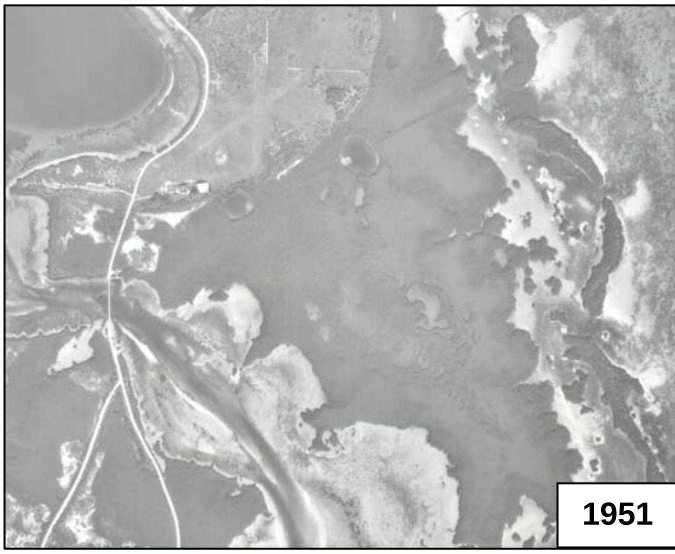
Wetland Habitat Use by the Nekton Community at Weedon Island County Preserve and Feather Sound: Summary of 2004 Data



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Introduction

Coastal wetlands are defined as those vegetated lands and associated intertidal features (e.g., creeks) that are alternatively flooded and drained by lunar tides. By this definition, a wetland extends from the upland interface with terrestrial systems to the low-tide interface with permanent subtidal waters (e.g., creeks, channels, tidal rivers, embayments, lagoons). For the purposes of this report, we consider those small, primarily subtidal, linear (creeks, mosquito-control ditches, stormwater-conveyance ditches) and circular features (ponds) nested within the wetland landscape to be functional parts of the wetland.

Saltmarsh and mangrove wetlands provide habitat for numerous species of estuarine fishes and invertebrates, many of which are ecologically or economically valuable (Kneib 1997; Laegdsgaard and Johnson 1995). Anthropogenic alteration of wetlands is visibly evident along the Gulf Coast of Florida, in the form of dredged channels, spoil mounds, and water-control structures. The ecological consequences of such habitat alteration, however, are not always as apparent. Understanding the fundamental differences between natural and altered wetlands, and how faunal assemblages vary between habitats, is necessary to evaluate the effects of alteration on the ecology of the system. In an effort to repair the effects of wetland disturbance, restoration and creation of wetland habitats have become more-widespread management tools during the last decade. However, the creation of a functional wetland system proves to be much more of a challenge than simply creating wetland structure (i.e., tidal creeks, ponds, salt barrens). A thorough understanding of faunal ecology, including that of the nekton communities (i.e., fishes, pink shrimp, blue crabs) that utilize wetland habitats, is necessary for the successful creation of a functional wetland.

Many of the Tampa Bay wetlands have been subject to dredge-and-fill activities since the mid-1900s. Current wetland-restoration plans in the bay seek to restore areas that have been modified for mosquito control, stormwater conveyance, and agriculture. However, hydrologic changes induced by these restoration efforts may affect biotic components such as fish communities. Because little is known of the composition and structure of nekton communities in the shallow wetland habitats of Tampa Bay, fish-community data will provide a useful baseline to assist resource managers with pre-restoration planning and post-restoration assessment.

Wetland-associated nekton communities are composed of a variety of fishes that can be grouped by their use of the estuary based on life-history strategy (Nordlie, 2003). Those fish that utilize the estuary for their entire life cycle are considered permanent residents. In contrast, those species that use the estuary only during a specific life stage are considered transients, of which there are two classes: those that use the estuary during the juvenile stage (marine nursery species), and those that use the estuary as subadults or adults (marine transients). Transient species can be distinguished as those that are of recreational or commercial importance (e.g., snook, *Centropomus undecimalis*, and red drum, *Sciaenops ocellatus*) and those non-recreational species that provide a forage base for larger fishes and piscivorous birds.

To assess fish-community response to habitat alteration and to provide baseline community conditions from which to plan and assess wetland-restoration projects, we initiated a three-year nekton sampling program in Tampa Bay wetlands. Project objectives were to: 1) characterize the species composition and abundance of the wetland nekton community, 2) assess temporal trends (seasonal and annual) in the utilization of wetland habitats by nekton, and 3) determine the spatial use of natural and altered habitats by nekton.

