Monitoring Fish Communities and Populations on the Eastern Boundary of Everglades National Park

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Introduction

Hydroperiod is a key driver of physical and biological differences among regions of the Everglades. Regions of 'long hydroperiod' are inundated with water for the majority of the year and may only dry during severe droughts. 'Short hydroperiod' regions dry each year and are only submerged during the wet season. Water storage impoundments (S332 structures) were constructed on the eastern boundary of ENP in 2002-2003 in an effort to control water levels. We monitored fish communities in the short hydroperiod wetlands adjacent to the S332 structures, un-affected sites in the same region and long hydroperiod sites in Shark River Slough (Figure 1). Our goals were to *identify community and biological patterns associated with variation in hydroperiod*, *to reveal edge effects at the park boundary* and to *evaluate environmental changes associated with the impoundments*.

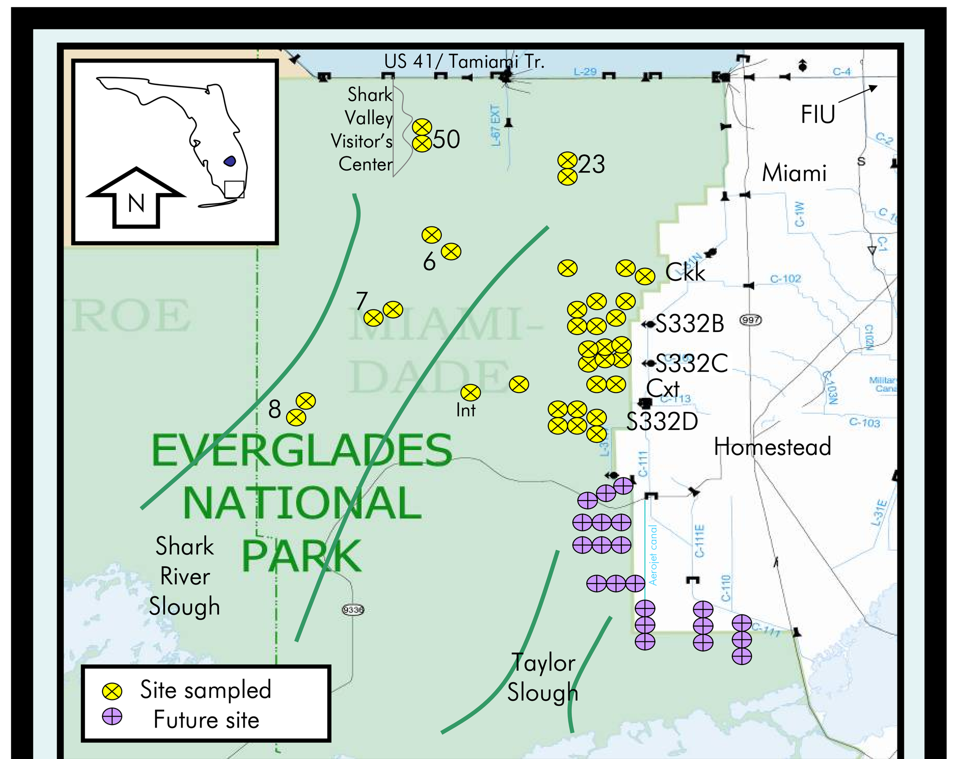


Figure 1: Map showing the study region (Everglades National Park), with sites sampled during the study interval and future sites. Map modified from 2005 SFWMD Structure map. Site locations are not shown to scale.

Methods

The limestone rocklands of the eastern Everglades (both the sites adjacent to the S332 structures and un-affected sites) and the wet-prairie sloughs of Shark River Slough were sampled between December 2003 and October 2009. We attempted to sample bimonthly in the eastern Everglades sites and monthly in Shark River Slough (when water depths permitted) using passive drift-fence trap arrays (figure 2). Ground-cloth fences corral fish into wire-mesh minnow traps embedded in center. These provide estimates of 'activity density' that is determined both by local fish density and movement rate. Traps were deployed for 24-hour periods, fish were collected, preserved and returned to the lab for data processing. We identified fish to species, measured their wet-mass, standard length and recorded sex for a sub-set of the most abundant fish. Overall we carried out 2416 trap-nights of sampling and collected more than 33,000 fish of 39 species, including ten non-native species.

