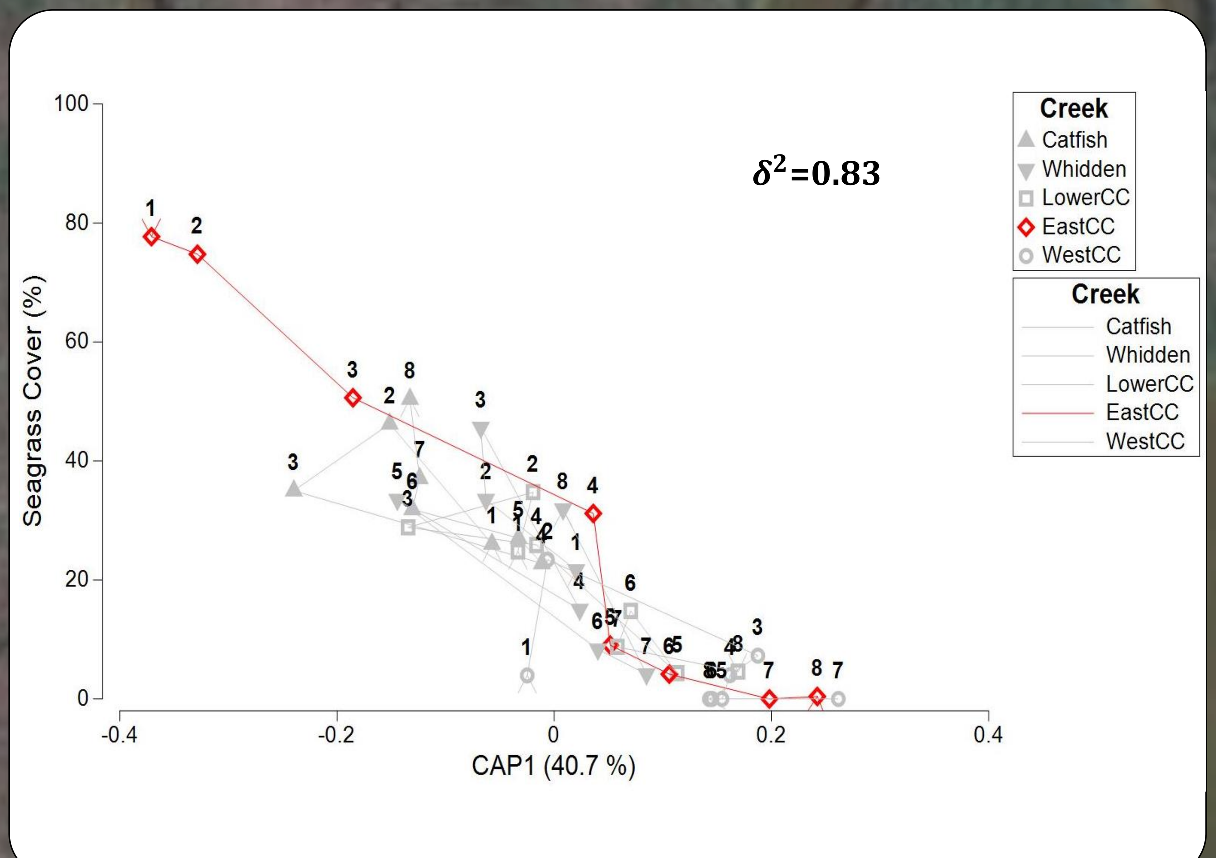


Figure. 4. CAP model correlating fish assemblage data along a seagrass cover gradient. Each point represents the centroid of assemblage structure per sampling year; labels correspond to sampling year. The percentage associated with the first canonical axis (CAP1) represents the percent of variability explained between sample points by that canonical axis alone. δ^2 denotes the squared canonical correlation coefficient, indicating the strength of the relationship between fish assemblages oriented along CAP1 and seagrass cover. The red points and trajectory line highlight a monotonic shift in fish communities in East Coral Creek related to seagrass loss.

