Fishes of Coral Creek and a Comparison of Fish Community Structure in Southwest Florida Tidal Tributaries

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The Charlotte Harbor National Estuary Program is a partnership of citizens, elected officials, resource managers, and commercial and recreational resource users working to improve the water quality and ecological integrity of the greater Charlotte Harbor watershed. A cooperative decision-making process is used within the program to address diverse resource management concerns in the 4,700 square mile study area. Many of these partners also financially support the Program, which, in turn, affords the Program opportunities to fund projects such as this. The entities that have financially supported the program include the following:

U.S. Environmental Protection Agency
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South Florida Water Management District
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SUMMARY

The Charlotte Harbor National Estuary Program (CHNEP) Comprehensive Conservation Management Plan stresses the importance of restoring and protecting juvenile fish habitats. Coastal wetlands and associated tidal creeks rank among the most productive habitats regionally and throughout the Gulf coast of Florida, particularly with respect to small-bodied fishes. A large area of mangrove forest with major tidal creeks lies on the Cape Haze peninsula in the Charlotte Harbor estuarine system. The largest tidal creek on Cape Haze is Coral Creek. Its position directly across from Gasparilla Pass increases the likelihood that it will serve as important juvenile habitat to offshore spawning species in the Gulf of Mexico. However, Coral Creek has undergone considerable habitat and hydrological disturbances as a result of coastal development within its watershed (i.e., large urban development upstream, impoundment of the west branch). Hydrologic and habitat restoration activities are being conducted in the Coral Creek watershed by a partnership between the Florida Department of Environmental Protection, Division of Recreation and Parks, and the Southwest Florida Water Management District. The restoration will be completed in phases, with the current phase scheduled to break ground in fall of 2016. An understanding of fish use of Coral Creek was needed prior to the restoration as a baseline for comparison to post-restoration.

The overall goal of this study was to describe the fish community and habitat use of fishes that inhabit Coral Creek and two adjacent reference creeks (Catfish and Whidden) on the Cape Haze peninsula prior to restoration activities. To meet these objectives, methods associated the Florida Fish and Wildlife Conservation Commission’s, Fisheries-Independent Monitoring (FIM) program were expanded into tidal creeks on the Cape Haze Peninsula. A stratified-random sampling design was used to collect monthly samples in Coral, Catfish, and Whidden creeks between July 2014 and June 2015 with 21-m and 40-m seines. To put the fish communities of Coral Creek into perspective

at a larger scale, a supplemental objective was added to compare fish community structure between tidal creeks on the Cape Haze peninsula to those of upper Charlotte Harbor.

The seagrass-associated tidal creeks of Cape Haze were found to be an uncommon feature of the Charlotte Harbor estuarine system, and likely along the Gulf coast of Florida in general. During the study, a total of 56,973 fish and over 60 different species were collected in the three Cape Haze tidal creeks, including Common Snook, Red Drum, Mangrove Snapper, and Spotted Seatrout. Compared to the tidal creeks of upper Charlotte Harbor, the density of fish in the Cape Haze tidal creeks was high (4 times greater) and differed in species composition. The distinguishing species were generally more abundant in the Cape Haze tidal creeks, with the exception of Bay Anchovy. Within Cape Haze, fish assemblages separated into two distinct groups. A group comprised of the west and lower branches of Coral Creek had more Bay Anchovy, Tidewater Mojarra, Clown Goby, Silver Jenny, Striped Mojarra, and Redfin Needlefish; whereas, a group comprised of the east branch of Coral Creek, Catfish Creek, and Whidden Creek had more Rainwater Killifish, Silversides, Goldspotted Killifish, and Pink Shrimp. The dissimilarity between fish communities of these two groups was most likely attributed to differences in seagrass coverage and depth. The shallow and unvegetated west branch and the deeper, sinuous lower branch of Coral Creek supported a fish assemblage that closely resembled that of a tidal creek in upper Charlotte Harbor, or a lower portion of a tidal river; whereas, the tidal creeks that had expansive seagrass flats (Catfish, Whidden, and east branch of Coral) supported fishes that are typically associated with seagrass beds and backwater marshes. Although depths and salinities were presumably suitable for seagrasses, similar to the other Cape Haze tidal creeks, the west branch of Coral Creek stood out as being different in its physical characteristics and fish assemblages. It would be worthwhile to investigate the causes for a lack of seagrasses in the west branch; there may be opportunity there for future restoration, so that it supports seagrasses similar to other tidal creeks on Cape Haze.

INTRODUCTION

The project study area is located in southwest Florida within the Charlotte Harbor National Estuary Program (CHNEP) (Figure 1). CHNEP is a partnership of citizens, elected officials, resource managers, and commercial and recreational resource users who are working to improve the water quality and ecological integrity of Charlotte Harbor's estuaries and watersheds. Establishing a baseline of the current state of the estuary is a critical step for measuring future changes. With respect to fishery resources, Charlotte Harbor is one of seven estuarine systems monitored long-term by the Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute, Fisheries-Independent Monitoring (FIM) program. Much of the CHNEP study area has been sampled by the FIM program: Charlotte Harbor, Gasparilla Sound, Pine Island Sound, and the Peace and Myakka rivers have been sampled since 1989 (Poulakis et al. 2004); Estero Bay was sampled 2005-2007 (Stevens et al. 2008a); the Caloosahatchee River estuary was sampled 2005-2008 (Stevens et al. 2008b, Stevens et al. 2010); Lemon Bay was sampled 2009-2010 (Idelberger et al., in press), and the Venice Inlet area was sampled 2004-2005 (Peebles et al. 2006). A variety of fish habitats have been sampled during these studies, including tributaries and tidal creeks leading into the Caloosahatchee River, Peace and Myakka rivers, Estero Bay, and Lemon Bay. However, tidal creeks associated with Charlotte Harbor proper (over 15 creeks) and Gasparilla and Pine Island sounds remain relatively unstudied, with the exception of four tidal creeks along the eastern portion of Charlotte Harbor (Adams et al. 2007, Adams et al. 2009, Walton et al. 2013; Locascio 2014).

The CHNEP's Comprehensive Conservation Management Plan (CCMP) stresses the importance of restoring and protecting juvenile fish habitats, including coastal wetlands and tidal creeks. A large area of mangrove forest with major tidal creeks lies on the Cape Haze peninsula in the Charlotte Harbor estuarine system (Figure 1). The largest tidal creek in Cape Haze is Coral Creek. Its position directly across from Gasparilla Pass increases the likelihood that it will serve as important juvenile habitat to offshore spawning species in the Gulf of Mexico. However, Coral Creek and its watershed have undergone considerable hydrologic disturbance as a result of upstream coastal development, degradation of wetlands, and channelization. Hydrologic and habitat restoration activities are being conducted upstream of Coral Creek by a partnership between the Florida Department of Environmental Protection, Division of Recreation and Parks, and the Southwest Florida Water Management District. Efforts will focus on restoring sheet flow to Coral Creek by backfilling relic freshwater canals, restoring impacted wetlands, and creating important habitat features for juvenile sportfish in a series of relic estuarine canals. The restoration will be completed in three phases, with the current phase (2) scheduled to break ground in fall of 2016. Restoration of natural, seasonal variability of flows and native vegetation will improve the efficiency of overall management of the Cape Haze Peninsula, which is a part of the Charlotte Harbor Buffer Preserves. An understanding of the distribution, abundance, and habitat use of fishes within Coral Creek (pre-restoration) was needed to better inform managers and those conducting the restoration.

The overall goal of this study was to describe the fish community and habitat use of fishes that inhabit Coral Creek and two adjacent reference creeks (Catfish and Whidden) on the Cape Haze peninsula prior to restoration activities. Specifically, this study was designed to: 1) provide a list of fishes and select invertebrates that inhabit Coral Creek and the adjacent reference creeks; and 2) examine spatial differences in species composition and relative abundance within the tidal creeks on the Cape Haze peninsula. In addition, to put the fish communities of Coral Creek into perspective at a larger scale, a supplemental objective was added to compare fish community structure between tidal creeks on the Cape Haze peninsula to those of upper Charlotte Harbor.

This study implements the following CHNEP CCMP Update 2013 Priority Actions and Environmental Indicators:

FW-f: Restore and protect a balance of native animal communities

FW-d: Fish community composition by strata

METHODS

Gear Specification and Sampling Technique

The FIM program sampled the Cape Haze tidal creeks (Coral, Catfish, Whidden) and the upper Charlotte Harbor tidal creeks (July 2014–June 2015) following established FIM procedures and protocols. The FIM program uses a stratified-random sampling design and a multi-gear approach to collect data on fish from a wide range of habitats and life history stages. This sampling design provides comprehensive data on size-specific, spatial and temporal patterns of abundance for the fish community and for individual species. Specimens collected during this sampling are also used for various other assessments, such as fish health, mercury levels, diet, age/growth, and reproduction.

