Identification of fish habitat hotspots and suitability for use in prioritizing conservation and restoration projects in coastal rivers

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Abstract

Coastal rivers of southeastern Florida have been ranked high for restoration by conservationists, because of the potential for projects to benefit human assets and aquatic communities. A fisheries-independent monitoring dataset was analyzed to identify fish habitat using hotspot analysis and habitat suitability. Initial testing for broad seasonal changes (high vs. low flow) in species distributions showed little change suggesting habitat was important for supporting fishes in this system. A river section (23-45 km from the river mouth) comprised of braided river channels and mangrove backwaters was a hotspot for Common Snook and Red Drum. The same low salinity section supported several regionally unique tropical species including Opossum Pipefish, Smallscale Fat Snook, and Bigmouth Sleeper. Restoration efforts can be prioritized by maintaining low salinity (<15 PSU), reconnecting floodplains and riverine backwaters in the areas comprised of fish hotspots and exploring strategies to improve fish habitat in other areas currently less used.

Introduction

Fish habitats in coastal areas worldwide are greatly impacted by a combination of stressors such as direct loss (e.g., through development, dredging), altered watersheds, pollution, eutrophication, and sea level rise, which have led to losses in ecosystem services (Lotze et al. 2006; Halpern et al. 2008; Barbier et al. 2011). Estuaries along highly urbanized coasts such as those in Florida, suffer from high stress relative to other conterminous national estuaries (NFHB 2010; Green et al. 2014). Economic analysis incorporating hydrological and ecological benefits has proven useful in justifying widespread and complex environmental restoration programs (Russell and Greening 2015; Wiederholt et al. 2020). However, it is important to prioritize where restoration efforts occur and to carefully plan how overlapping, contiguous projects can be implemented to maximize benefits (Bayraktarov et al. 2016).

Within the heavily developed southeastern portion of Florida, U.S.A., conservationists have identified the St. Lucie and Loxahatchee rivers, tributaries of the southern Indian River Lagoon Estuary, as a high priority for restoration. To prioritize restoration projects, there is a need for more information on how habitat and regions of estuaries are used by fish and wildlife. Using gained knowledge from a great body of literature detailing salmonid use of habitat, population dynamics, life history, and anthropogenic impacts, restoration efforts have in many cases successfully improved habitat quality and fish populations (Roni et al. 2014). In the case of St. Lucie and Loxahatchee rivers, the goal is to similarly generate necessary and important data about the connection between habitat and fishes that can be used to inform restoration efforts and maximize success. Restoration of degraded habitats in the St. Lucie and Loxahatchee rivers is ongoing, but there remains a need for information about how fish currently use these habitats. The objective of this study is to analyze a newly available fisheries-independent monitoring dataset to identify important fish habitats in the coastal rivers that can be used in restoration planning.

Methods

Sampling effort by the Fisheries Independent Monitoring program was stratified spatially and sampling sites were randomly selected within each estuary (Figure 1). Sampling included backwater and main-stem habitats within tidal rivers. A subset of fishes collected in 21.3-m seines (fish are typically <150 mm SL) representing juveniles of economically important taxa were examined for distribution and habitat use through hotspot analysis (using Global Moran's I and Getis-Ord-Gi*). Habitat suitability analyses were conducted for all areas, and for those species where hotspots overlapped.