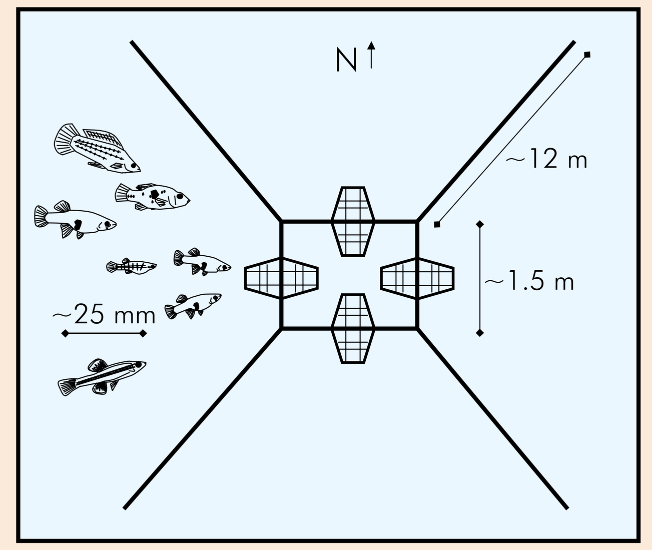
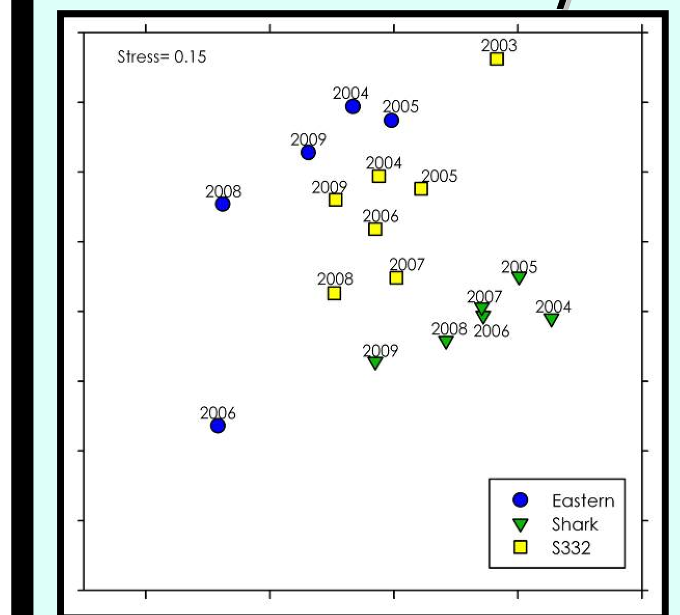


Figure 2: A schematic of a drift-fence array (not to scale). The fence corrals fish to the traps in the center.

Technicians (L to R: Aaron Parker, Justin Dummit, Carlos Tudela) setting traps and performing maintenance on an array in a site adjacent to the S332B impoundment (30 Sept. 2009).

An array in Shark River Slough; the water here is nearly too deep for the traps. Prior to setting the minnow traps, the fences had to be tightened so that they emerged from the water for their entire length (24 Sept. 2009).

Community Similarity



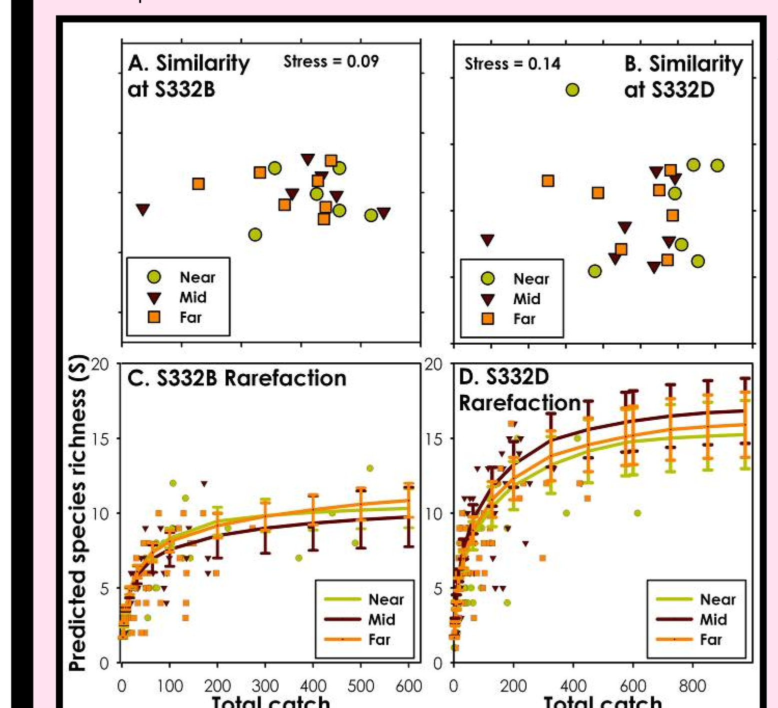
MDS plot showing similarity between fish communities in each region, for each water-year (a wet-season from beginning to end; often, water levels do not recede until the next calendar year).