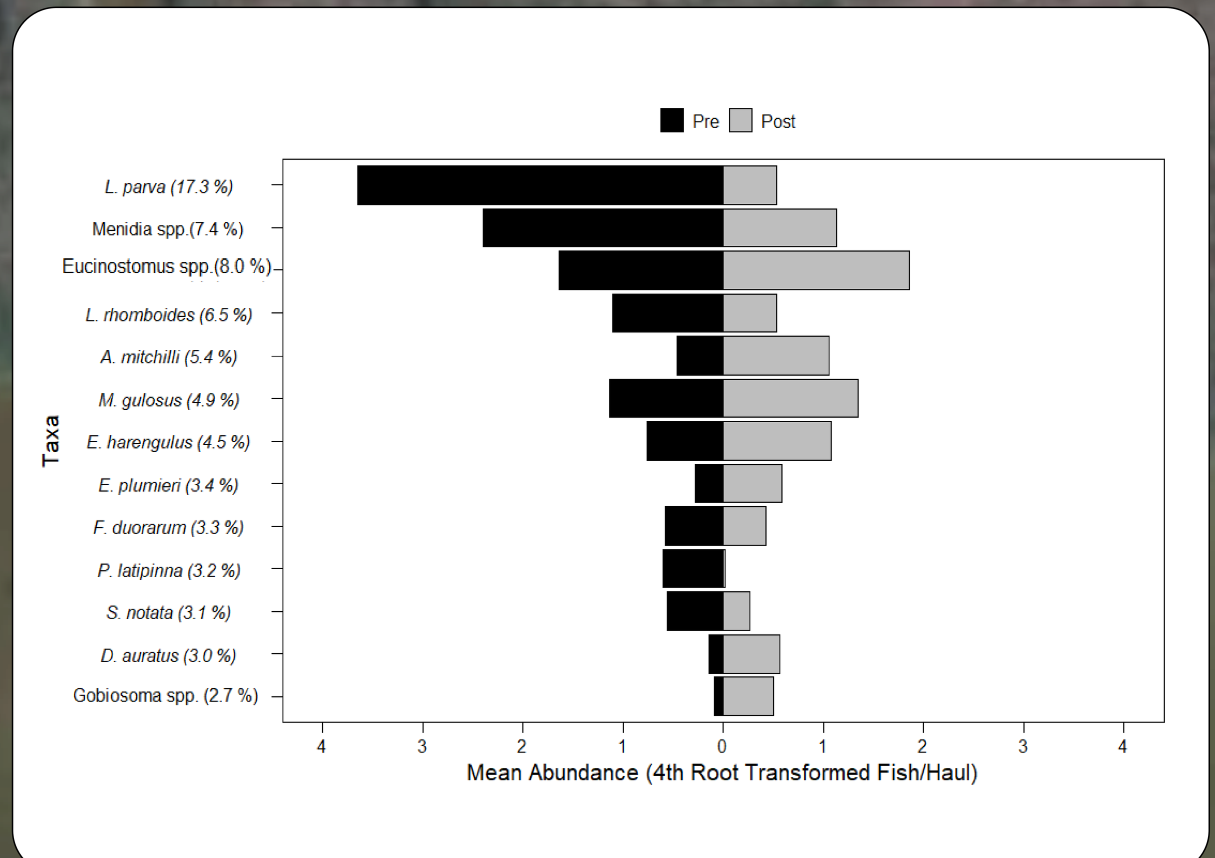
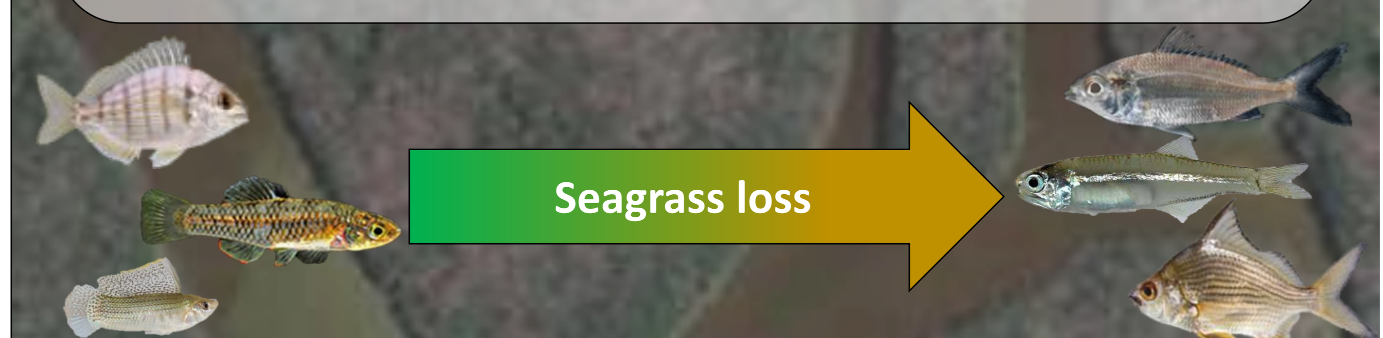


Figure. 5. Fourth-root transformed mean abundance (fish/haul) and percent contributions of fishes accounting for 70% of the dissimilarity between pre- and post-seagrass die-off groups in East Coral Creek (SIMPER analysis). Taxa are ordered in decreasing mean percent contribution. Post seagrass loss, reduced abundance of Rainwater Killifish *Lucania parva*, Pinfish *Lagodon rhomboides*, and Sailfin Mollies *Poecilia latipinna* were offset by increases in Bay Anchovy *Anchoa mitchilli*, Tidewater Mojarra *Eucinostomus harengulus*, and Striped Mojarra *Eugerres plumieri*.

Discussion

- Environmental variables driving differences in community structure between creeks—where creeks explained the greatest amount of variation amongst assemblages—are indicative of the degree of respective seagrass coverage and distance to uplands (Table 1, Fig. 3). Such differences were especially apparent between reference and study creek groups, supporting previous work demonstrating the cascading effect of habitat alteration on tidal creek nekton communities[7].
- Fig. 4 shows a substantial relationship between seagrass cover and community structure, and a nearly monotonic trend in East Coral Creek over the study period. Coupled with the exchange in abundance of benthivorous, seagrass associated taxa to planktivorous, habitat generalists between pre and post groups (Fig.5) [4,8], East Coral Creek appears to have undergone a phase shift related to seagrass loss and eutrophication.
- Rapid changes in assemblage structure may have important implications for tidal creek ecosystems, such as altered food webs and disturbance resilience, which in turn may lead to larger, estuarine-scale effects[1,9]. Future work is needed to elucidate the impact of structural shifts on tidal creek function.
- The phase shift in tidal creek fish communities related to seagrass loss is of particular concern considering large-scale seagrass declines occurring within the greater Charlotte Harbor estuary[2]. The position of tidal creeks in the landscape makes them particularly sensitive to coastal development and some of the first habitats to exhibit noticeable signs of its effects. An estuary-wide phase shift akin to that documented in East Coral Creek could result in substantial restructuring of broader ecosystem functions and a reduction in the aesthetics of the southwest Florida coast, often prized for its clear water and dense seagrass beds.



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