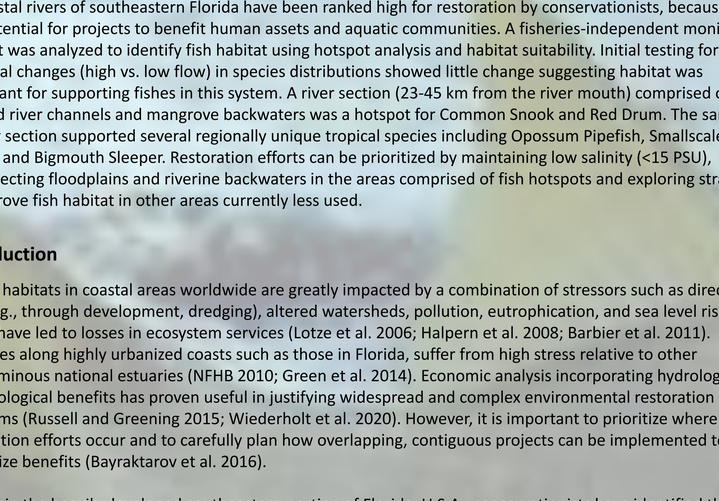

Figure 1. Locations of 21.3-m seine (3.2 mm stretched mesh) sampling within the St. Lucie and Loxahatchee rivers during stratified-random sampling, 2016 - 2018.

Results

The North Fork St. Lucie River stood out as being important to the species analyzed (Figure 2; Table 1). Changes in the distributions of hotspots between seasons differed depending on the species life history. Red Drum has a distinct spawning period (September–November) and juveniles exhibited ontogenetic habitat shifts between seasons (confluence during dry season and North Fork St. Lucie River during wet season). Common Snook has a protracted spawning period (May–September) and the juveniles use similar riverine habitat in both seasons. Opossum Pipefish, a species of special concern, is small-bodied and both juveniles and adults use riverine habitat throughout the year.

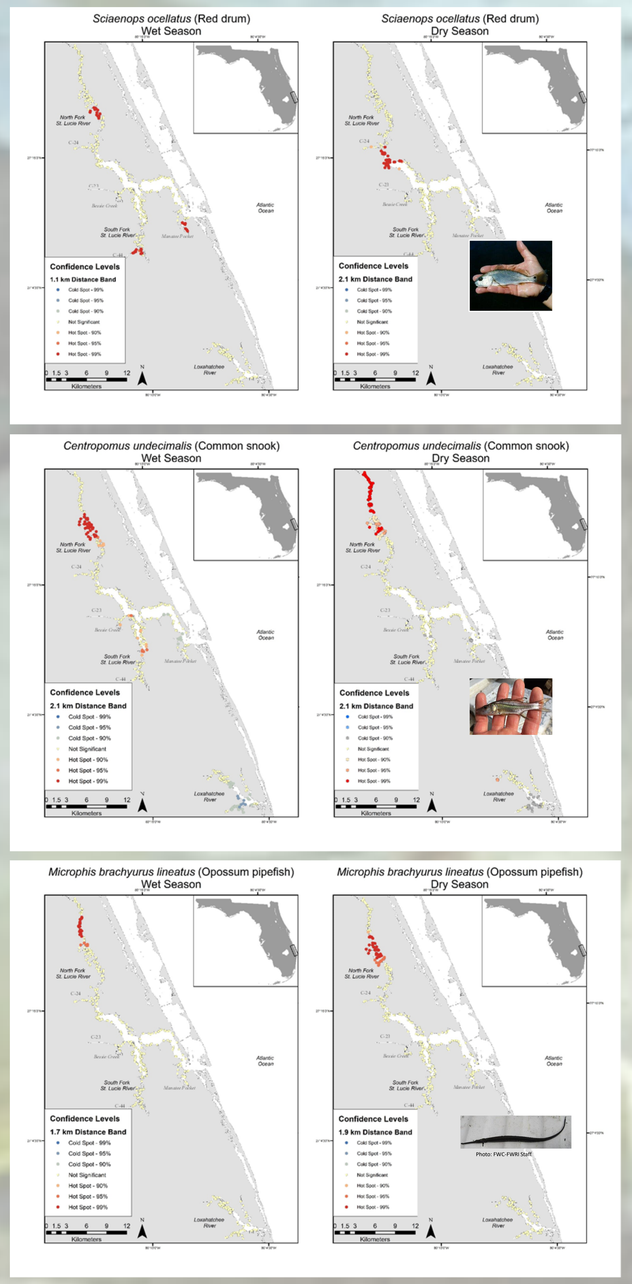

Figure 2. Spatial clustering of representative fishes selected for hotspot analysis (wet season defined as May–October; dry season is November–April). Circles are graded on significance from red (significant hot spots) to blue (significant cold spots) using Getis-Ord hot spot analysis.