The community structure of each region is distinct.

The community structures of each region were significantly different from each other (ANOSIM $p < 0.05$). Similarity within regions was driven mostly by mosquitofish (all sites), dollar sunfish (all sites), flagfish (Eastern), marsh killifish (Eastern) and Sailfin Mollies (Shark). Differences between regions were driven mostly by jewelfish (S332-Shark and S332-Eastern) and Sailfin Mollies (Eastern-Shark).

Edge Effects

We hypothesized that edge effects might impact the communities in the sites adjacent to the park boundary, possibly as a result of disturbances such as nutrient addition. Our S332 arrays were positioned at approximately 50 m (near), 200 m (mid) and 500 m (far) into the wetland. We compared communities at each distance for S332B and S332D.



A) MDS plot showing similarity of assemblages at the S332B sites. Each point represents one water-year.

B) MDS plot (as A) for the S332D structure.

C) The points show species richness plotted against the total number of fish caught at a distance in one month at the S332B sites. The lines show rarefaction curves, (created with resampling; Primer 5.2.9) showing the predicted species richness, for a given magnitude of fish catch. Error bars show standard error.

D) Rarefaction curve (as C) for the sites at S332D.

There were no clear edge effects.

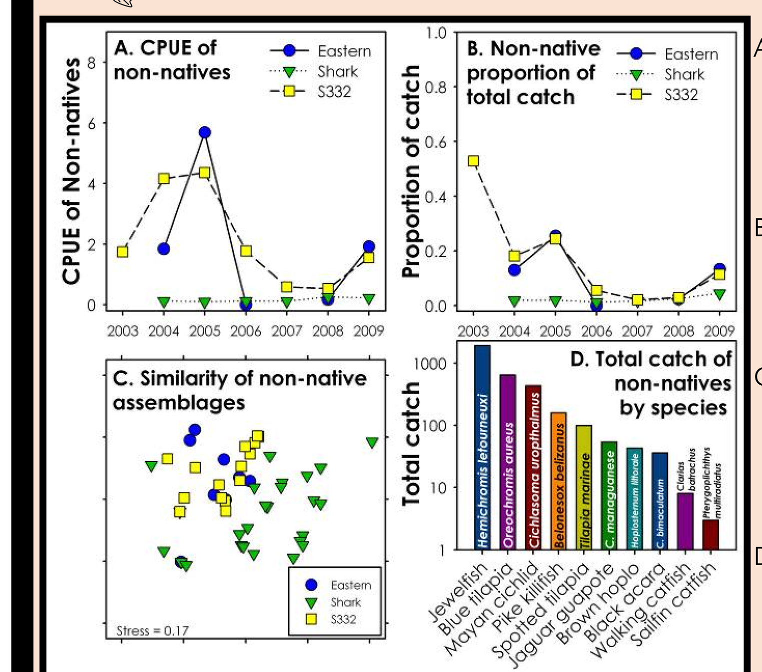
S332B
Community structure varied significantly among years (ANOSIM $p = 0.020$) but not distances ($p = 0.253$).

Mosquitofish (all distances), flagfish (all distances), dollar sunfish (close, far), jewelfish (mid, far) sailfin mollies (close), and marsh killifish (mid) contributed most to similarities within distances.

S332D
Community structure varied significantly among Distances (ANOSIM $p = 0.028$) and years ($p = 0.30$).