Methods

Baywide experimental design

Three wetland regions along a north/south axis within Tampa Bay were chosen for study (Fig. 1), within which creek, ditch, and pond sites were established. Each sample region was located within a County or State Preserve (Mobbly Bayou, Weedon Island/Feather Sound, and Terra Ceia). These particular wetland preserves were selected for study because of proposed restoration plans in the areas and thus the need for pre-restoration data. Regions were sampled seasonally (i.e., every third month; n=4 seasons) from December 2003 through November 2004 and will continue to be sampled through 2006. Sample sites were chosen using a pragmatic stratified random design in which suitable habitat types were first delineated within a particular wetland, and points were randomly generated within these habitats. Then fixed sites were installed as close as possible to the random point, while avoiding areas of heavy vegetative structure that would prevent efficient and standardized gear deployment and retrieval. This

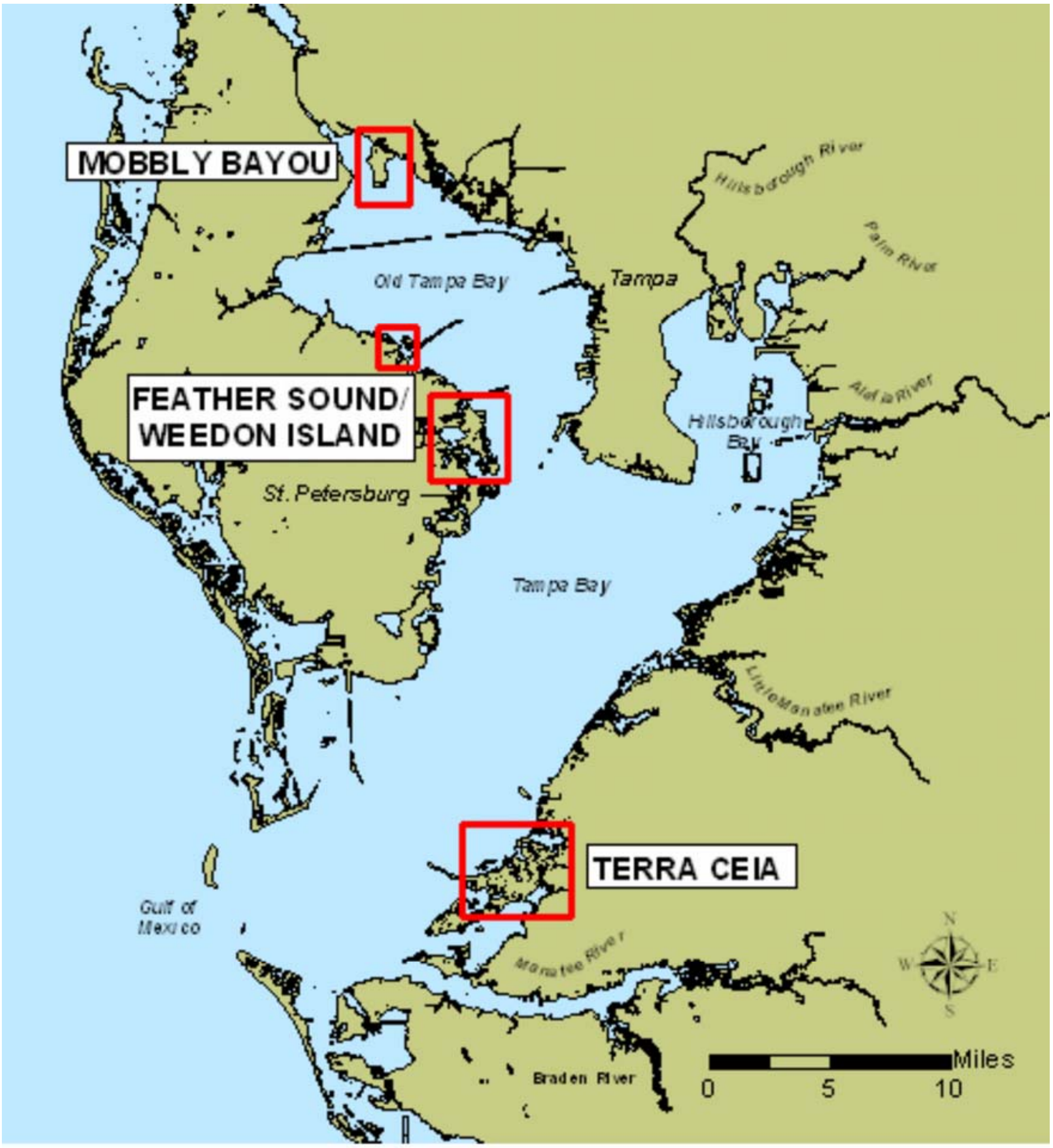

Figure 1. The three wetland regions chosen for sampling in Tampa Bay, FL.

document will report the findings from the first year of data collected from the middle of Tampa Bay at Weedon Island and Feather Sound.