Two seine types were used to sample fishes along shallow (<1.8 m) tidal creek shorelines: 1) 21-m, 3.2-mm-stretched-mesh, center-bag seines for small-bodied fishes (typically <50 mm SL); and 2) 40-m, 25 mm-stretched-mesh, center-bag seines for large-bodied fishes (typically >50 mm SL). Both seine types were set and retrieved in the same manner using a standardized FIM "river seine" technique. Seines were deployed from the back of a boat in a shallow arc along the shore and then hauled directly to the shoreline to force the sample into the bag. Each 21-m and 40-m seine deployment sampled an area of ~ 68 m^2 and ~180 m^2, respectively.

During each net deployment, water conditions including temperature (°C), salinity (ppt), and dissolved oxygen ($mg \bullet l^{-1}$) were profiled with a water quality datasonde (measurements taken at 0.2 m depth from the surface, every meter thereafter, and at 0.2-m from the bottom). A variety of qualitative habitat assessments were also made, such as characteristics of the shoreline (e.g., vegetation type, inundation), substrate (e.g., sediment type, presence of submerged aquatic vegetation), and bycatch (i.e., total volume, type, and composition). All sampling was conducted during daytime hours (one hour after sunrise to one hour before sunset).

Fishes and select invertebrates collected in each gear deployment were identified to the lowest practical taxonomic level (nomenclature for fishes follows Nelson et al., 2004). To avoid introducing additional taxonomic terms throughout this report, we include the commercially-important stone crab, *Menippe* spp., and several swimming invertebrates, blue crab *Callinectes sapidus*, pink shrimp *Farfantepenaeus duorarum*, and Portunus crabs *Portunus* spp. in the terms 'fish' and 'fish assemblage'. A maximum of twenty individuals of each species in each haul were measured to the nearest millimeter (mm), except for certain economically valuable fish for which forty individuals were measured. Size was recorded as standard length (SL) for most fish, total length (TL) for seahorses, disk width (DW) for rays, post-orbital head length (POHL) for shrimp, and carapace width (CW) for crabs. Fishes and invertebrates that were not measured were identified and counted. When large numbers of individuals (>1,000) were captured, the total number was estimated by fractional expansion of sub-sampled portions of the total catch split with a modified Motoda box splitter (Winner and McMichael 1997). Representative samples (three individuals of each species from each gear on each sampling trip) and species for which field identification was uncertain were brought back to the laboratory to confirm field identification. Fish not chosen for further laboratory examination were returned to the water.

Due to frequent hybridization and/or extreme difficulty in the identification of smaller individuals, members of several abundant species complexes were not identified to species. We did not separate menhaden, *Brevoortia*, species. *Brevoortia patronus* and *B. smithi* frequently hybridize, and juveniles of the hybrids and the parent species are difficult to identify (Dahlberg 1970). *Brevoortia smithi* and hybrids may be the most abundant forms in the Tampa Bay area, especially in tidal rivers (Dahlberg, 1970), and we treated them as one functional group. The two abundant silverside species (genus *Menidia*) are not considered at the species level in this study because of the tendency for this genus to hybridize and to form all-female clones and their great abundance renders identification impractical due to the nature of the diagnostic characters (Duggins et al. 1986; Echelle and Echelle 1997). Analyses of mojarras (genus *Eucinostomus*) to the species level were limited to individuals ≥ 40 mm SL due to great difficulty in separating *E. gula* and *E. harengulus* below this size (Matheson, personal observation). Gobies of the genus *Gobiosoma* (i.e., *G. robustum* and *G. bosc*) were not identified to species at sizes less than 20 mm SL for the same reason. Similarly, needlefishes (*Strongylura* spp.) other than *S. notata* were only identified to species at lengths ≥ 100 mm SL.

Study Area and Study Design

Coral Creek is located in southwest Florida on the Cape Haze peninsula in Placida (Figure 1). The creek is comprised of two branches (east and west branches), which connect to form one main branch (lower branch) that leads into Gasparilla Sound directly across (2.5 km) from Gasparilla Pass to the Gulf of Mexico (Figure 2). The creek receives sheet flow from natural uplands and wetlands, and from a large canal system that drains Rotonda (a large urban housing development located just to the north). The east and west branches are both very shallow (<1 m, mean low water) and lack the typical natural channelization that occurs in most southwest Florida tidal creek systems; whereas the lower branch has natural channelization (up to 1.8 m depth) mixed with shallow flats (<1 m). In terms of surrounding land use, the east branch is the most pristine area of Coral Creek. This branch has a large buffer from development, comprised of approximately a 1 km buffer of state preserved lands on each side. The shorelines are lined with mangroves and the bottom is dominated by *Halodule* spp. and *Ruppia* spp. seagrasses. The west branch has been impacted by several large anthropogenic alterations. Halfway along its course is a dam constructed in the 1950's, and extensive residential development (dredged and filled with seawalls) extends south of the dam along the western shoreline. State buffer lands border its eastern shoreline, which is dominated by mangroves. The bottom is primarily sand/mud with no bottom vegetation, with the exception of a small area downstream with *Halodule* spp. seagrass. The lower branch is surrounded on both sides with development (housing on one side and a golf course and marina on the other); however, a narrow mangrove buffer was preserved along its entire shoreline. This branch is dominated by mangrove and oyster island habitat and the bottom is a mix of deep natural channels (up to 1.8 m deep) and shallow seagrass flats (<1 m) comprised of *Halodule* spp.

The two reference creeks (Catfish, Whidden) are located just southwest of Placida and south of the South Gulf Cove housing development. Each tidal creek system is surrounded by extensive areas of undeveloped uplands, salt marsh, and mangrove forests (some mosquito ditching to the west of Catfish Creek), much of which is state buffer lands. Catfish Creek is a uniformly shallow system (< 1 m) dominated by seagrasses (*Halodule*, *Thalassia*, and *Ruppia*) with only a few small areas of natural deep channelization downstream. The mangrove marsh system to the west of Catfish Creek has extensive mosquito ditching. Whidden Creek is also predominantly a shallow system (< 1 m) with seagrasses (*Halodule*, *Thalassia*, and *Ruppia*) but its upstream section narrows and has deep natural channelization (up to 1.5 m depth).

For sampling purposes the study area was divided into five logistical zones (Lower-Coral, West-Coral, East-Coral, Catfish, and Whidden). During July 2014 to June 2015, ten sampling sites were randomly selected each month (two in each zone). At each site a 21-m seine haul and a 40-m seine were pulled (random order), for a total of 20 seine hauls each month. During the study a total of 120 samples were collected with the 21-m seine and 120 samples with the 40-m seine in tidal creeks on the Cape Haze Peninsula (Figures 1 and 2, Table 1).

For a larger regional comparison of tidal creek fish assemblages, we used additional data collected by FIM during monthly sampling of tidal creeks in upper Charlotte Harbor. Sampling of these tidal creeks followed the same protocols and time frame, but sample size and site selection varied slightly. At each site a 21-m seine haul and a 40-m seine were pulled (random order), for a total of 26 seine hauls each month; 12 seine hauls were collected in Alligator Creek, and 14 were collected among 17 smaller tidal creeks (i.e., Trout, Sam Knight, Winegourd) in the upper harbor. During the study a total of 156 samples were collected with the 21-m seine and 156 samples with the 40-m seine in upper Charlotte Harbor (Figure 1).