Table 1. Summary of the distribution of "hotspots" for species selected for 21.3-m seine data analysis in the St. Lucie and Loxahatchee rivers, Florida.

	Species											
Location	Gray Snapper	Red Drum	Atlantic Croaker	Common Snook	Smallscale Fat Snook	Opposum Pipefish	Fat Sleeper	Spinycheek Sleeper	Bigmouth Sleeper	Crested Goby	Lyre Goby	Highfin Goby
St Lucie River												
Upper North Fork			X	X	X	X	X	X				X
Mid North Fork				X	X	X	X		X		X	
C-24					X				X			
Lower North Fork	X	X							X	X		
C-23												
Bessie Creek								X	X	X	X	
Confluence	X		X									
South Fork		X	X	X							X	X
C-44		X									X	
Manatee Pocket	X	X										
Loxahatchee River												
Northeast Branch	X									X		
North Fork	X				X		X		X	X	X	
South Fork	X											
Confluence	X											X

Given the number of hotspots that occurred in the North Fork St. Lucie River, the habitat suitability analyses were used to determine if habitat is partitioned by species within this river (Figure 3). Smallscale Fat Snook, compared to the Common Snook, used areas of lower salinity (<15 PSU), lower dissolved oxygen, greater depths, and shore types lacking intertidal vegetation. Compared to its congeners, Spinycheek Sleeper used areas of higher salinity (up to 15 PSU) and shore types comprised of mangrove. The gobies also overlapped in their habitat affinities, although Crested Gobies used areas of higher salinity (up to 32.5 PSU) and slightly deeper depths than its congeners.

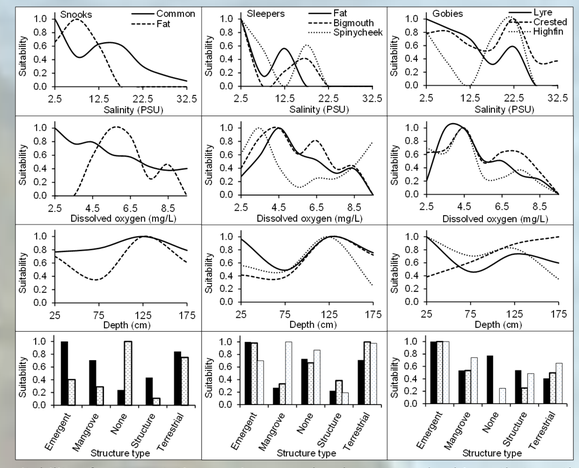

Figure 3. Habitat suitability of representative species—snooks, sleepers, and gobies—that use the St. Lucie River North Fork. For structure types, emergent refers to emergent vegetation such as leather fern, cattails, and swamp lilies; mangroves refer to black, white, and red mangroves; None refers to areas that lack intertidal vegetation such as sandy or muddy shorelines and steep riverbanks; structure refers to manmade structures such as docks, seawalls, and riprap; terrestrial refers to shorelines lined with terrestrial lawns, bushes, or trees.

Summary

Common Snook hotspots were located primarily in the North Fork St. Lucie River during both seasons. The North Fork St. Lucie River stood out as being important to the ecologically important species analyzed. For example, hotspots for Opossum Pipefish occurred exclusively in the North Fork St. Lucie River during both seasons, although there was greater use of backwaters during the dry season. For those species that overlapped in distribution in the St. Lucie River, some niche partitioning was evident and demonstrates the importance of maintaining habitat heterogeneity. The species chosen for analyses appear to be appropriate for evaluating the effects of habitat availability and freshwater inflow. To preserve the unique fish communities of the southern Indian River Lagoon, protecting and restoring habitat in the St. Lucie and Loxahatchee rivers, and ensuring appropriate salinity regimes, should be the highest priorities for conservation. The identification of specific locations and habitats used by fishes of economic and ecological importance, as was done here, can help to prioritize conservation or restoration.

Acknowledgements

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Literature Cited available upon request