Sample design at Weedon Island and Feather Sound

At Weedon Island/Feather Sound, we sampled fishes, and macro-invertebrates (pink shrimp and blue crabs only) in a natural tidal creek (Grassy Creek), a wetland altered by man-made mosquito-control ditches (Weedon Island County Preserve), and two wetland ponds located within the mosquito-ditched wetlands (Fig. 2). Grassy Creek retains the same large-scale geomorphology it exhibited prior to mosquito-control ditching in this area (USGS, unpublished data). The creek is modified, however, in that it is now intersected by mosquito ditches that criss-cross its course. Six sample sites along Grassy Creek were chosen randomly from upstream to the mouth of the creek where it enters Feather Sound. Ten sample sites were established in mosquito-control ditches at Weedon Island County Preserve and were classified into one of three primary categories (canoe trail, interior, or perimeter) based on their spatial configuration. Perimeter sites were located along a boundary ditch that bordered the upland portion of the preserve, and the canoe-trail sites were located along a series of ditches maintained for canoe and kayak recreation. The interior sites were more removed from the others and were located toward the center of the mosquito-grid complex. In addition, two wetland karst ponds with tidal connections to both sides of the Weedon Island peninsula were also selected for study, and three randomly selected replicate sites were sampled within each pond every season. Samples were taken in each habitat during four seasons (winter-February, spring-May, summer-August, and fall-November). As a result of the differences in sample methods, pond samples could not be directly compared with creek and ditch samples and were treated separately.

Sampling methodology

Sample sites in each of the habitats within the preserve were characterized by documenting substrate type, substrate depth, water depth, shoreline vegetation, and bottom vegetation. Additionally, channel width, bottom profile, and current velocity at time of sampling were recorded for creek and ditch sites. Water-quality measurements of temperature, salinity, dissolved oxygen, and pH were also taken at