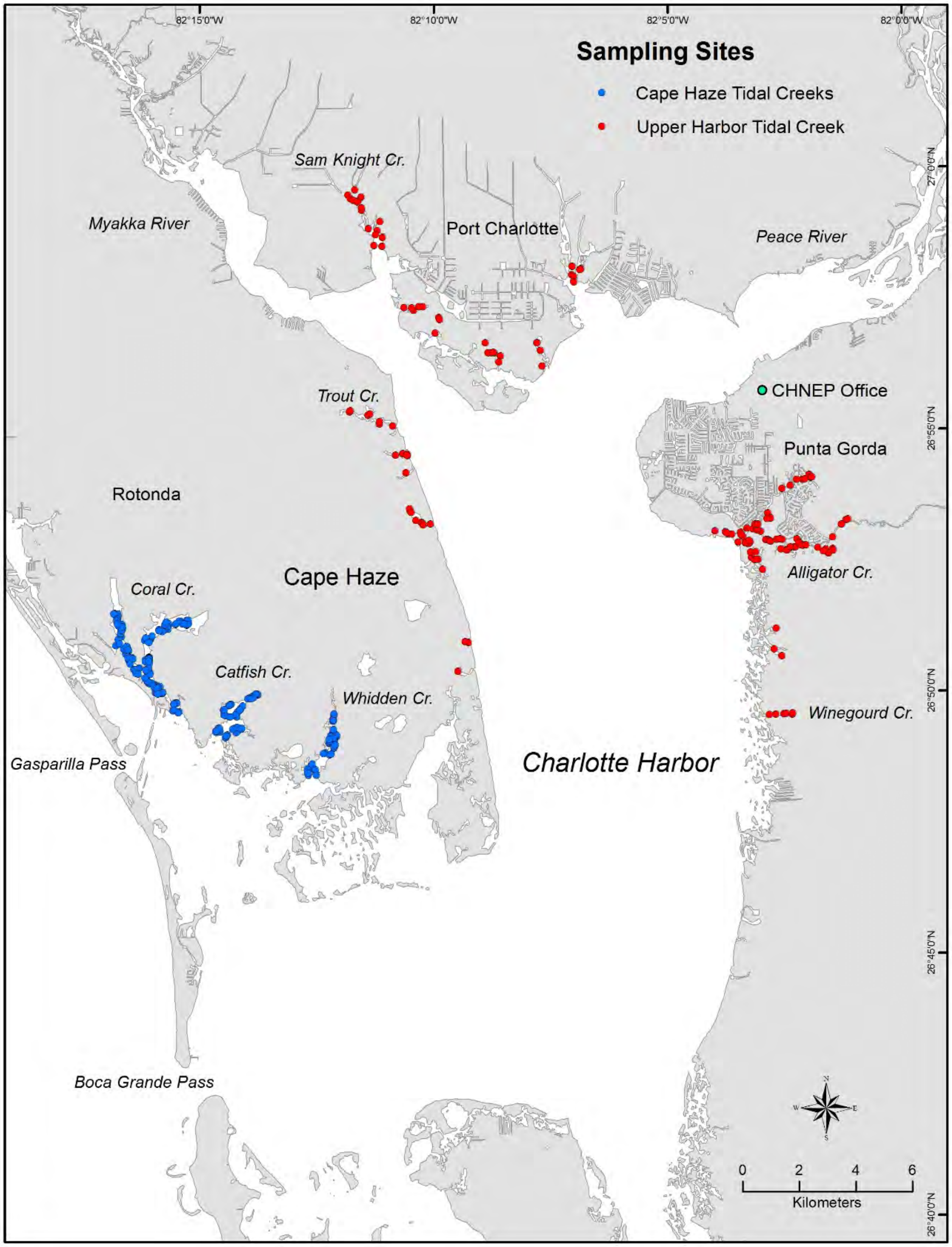

Figure 1. Fisheries-Independent Monitoring sampling sites: Cape Haze peninsula tidal creeks (Coral, Catfish and Whidden; blue dots) and upper Charlotte Harbor tidal creeks (red triangles). Each dot represents a paired seine sample (one 21-m and one 40-m seine haul).

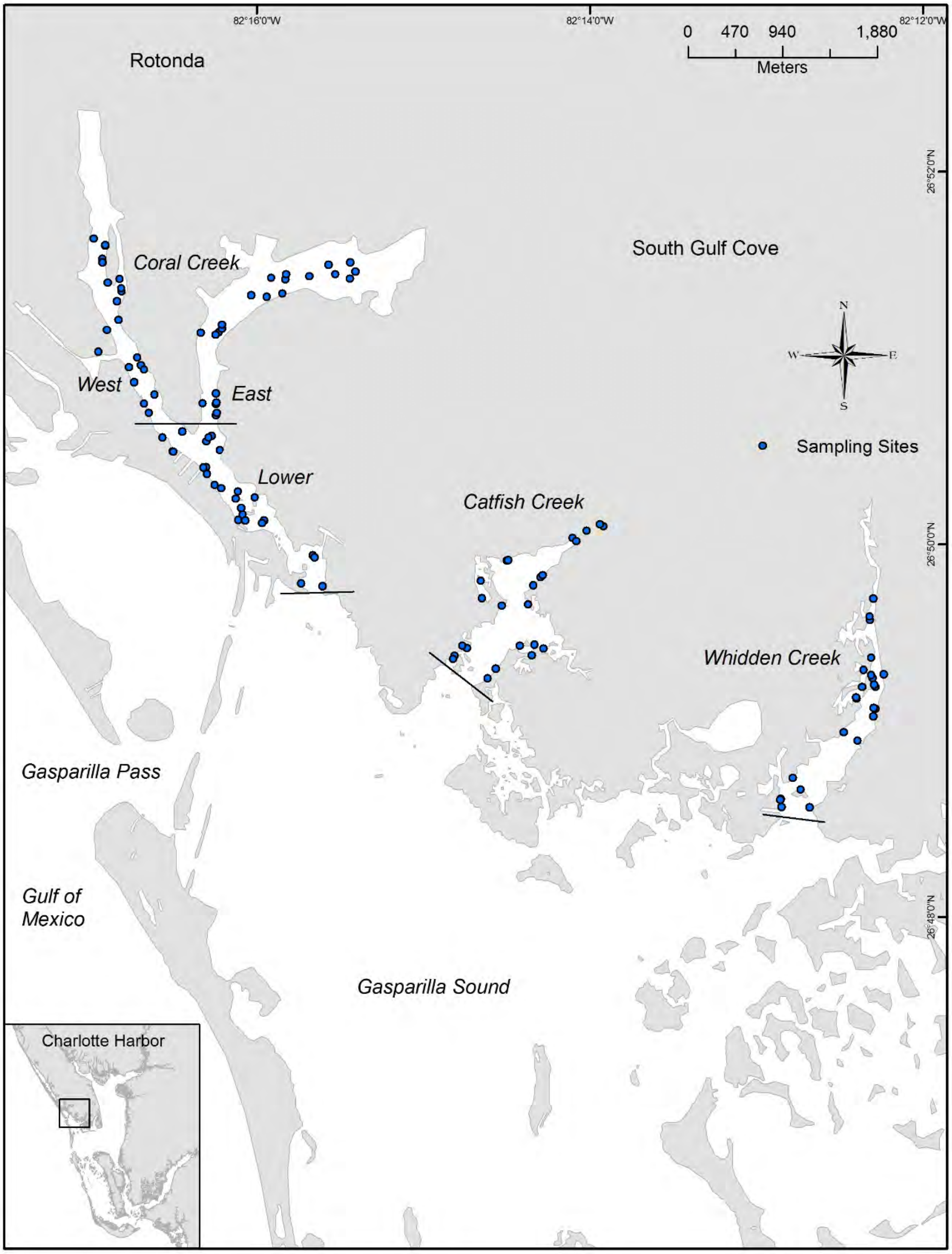

Figure 2. Fisheries-Independent Monitoring sampling sites in Coral Creek (Lower, West, and East) and two reference creeks (Catfish and Whidden) represented as blue dots (one 21-m and one 40-m seine haul at each site). Solid vectors denote the boundaries of the study area and the separations between zones.

Analysis

Spatial patterns in fish assemblage structure from 21-m seine catches were analyzed using multivariate techniques (PRIMER version 6, PRIMER-E, Plymouth, UK). Sample abundance indices for each species (fish/set) were square root transformed to reduce the influence of highly abundant species. To explore for any differences between the tidal creek fish assemblages of the Cape Haze peninsula, nonmetric multidimensional scaling (MDS, Clarke and Warwick, 2001) and hierarchical agglomerative cluster analysis (CLUSTER, Clarke and Warwick, 2001) were used to graphically depict relative differences in fish assemblages after averaging data by creek zone (Lower-Coral, West-Coral, East-Coral, Catfish and Whidden). Similarity percentage analysis (SIMPER, Clarke and Warwick, 2001) was used to identify species representative of dissimilarities between groups determined from MDS and CLUSTER. Species that contributed >2% to the total average dissimilarity between groups were considered distinguishing.

Mean environmental conditions sampled within Coral (Lower, West, East), Catfish, and Whidden creeks (five zones) were explored using principal component factor analysis (PCA). A PCA was conducted to describe relationships between five intercorrelated environmental variables (temperature, salinity, dissolved oxygen, depth, and bottom vegetation cover) and resolve uncorrelated (orthogonal) components based on a correlation matrix. The PCA was conducted using the Factor procedure in SAS software (SAS Institute, Cary, North Carolina), and important principal components (eigenvalues > 1) were rotated using the SAS Varimax option to facilitate interpretability of each component. Variable loadings and principal-component scores were estimated for each sample. Average principal component scores were then calculated for each estuarine system and habitat type.