Mosquitofish (all distances), dollar sunfish (all distances), flagfish (close) and sailfin mollies (close) contributed most to similarities within distances. Mosquitofish (all) and dollar sunfish (all) contributed most to differences between distances.

Non-native fish



A) Catch per unit effort of non-native fish for each region, across years.

B) Proportion of total catch made up of non-native fish.

C) Similarity (MDS plot) of non-native assemblages in each region.

D) Total catch of non-native fish species

S332 and the eastern sites had more non-native fish than Shark River Slough.

The dry years (2006 and 2007) sharply reduced non-native abundance.

Each region has a distinct non-native assemblage.

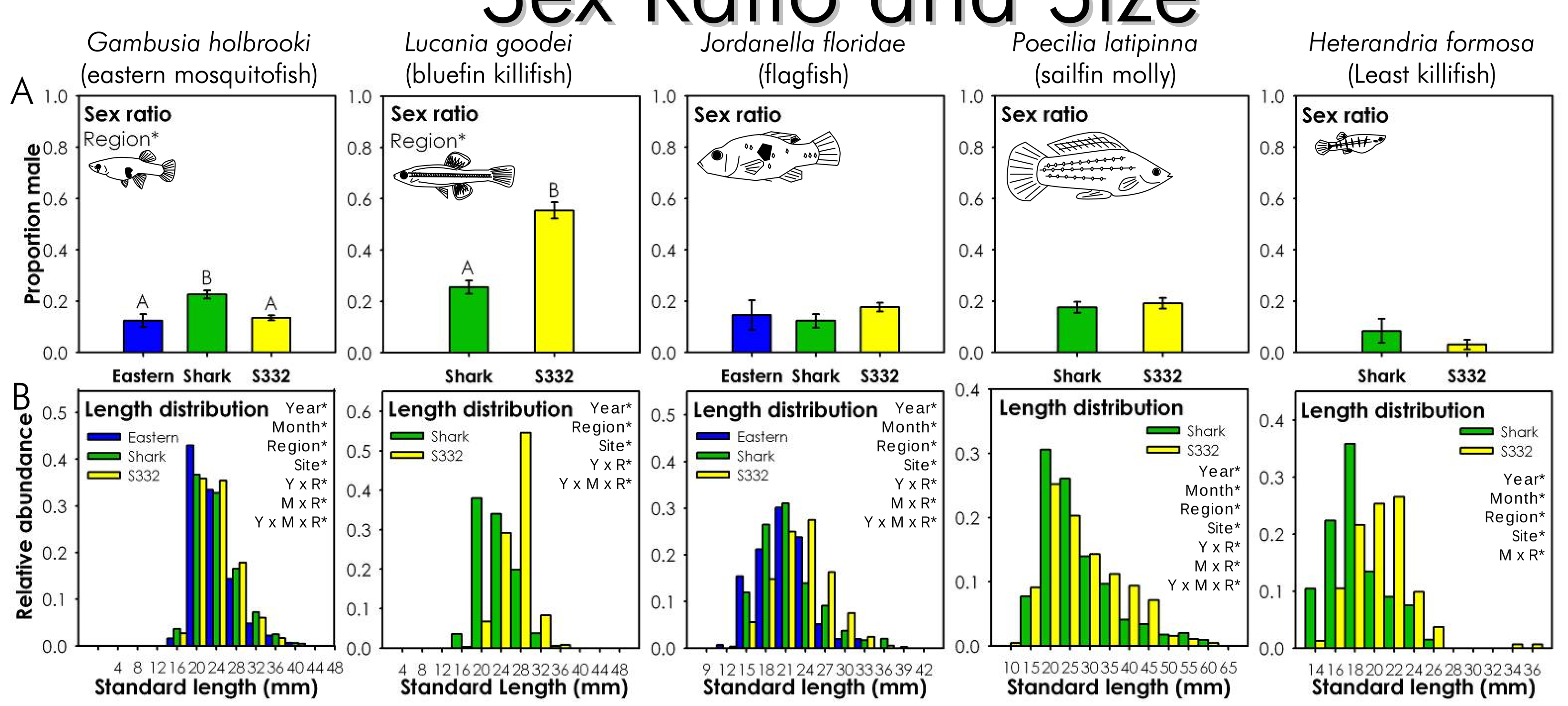
The assemblages of non-native fish were significantly different among regions (ANOSIM $p = 0.010$) and years ($p = 0.010$).