To place the tidal creeks of Cape Haze into a broader ecological context, the fish assemblages of Cape Haze were compared to those of upper Charlotte Harbor. Total fish densities, and densities of juvenile Common Snook (an economically important species that uses tidal creeks as nursery habitat), were plotted between the two regions. Fish assemblages were compared between regions using a one-way analysis of similarity (ANOSIM, Clarke and Warwick, 2001). Sample abundance indices for each species (fish/set) were square root transformed to reduce the influence of highly abundant species. The factor of interest was creek region (Cape Haze vs. upper Charlotte Harbor). Before ANOSIM was performed, Bray-Curtis similarity matrices were calculated for data averaged by region and sampling event (month-year) to include an appropriate level of variability in the statistical test. Similarity percentage analysis (SIMPER) was used to identify species representative of any dissimilarities between regions. Species that contributed >2% to the total average dissimilarity between regions were considered distinguishing.

RESULTS AND DISCUSSION

Fish inventory of the Cape Haze creeks

A total of 54,729 fishes (59 taxa) and selected invertebrates (3 taxa) were collected in the three Cape Haze tidal creeks from 240 samples (Table 1). Dominant species in the tidal creeks included Rainwater killifish *Lucania parva*, Eucinostomus mojarras *Eucinostomus* spp., Menidia silversides *Menidia* spp., and Bay Anchovy *Anchoa mitchilli*, which collectively comprised 77.8% of the catch (Table 2). The most abundant recreational and commercial species collected were Red Drum *Sciaenops ocellatus*, Pink Shrimp *Farfantepenaeus duorarum*, Common Snook *Centropomus undecimalis*, and Spot *Leiostomus xanthurus* (Table 3). The species found in these tidal creeks are consistent with a comprehensive list of fishes reported in the Charlotte Harbor estuarine system (Poulakis et al. 2004), and with studies examining habitat use of fish in Charlotte Harbor (Poulakis et al. 2003; Idelberger and Greenwood 2005; Greenwood et al. 2006; Greenwood et al. 2007; Stevens et al. 2013).

Three exotic species were collected in low numbers during the study including: Mayan Cichlid *Cichlasoma urophthalmus* (n=4), African Jewelfish *Hemichromis letourneuxi* (n=1), and Blue Tilapia *Oreochromis aureus* (n=1). All of the exotic fishes were collected in the east branch of Coral Creek during summer. Freshwater and euryhaline exotics (e.g., Mayan Cichlids) tend to push downstream into lower tributaries during times of high freshwater flows and their abundance has been shown to be higher in tidal creek systems that receive freshwater flow from altered freshwater habitats, such as man-made canal systems (Adams and Wolfe 2007).

Table 1. Catch summary by seine type and zone (L=Lower, W=West, E=East). Sampling effort or total number of hauls is labeled 'N=' by column.

	Charlotte Harbor Estuary										All
	Cape Haze Tidal Creeks										
	Gear										
	21-m seine					40-m seine					
	Zone					Zone					
	L-Coral	W-Coral	E-Coral	Catfish	Whidden	L-Coral	W-Coral	E-Coral	Catfish	Whidden	
	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=240
Scientificname											
Achirus lineatus	1	1	1	2	2	.	.	.	.	.	7
Adinia xenica	.	.	.	2	3	.	.	.	.	.	5
Anchoa hepsetus	6	.	.	.	.	.	.	.	.	.	6
Anchoa mitchilli	852	5788	38	129	37	.	.	.	.	.	6844
Archosargus probatocephalus	7	3	.	3	2	3	4	1	1	3	27
Bairdiella chrysoura	53	4	3	1	.	2	10	.	.	.	73
Bathygobius soporator	.	3	.	.	.	.	.	.	.	.	3
Brevoortia spp.	908	.	.	.	.	.	.	.	.	.	908
Callinectes sapidus	12	4	5	23	22	4	3	1	3	.	77
Caranx hippos	1	.	.	.	.	.	3	.	.	1	5
Centropomus undecimalis	12	7	42	3	7	21	12	34	12	163	313
Cichlasoma urophthalmus	.	.	3	.	.	.	.	1	.	.	4
Ctenogobius smaragdus	1	.	.	.	.	.	.	.	.	.	1
Cynoscion arenarius	.	1	.	.	2	.	.	.	.	.	3
Cynoscion nebulosus	3	3	.	.	1	.	10	2	.	.	19
Cyprinodon variegatus	.	4	12	407	122	.	.	.	.	1	546
Cyprinodontidae spp.	.	1	.	.	.	.	.	.	.	.	1

	Charlotte Harbor Estuary										All
	Cape Haze Tidal Creeks										
	Gear										
	21-m seine					40-m seine					
	Zone					Zone					
	L-Coral	W-Coral	E-Coral	Catfish	Whidden	L-Coral	W-Coral	E-Coral	Catfish	Whidden	
	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=240
Dasyatis sabina	.	.	.	.	.	.	1	.	.	.	1
Diapterus auratus	13	520	24	1	.	5	93	3	.	3	662
Elops saurus	.	.	.	1	1	.	.	.	1	5	8
Eucinostomus gula	245	18	14	185	21	241	12	8	62	19	825
Eucinostomus harengulus	105	461	70	198	173	33	186	44	92	30	1392
Eucinostomus spp.	1588	1909	1854	2620	1830	.	.	.	.	1	9802
Eugerres plumieri	236	187	93	4	7	7	140	13	1	.	688
Farfantepenaeus duorarum	105	7	25	99	106	5	1	4	4	1	357
Floridichthys carpio	50	23	51	715	52	3	1	.	13	.	908
Fundulus grandis	.	.	2	40	115	.	.	.	1	10	168
Fundulus similis	.	.	.	17	8	.	.	.	.	4	29
Gambusia holbrooki	.	.	18	2	3	.	.	.	.	.	23
Gobiosoma bosc	.	1	1	.	.	.	.	.	.	.	2
Gobiosoma robustum	51	3	15	32	20	.	.	.	.	.	121
Gobiosoma spp.	27	11	3	4	2	.	.	.	.	.	47
Harengula jaguana	.	.	.	2	.	5	.	.	3	1	11
Hemichromis letourneuxi	.	.	1	.	.	.	.	.	.	.	1
Hippocampus zosterae	.	.	.	1	2	.	.	.	.	.	3
Lagodon rhomboides	570	219	482	441	103	149	33	105	117	271	2490
Leiostomus xanthurus	2	5	.	41	71	3	7	.	27	8	164
Lophogobius cyprinoides	21	30	2	.	.	.	.	.	.	.	53
Lucania parva	707	2005	11329	2719	2912	.	.	.	.	.	19672
Lutjanus griseus	38	.	1	.	2	21	1	3	1	2	69

	Charlotte Harbor Estuary										All
	Cape Haze Tidal Creeks										
	Gear										
	21-m seine					40-m seine					
	Zone					Zone					
	L-Coral	W-Coral	E-Coral	Catfish	Whidden	L-Coral	W-Coral	E-Coral	Catfish	Whidden	
	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=24	N=240
Membras martinica	.	.	.	1	.	.	.	.	.	.	1
Menidia spp.	281	1012	3200	1536	1961	.	.	.	.	.	7990
Microgobius gulosus	203	458	152	96	108	.	.	.	.	.	1017
Mugil cephalus	1	1	.	18	1	.	5	3	9	6	44
Mugil curema	.	.	.	1	2	.	.	.	.	.	3
Oligoplites saurus	2	6	.	2	1	.	3	.	.	.	14
Opsanus beta	4	.	.	1	1	2	.	.	.	2	10
Oreochromis aureus	.	.	1	.	.	.	.	.	.	.	1
Orthopristis chrysoptera	120	.	4	1	.	6	.	2	.	.	133
Poecilia latipinna	.	5	485	80	46	.	.	.	.	3	619
Portunus spp.	1	.	.	.	.	.	.	.	.	.	1
Prionotus tribulus	.	.	1	1	1	.	.	.	.	.	3
Rivulus marmoratus	.	.	.	.	1	.	.	.	.	.	1
Sciaenops ocellatus	1	319	24	1	30	1	1	.	1	3	381
Sphoeroides nephelus	3	.	1	.	1	.	.	.	.	.	5
Sphyraena barracuda	.	.	.	1	.	.	.	.	.	.	1
Strongylura notata	67	37	71	54	12	14	13	16	23	23	330
Strongylura spp.	.	.	1	1	.	.	.	.	.	.	2
Strongylura timucu	2	.	4	2	1	1	2	4	.	.	16
Symphurus plagiusa	2	.	.	.	.	.	.	.	.	.	2
Syngnathus scovelli	18	2	9	8	16	.	.	.	.	.	53
Synodus foetens	.	.	.	2	.	.	.	.	.	.	2
Trinectes maculatus	.	4	.	.	.	.	2	.	.	.	6
All	6319	13062	18042	9498	7808	526	543	244	371	560	56973

Table 2. Top 10 most numeric species collected in 21-m seine catches in Coral, Catfish, and Whidden creeks.

Scientific Name	Common Name	Number	% Composition
Lucania parva	Rainwater Killifish	19,672	34.5
Eucinostomus spp.	Eucinostomus mojarras	9,802	17.2
Menidia spp.	Menidia silversides	7,990	14.0
Anchoa mitchilli	Bay Anchovy	6,844	12.0
Lagodon rhomboides	Pinfish	2,490	4.4
Eucinostomus harengulus	Tidewater Mojarra	1,392	2.4
Microgobius gulosus	Clown Goby	1,017	1.8
Brevoortia spp.	Brevoortia menhadens	908	1.6
Floridichthys carpio	Goldspotted Killifish	908	1.6
Eucinostomus gula	Silver Jenny	825	1.4

Table 3. Top 10 most numeric species (recreationally and commercially important) collected in 21-m seine catches in Coral, Catfish, and Whidden creeks.

Scientific Name	Common Name	Number	% Composition
Sciaenops ocellatus	Red Drum	381	0.7
Farfantepenaeus duorarum	Pink Shrimp	357	0.6
Centropomus undecimalis	Common Snook	313	0.5
Leiostomus xanthurus	Spot	164	0.3
Callinectes sapidus	Blue Crab	77	0.1
Lutjanus griseus	Mangrove Snapper	69	0.1
Mugil cephalus	Striped Mullet	44	0.1
Archosargus probatocephalus	Sheepshead	27	0.0
Cynoscion nebulosus	Spotted Seatrout	19	0.0
Elops saurus	Ladyfish	8	0.0

Comparison of Coral Creek and Cape Haze reference tidal creek fish assemblages

Differences were found between fish assemblages in the three branches of Coral Creek and the two reference creeks. Fish assemblages separated into two distinct groups at a level of similarity of 56% (MDS; Figure 3). Coral Creek fish assemblages were similar in the west and lower branches, but differed from those of the east branch, Catfish, and Whidden creeks. The group comprised of the west and lower branches of Coral Creek had more Bay Anchovy, Tidewater Mojarra, Clown Goby, Silver Jenny, Striped Mojarra, and Redfin Needlefish; whereas, the group comprised of the east branch of Coral Creek, Catfish, and Whidden had more Rainwater Killifish, Silversides, Goldspotted Killifish, and Pink Shrimp (SIMPER; Figure 4).

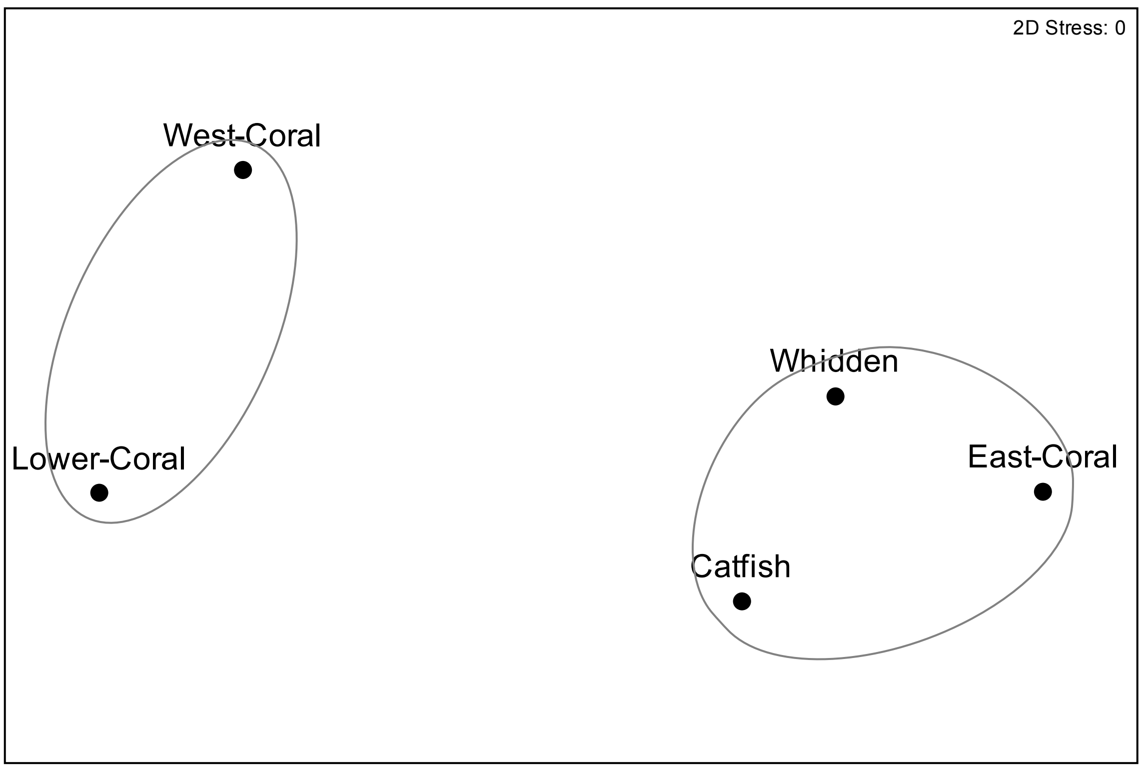

Figure 3. Nonmetric multidensional scaling (MDS) ordination of fish assemblages collected in 21-m seines set along shorelines in Coral (Lower, West, East), Catfish, and Whidden. The ellipses denoting the two different groups were determined using Bray-Curtis similarity percentages of 56% from hierarchical agglomerative cluster analysis.

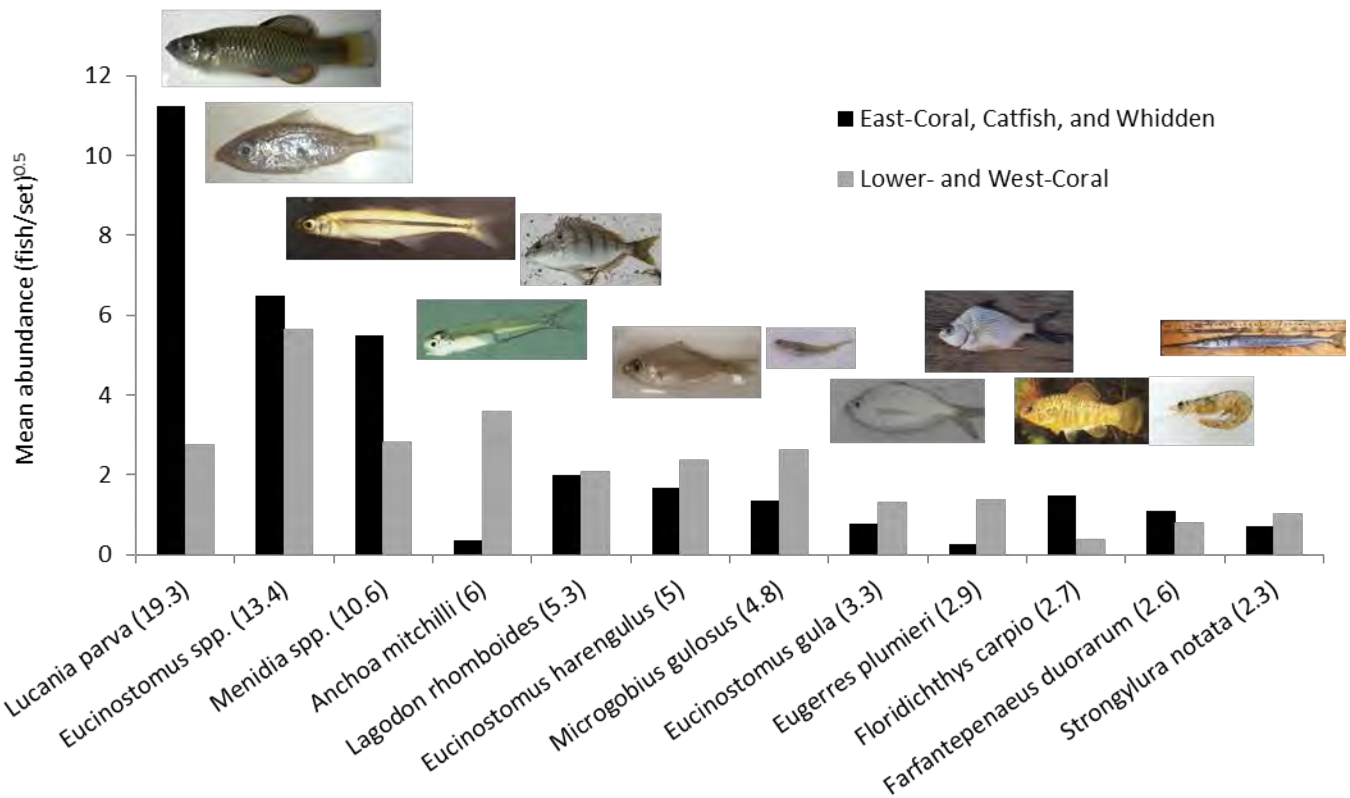

Figure 4. Fishes distinguishing Catfish Creek, Whidden Creek, and East Coral Creek (black bar) from Lower and West Coral Creek (gray bar). Abundance is the square root of average abundance (fish/set; 21-m seine) as output from SIMPER. The contribution of each species to the total average dissimilarity is shown in parentheses.