Each region was significantly different from the others ($p < 0.05$)

Years different at $p < 0.05$: 2004-2009, 2005-2007, 2005-2009, 2006-2009, 2007-2009

Mayan cichlids (all regions), jewelfish (Eastern, S332), pike killifish (Shark, S332) and black acara (Eastern) contributed most to similarities within regions. Differences between regions were driven by Jewelfish (all regions), Mayan cichlids (all regions), pike killifish (all regions) black acara (Eastern-Shark, Eastern-S332) and blue tilapia (Eastern-S332, S332-Shark).

Sex Ratio and Size



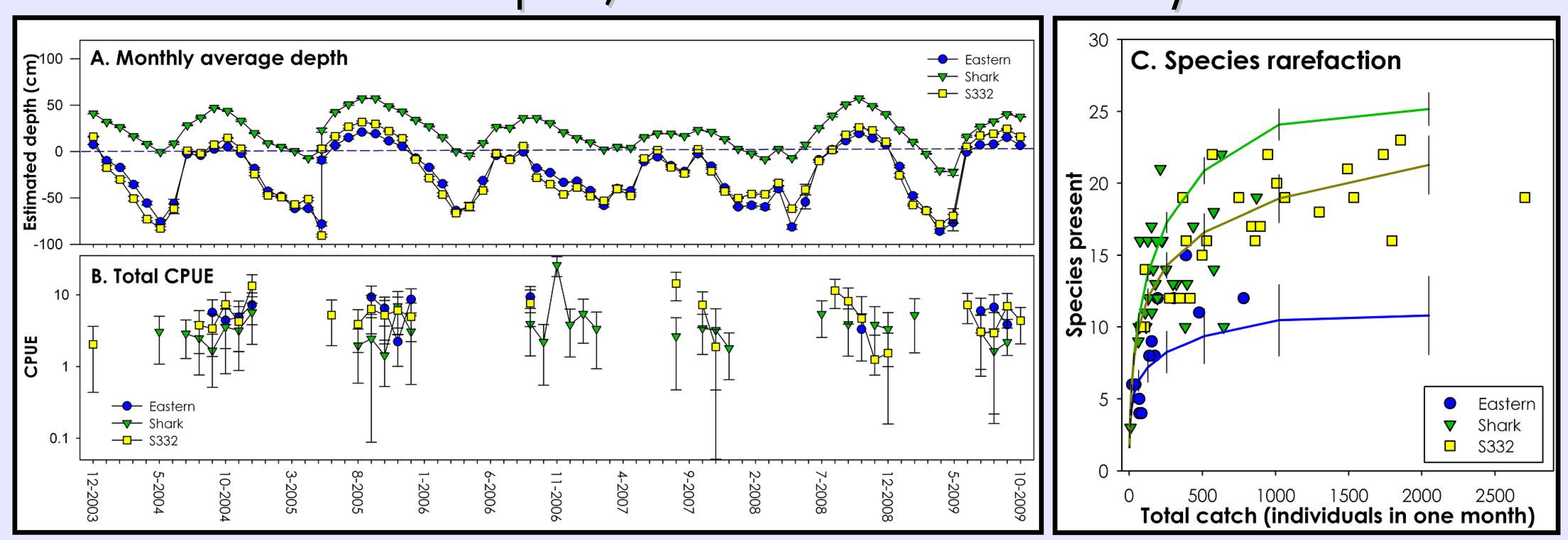
A) Bar graphs showing proportion male. In some cases too few fish were caught in the eastern control sites to compare sex ratio. These results may be biased as a result of differences in activity between the sexes or sizes of the sexes; smaller males may escape traps more often. (*$p < 0.05$)

B) Histograms of standard length for each species. (*$p < 0.05$)

Sex ratio was female biased for each species and varied among regions for mosquitofish and bluefin killifish.

Fish were larger in the S332 sites, especially bluefin killifish, flagfish and least killifish.