The dissimilarity between fish communities among the five Cape Haze creek zones is most likely attributed to differences in the physiochemical conditions and habitat metrics of the west branch of Coral Creek. Mean water chemistry, seine bag depth and seagrass coverage conditions observed in the five tidal creek zones for the study period are shown in Table 4. The PCA of environmental data identified two major axes of environmental variability (eigenvalues > 1) that together explained 58% of the total environmental variability (Table 5). The first principal component loaded positively for dissolved oxygen and negatively for temperature, and positioned West-Coral as the zone with the warmest temperature and lowest dissolved oxygen level. The second principal component loaded positively for depth and negatively for seagrass coverage. A plot of mean principal-component scores identified clear separation between West-Coral and all the other zones (Figure 5). Seagrass coverage was much lower in West-Coral compared to all other zones, and depth was deeper in Lower-Coral. Based on the study results, lower seagrass coverage in the west branch of Coral Creek and greater water depths in the lower branch appear to support a fish assemblage that closely resembles that of a tidal creek in upper Charlotte Harbor, or a lower portion of a tidal river; whereas, those zones with greater seagrass coverage and shallower depths (East-Coral, Catfish, and Whidden) support fishes that are associated with seagrass beds and backwater marshes.

Table 4. Mean (SE in parentheses) physiochemical conditions and habitat metrics observed during 21-m seine sampling in five creek zones in the Cape Haze region (each zone, N=24).

	Creek zone				
Measurements	Lower-Coral	West-Coral	East-Coral	Catfish	Whidden
Temperature (°C)	26.63 (1.13)	27.00 (1.03)	26.61 (0.99)	25.96 (0.93)	25.43 (1.03)
Salinity (PSU)	30.62 (0.90)	28.46 (1.18)	25.71 (2.11)	34.31 (0.97)	31.45 (1.38)
Dissolved oxygen (mg/l)	4.47 (0.31)	4.77 (0.38)	4.39 (0.53)	4.46 (0.57)	3.45 (0.46)
Bag Depth (m)	0.89 (0.06)	0.52 (0.05)	0.45 (0.03)	0.59 (0.05)	0.61 (0.05)
Seagrass Cover (%)	24.79 (7.54)	3.96 (3.96)	77.71 (3.66)	26.04 (6.23)	21.67 (5.79)

Table 5. Results of a principal-component analysis with varimax rotation conducted on environmental data associated with nekton samples collected along the shoreline of Coral (Lower, West, and East), Catfish, and Whidden creeks (July 2014 – June 2015; 21-m seine). The analysis resolved five intercorrelated variables into two orthogonal components (PC 1-2) with eigenvalues > 1. The sign and magnitude of individual principal-component loadings indicates the strength and direction of the relationship between each variable and each principal component (text in bold italics denotes high variable loadings).

Variable	PC 1	PC 2
Temperature (°C)	**-0.53**	-0.04
Salinity (psu)	0.29	0.36
Dissolved oxygen (mg/l)	**0.53**	-0.01
Bag Depth (m)	-0.13	**0.53**
Seagrass Cover (%)	-0.06	**-0.56**

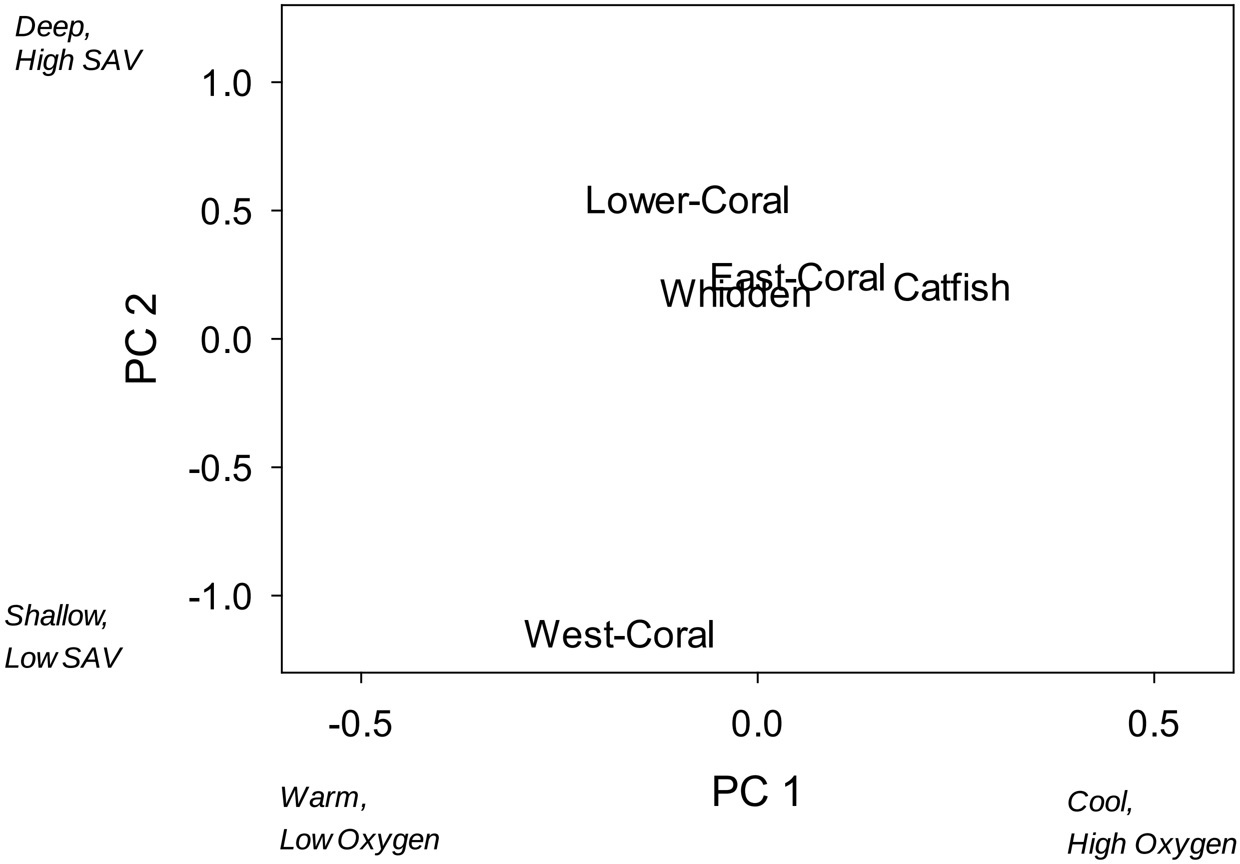

Figure 5. Average environmental conditions sampled along shoreline of Coral (Lower, West, and East), Catfish, and Whidden creeks (July 2014 – June 2015; 21-m seine) in three-dimensional principal-component (PC1 and PC2) space. Abbreviations are as follows: SAV = submerged aquatic vegetation, oxygen = dissolved oxygen.

Comparison of Cape Haze and upper Charlotte Harbor tidal creek fish communities

To put the fish communities of Coral Creek into a regional context, the Cape Haze tidal creek fish assemblage was compared to the upper Charlotte Harbor tidal creek fish assemblage that was sampled during the same time period (July 2014 – June 2015). The density of fish (total number fish/set) in the Cape Haze tidal creeks was four times that of tidal creeks in upper Charlotte Harbor (Figure 6). Fish assemblage structure greatly differed as well (ANOSIM R=0.71; P=0.001). Almost all species were more abundant in the Cape Haze tidal creeks except for Bay Anchovies *Anchoa mitchilli* and Striped Mojarra *Eugerres plumieri* (SIMPER; Figure 7). Several species were drastically more abundant in the Cape Haze tidal creeks. For example, two species of killifish, Rainwater Killifish *Lucania parva* and Goldspotted Killifish *Floridicthys carpio*, were eight times more abundant, and Pinfish and Pink Shrimp were three times more abundant in the Cape Haze tidal creeks.

The greater number of fish, and the assemblage differences, in the Cape Haze tidal creeks compared to the tidal creeks in upper Charlotte Harbor are most likely related to differences in seagrasses, creek morphology, and proximity of habitat to the Gulf of Mexico (Table 6). The tidal creeks sampled in upper Charlotte Harbor typically lack seagrass, are narrow, sinuous, and have consistent deep channelization (> 1 m) along outer bends. The ecology is likely driven by plankton and benthic microalgae as demonstrated by the prevalence of Bay Anchovy and Striped Mojarra. Both species do well in low-salinity habitats without seagrass (Greenwood et al. 2007, Stevens et al. 2013). Bay Anchovy diet is comprised of zooplankton (Pattillo et al. 1997) and the diet of mojarras is comprised of benthic microalgae and invertebrates (Pessanha and Araujo 2014). The three study creeks on the Cape Haze peninsula (Coral, Catfish, and Whidden) are uncommon in the Charlotte Harbor estuary, and along the southwest Gulf coast in general. They are wide and shallow systems (< 1 m; abundant seagrass) with fewer areas of deep channelization (> 1 m), and they are within close proximity of the Gulf of Mexico passes (<8 km). The ecology of these tidal creeks appears to be seagrass based, as demonstrated by the prevalence of Rainwater Killifish and Goldspotted Killifish. In subtropical Gulf estuaries, these species are abundant in *Halodule* and *Ruppia* seagrass beds close to the land margin (Poulakis et al. 2003). Juvenile Pinfish and Pink Shrimp are also abundant in seagrass beds (Poulakis et al. 2003). Because of the close proximity of the Cape Haze peninsula to Gulf passes, larvae from these offshore spawning species can recruit in larger numbers compared to seagrasses and other habitats farther from Gulf passes (Bell et al. 1988).

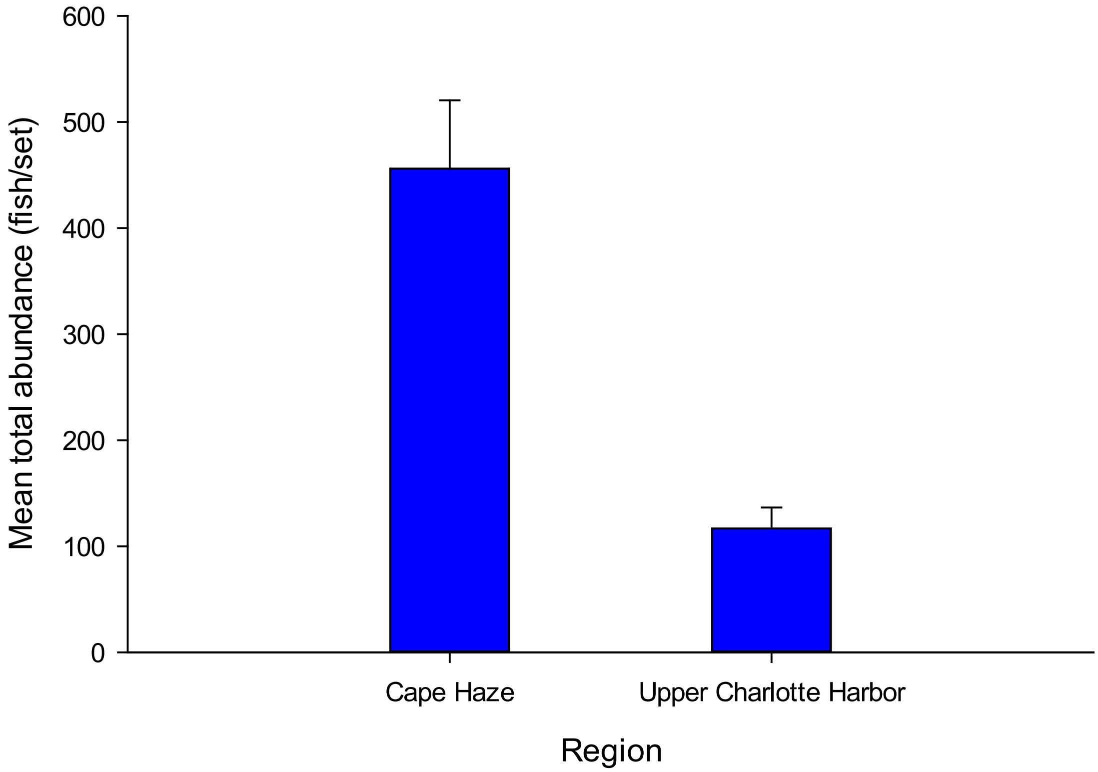

Figure 6. Mean (±SE) total fish densities in the tidal creeks of Cape Haze (Coral Creek, Catfish, and Whidden) compared to those of upper Charlotte Harbor (21-m seine collections). Fish assemblage structure differed as well (ANOSIM R=0.71; p=0.001).

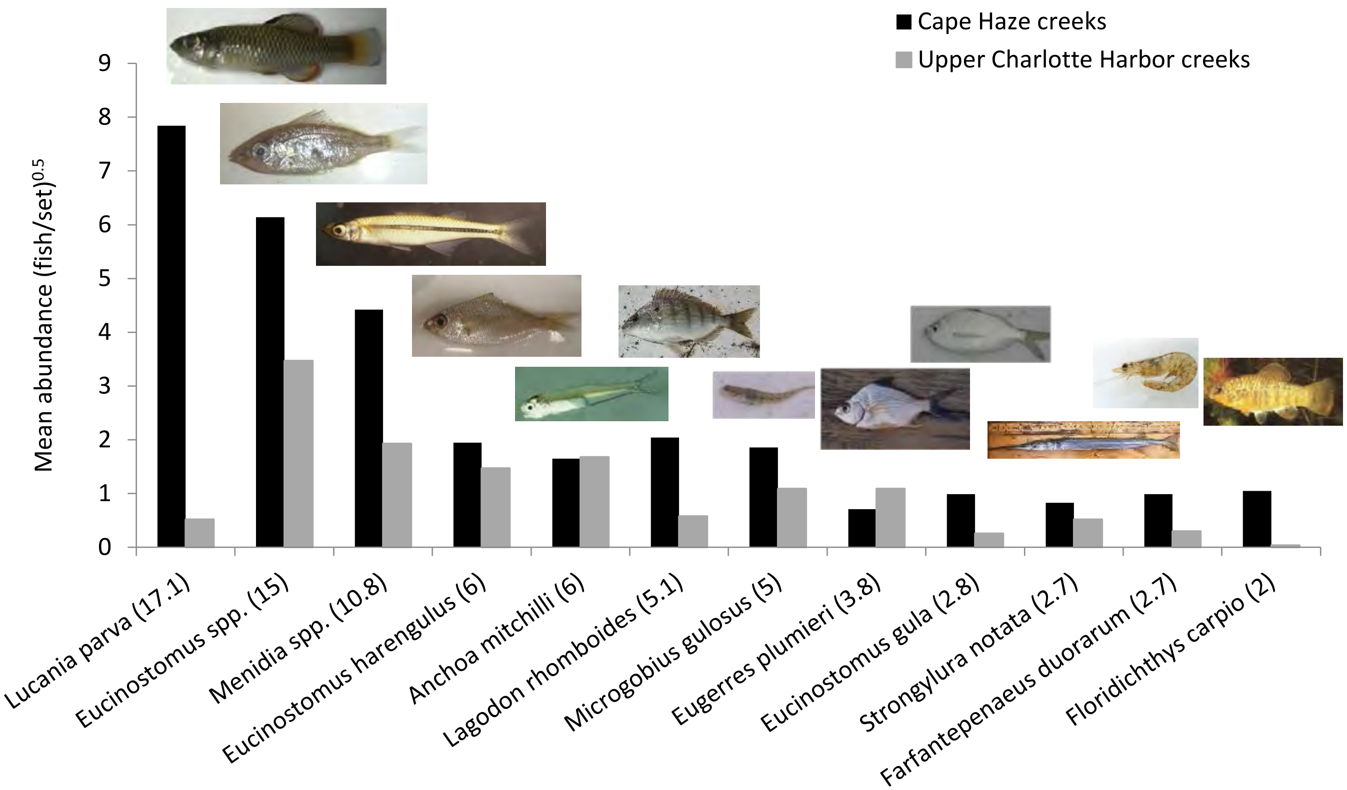

Figure 7. Fishes distinguishing the tidal creeks of Cape Haze (black bar) from those of upper Charlotte Harbor (gray bar). Abundance is the square root of average abundance (fish/set; 21-m seine) as output from SIMPER. The contribution of each species to the total average dissimilarity is shown in parentheses.