Depth, Catch and Diversity



A) Average monthly depth. Sites are pooled within regions. Depths were estimated using *EDEN*. Hydroperiod was shorter at the Eastern sites than represented by the predictions, owing to restrictions of model grain-size and variation in the topography of the sites. Because sampling was limited to periods with deeper water, effort was lower in those sites.

B) Total Catch-per-unit-effort (CPUE) for the duration of the study. CPUE is calculated as the number of fish caught divided by the number of traps set. Error bars show standard error; note the logarithmic scale.

C) Rarefaction: The symbols show the number of species present against the number of fish caught in one month. The lines show rarefaction curves (predicted species richness) generated by resampling. Error bars are standard error.

Hydroperiod is longest in Shark River Slough.

CPUE is greatest in S332 and the Eastern Sites.

Species richness is greatest in Shark River Slough, followed by S332.

Conclusions

The communities in each region were distinct from one another. The differences between the eastern sites and the S332 sites suggests that management, especially increased hydroperiod, may contributing to differences community structure, and making S332 more similar to longer hydroperiod sites, like Shark River Slough. The S332 sites also have greater diversity and standing crop than the eastern sites. We did not see any edge effects on fish community structure. It is possible that such effects (like increased P) have not yet scaled up to fish communities, that fish move over a larger range than the relatively narrow area influenced by edge effects or that edge effects simply are not present. Non-native fish were most abundant in the S332 sites and the eastern sites, most likely due to the proximity of these sites to the edge of the park and potential points of introduction. Sex ratio was female biased in the species of fish for which it was recorded. This is a well-documented phenomenon for these taxa, although differences in sex-ratio between long and short hydroperiod regions may be an interesting subject for future studies. Bluefin killifish, flagfish, sailfin mollies and least killifish were larger in the S332 and eastern control sites than in Shark River. This may be a result of greater food resources higher temperature, relaxed competition or fewer predators (allowing more foraging opportunity). These differences in life history characteristics may be important for population growth potential for these species.

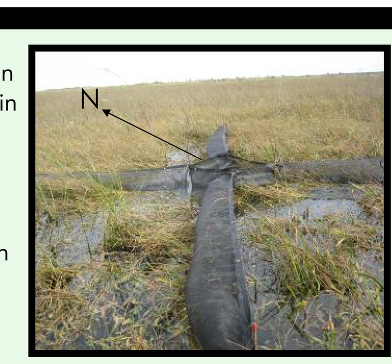
Future Work

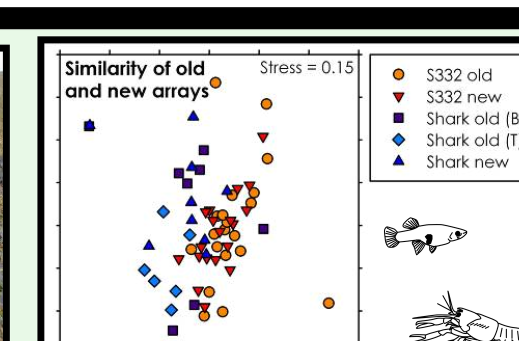
Future challenges to this work include making estimations as to the efficiency and limitations of the drift-fence traps, re-designing drift-fences and adding new sites and regions to the monitoring effort. We have begun to use new drift-fences in the existing sites and sampling new sites in Taylor Slough and the Everglades panhandle (figure 1). These drift- fences are re-built for each sampling event, are only set for one day, are smaller and do not act as a "fish attractor" by creating semi-permanent habitat. Here, we compare fish catch between these and permanent traps with the long term plan of exclusively using the new traps for future sampling.

Left: Eric Fortman (foreground) and Jim Easton installing a new array; the old array is visible in the background.

Right: A new, temporary drift-fence array. It will be removed after one night.

Far right: MDS plot showing similarity of catch in new, temporary drift-fence traps to the original permanent traps, for overlapping periods in the same region.





New and old trap array types were not signficantly different in catch (ANOSIM $p = 0.1490$). Regional differences in catch were significant ($p = 0.001$).

Similarity within X-array types (SIMPER) was primarily driven by dollar sunfish, jewelfish, mosquitofish and flagfish in the old type and mosquitofish, dollar sunfish and flagfish in the new type. Dollar sunfish, mosquitofish, jewelfish and flagfish contributed to the non-significant differences between fence types.

Acknowledgments

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