Table 6. Mean (SE in parentheses) physiochemical conditions and habitat metrics observed during 21-m seine sampling in creeks in two different regions of the Charlotte Harbor estuary (Cape Haze N=120, upper Charlotte Harbor N=156).

	Region	
Measurements	Cape Haze	Upper CH
Temperature (°C)	26.33 (0.45)	25.22 (0.37)
Salinity (PSU)	30.11 (0.66)	19.58 (0.52)
Dissolved oxygen (mg/l)	4.32 (0.21)	4.85 (0.16)
Bag Depth (m)	0.61 (0.03)	0.85 (0.02)
Seagrass Cover (%)	30.83 (3.36)	1.06 (0.64)

<u>Putting the tidal creeks of Cape Haze into context: creeks as iuvenile Common Snook habitat</u>

To put Cape Haze and upper Charlotte Harbor tidal creeks into context as critical fisheries habitat, the abundance of an economically important sport fish in both regions was compared. A popular sport fish that specialize in tidal creeks and small rivers as its juvenile nursery habitat is Common Snook. Adults spawn at Gulf of Mexico passes and the larvae and small juveniles recruit far into the land margin (Stevens et al. 2007). Remote habitat and low dissolved oxygen are thought to provide refuge from predators (Peterson and Gilmore 1991). Where major rivers are far from passes, tidal creeks and upstream coastal wetlands appear to represent a greater proportion of the juvenile Common Snook habitat. Conserving tidal creeks and maintaining conditions suitable for use by juvenile Common Snook is becoming recognized as a relevant management target in SW Florida (e.g., Numeric Nutrient Criteria). Four tidal creeks in upper Charlotte Harbor served as sites in several studies that closely examined the use of tidal creeks by Common Snook (Adams et al. 2009, Barbour and Adams 2012). In this study we found that the density of Common Snook in tidal creeks of Cape Haze was comparable to that of upper Charlotte Harbor (0.49 and 0.35 fish/set respectively; Figure 8).

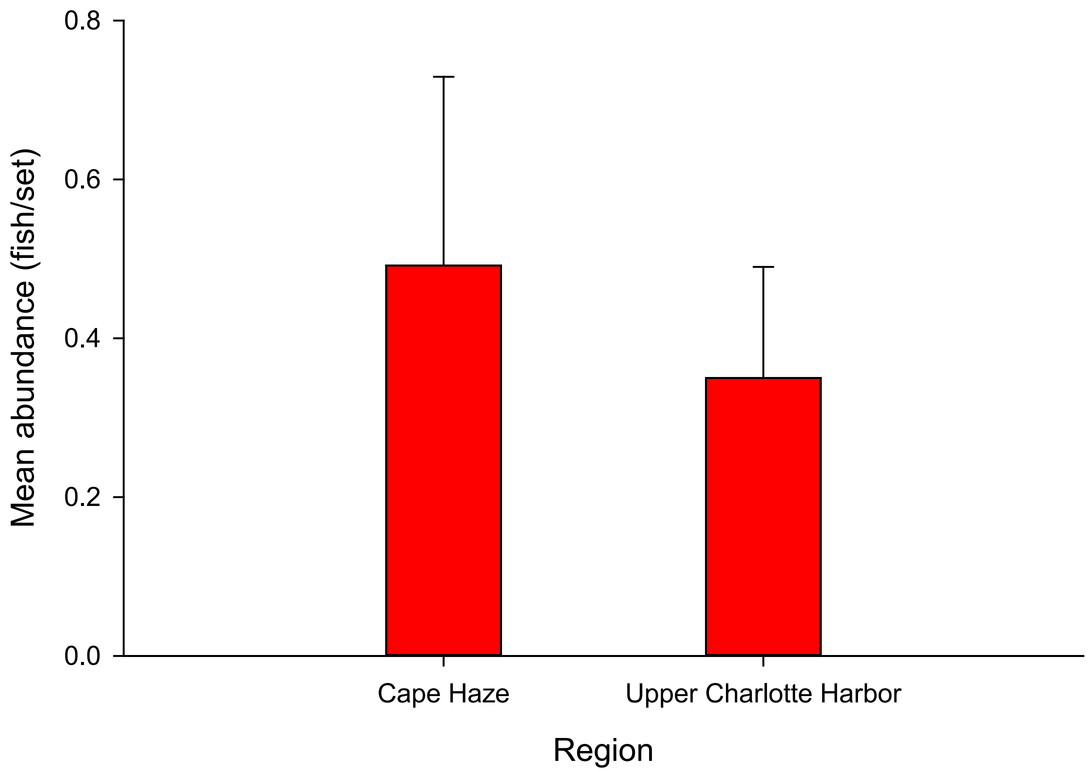

Figure 8. Mean (±SE) juvenile Common Snook (≤300 mm SL) densities in tidal creeks of Cape Haze (Coral, Catfish, and Whidden) compared to those of upper Charlotte Harbor (21-m seine collections).

CONCLUSIONS

In summary, the study evaluated the fishery communities of Coral Creek and two reference tidal creeks (Catfish and Whidden) on the Cape Haze peninsula prior to beginning hydrologic and habitat restoration activities in the Coral Creek watershed. The study results showed that the density of fish is high in the sampled tidal creeks in Cape Haze (4 times higher than tidal creeks in upper Charlotte Harbor) and composition of species is diverse and consistent with a seagrass-based ecosystem. In addition, the tidal creeks of Cape Haze support economically-important species. The habitat is particularly important for Common Snook; a species that specializes in the use of remote tidal creek systems and small rivers as its nursery habitat. The abundance of Common Snook in the Cape Haze tidal creeks is comparable to those of well-studied tidal creeks in upper Charlotte Harbor. A comparison of environmental conditions and fish assemblages of Cape Haze tidal creeks showed that the west branch of Coral Creek stood out as being different from the other branches of Coral Creek and Catfish and Whidden creeks. Although depths and salinities were presumably suitable for seagrasses, similar to the other Cape Haze tidal creeks, the fish assemblages of west Coral Creek were more similar to those of lower rivers and tidal creeks of upper Charlotte Harbor. It would be worthwhile to investigate the causes for a lack of seagrasses in the west branch of Coral Creek; there may be more opportunity to restore habitat and improve water conditions there, so that it supports seagrasses similar to other tidal creeks on the Cape Haze peninsula.

FUTURE DIRECTION

This study represents pre-restoration sampling of Coral Creek and benefitted greatly from a comparison at a broader context (two reference creeks and fish sampling in upper Charlotte Harbor). The goal is to repeat the study after restoration has occurred. This will allow for a pre and post restoration comparison. Such an analysis will help determine if project goals have been met. Restoration activities can sometimes have unforeseen consequences. In this case, it would be important to verify that Coral Creek continues to function as a high-quality nursery habitat for fishes after restoration has occurred. If this is not the case, the causes of alteration can be investigated and remedied. If the hydrologic restoration is successful, then similar activities can be conducted in other areas. For example, a need for hydrologic restoration has been identified on the nearby eastern shoreline of Charlotte Harbor (Charlotte Harbor Flatwoods Restoration). Tidal creeks have either been starved of their freshwater sources, or the delivery is flashy. Restoring a natural hydroperiod is known to be important for the tidal creek fauna (Adams et al. 2009; Walton et al. 2013) and the persistence of the tidal creek itself (ensuring it doesn't fill in over time as a result of flows that are too low, or wash out as a result of inflows that are too high). The success of the Coral Creek restoration can be applied to the Charlotte Harbor eastern shoreline.

We stress the importance of multi-year datasets in assessing fish communities. Conducting a study in only one year can lead to misleading results as disturbances have proven to be quite common (2004 Hurricane, 2005 red tide, 2007 severe drought, 2010 cold event, 2016 El Nino). Given the natural variability in fish recruitment and interannual variation in rainfall, it is very easy for any one year to be different from another. Locascio (2014) investigating tidal creeks in upper Charlotte Harbor concluded "The similarity between creeks during the post restoration project period may indicate that the effects of restoration are providing the intended purpose of restoring hydrology to natural overland sheet flow and creating a more balanced environmental gradient, but could also reflect that the limited duration of the post-restoration project period did not adequately capture inter or intra-annual cyclical variability." Coming to firm conclusions in a restoration context requires multiyear datasets. Because many restoration projects are planned in SW Florida, it is important to gauge the success of these projects to provide continual feedback into restoration design.

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