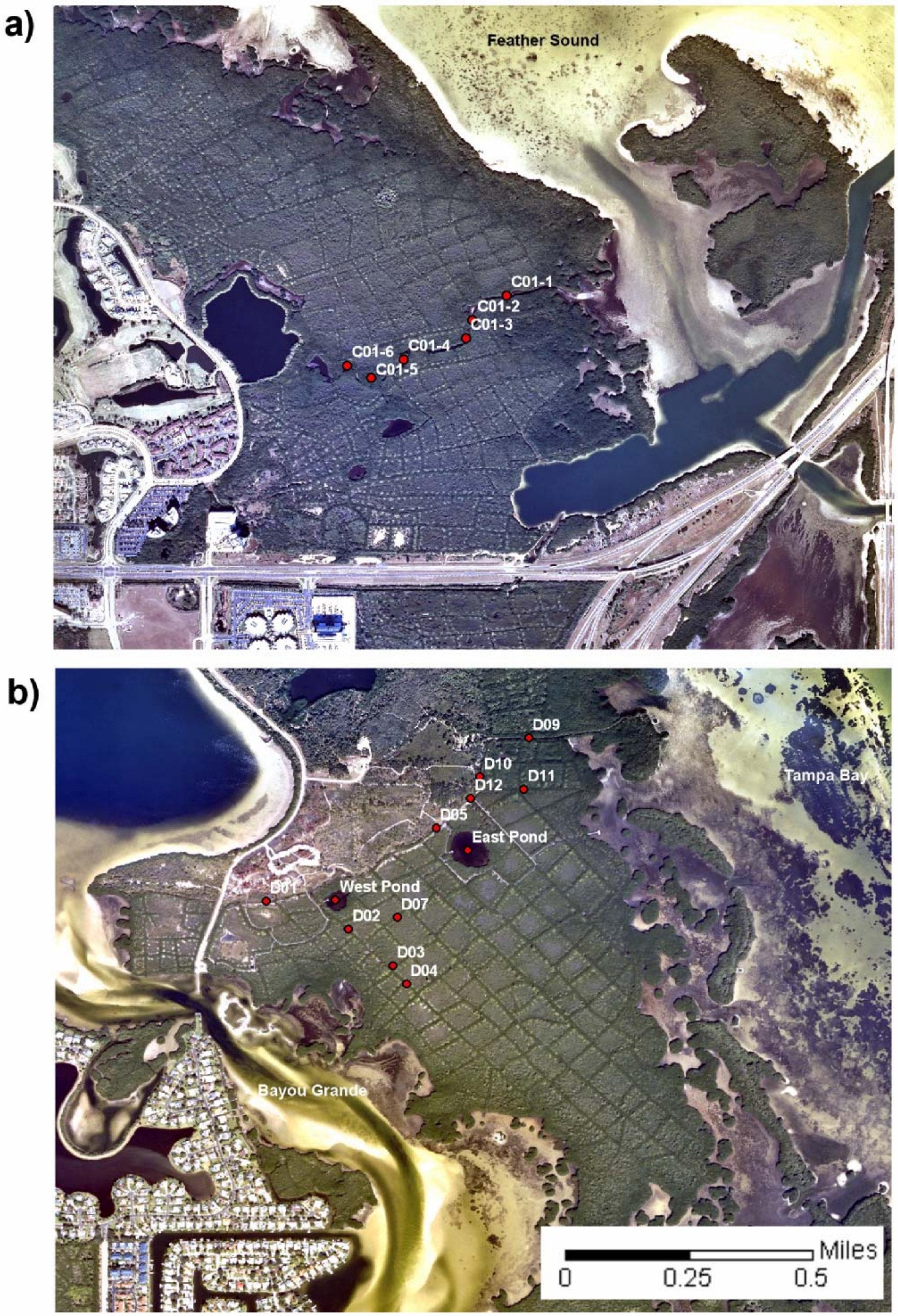

Figure 2. Location of sample sites at a) Grassy Creek in Feather Sound and b) the mosquito-ditched wetlands at Weedon Island County Preserve, Tampa Bay, Florida, 2004. Grassy Creek is located approximately 5 miles north of the Weedon Island preserve. U.S. Geological Survey 2002 aerial photographs.

each site during each sample using a YSI 556 MPS unit. Creek and ditch sites were sampled by isolating a 9-m long section of the habitat using two block nets (3-mm mesh) and then seining through the site using a center-bag haul seine (5 m x 1.2 m, 10 m x 1.2 m, or 15 m x 1.2 m, with 3-mm mesh) stretched from bank to bank (Fig. 3). Three hauls were made at each site, and each haul was processed individually using the depletion method (Zippin, 1958) to examine species-specific gear-avoidance tendencies and to estimate the percentage of nekton collected at each site. Size of block nets (5 m, 6 m, 10 m, 12 m, or 15 m) and haul seines was dependent on the width of the creek or ditch being sampled.

Unlike creeks and ditches, wetland ponds lack the stream banks that facilitate the use of block nets to isolate the sample site, so they were sampled using the State of Florida's Fisheries-Independent Monitoring Program's offshore seine technique (Fisheries-Independent Monitoring Program Procedure Manual, 2004). Each sample (regardless of habitat type) was processed in the field by identifying and enumerating fishes and decapod crustacean species collected in replicate seine samples. Up to 20 individuals of each species were measured to the nearest 1-mm standard length (fishes), carapace width (blue crabs), or post-orbital carapace length (pink shrimp) and released alive when possible.

Data analysis

A variety of methods was used to calculate measures of nekton-community structure. Nekton density was calculated as number of individuals per 100 m^2 to standardize catch data from sample sites of different sizes. Species richness was calculated using Margalef's index of richness represented by the formula $d = (S-1)/\log N$, where S equals the number of species present and N represents the total number of individuals collected. Simpson's diversity index (D) was calculated as $1-D = 1-[\Sigma(n/N)^2]$, where n equals the number of individuals of a certain species and N equals the total number of individuals for all species combined. Non-metric multidimensional scaling (MDS) from PRIMER v5 (Clarke and Warwick, 2001) was used to examine the association of nekton assemblages (species densities averaged by site) with sampled habitat types. Sample similarity (based on species density) was also plotted by site and season using MDS to assess seasonal trends in the wetland-associated nekton assemblages in creek and mosquito-ditched habitats. Using MDS, samples with nekton assemblages having similar species composition and abundances were grouped more closely in two-dimensional space than those samples that were less similar. Relegating a multidimensional dataset to two-dimensional space imposes a "stress," which

Figure 3. Nekton sampling method used in the tidal creek and mosquito-ditched habitats at Weedon Island and Feather Sound, Tampa Bay, FL. Notice the densely structured vegetation associated with this mosquito-ditch site.

typically distorts the true multidimensional relationships between samples (i.e., two samples appear to be similar based on spatial proximity when in fact they are not). Stress values (included with each MDS plot) are deemed acceptable at a level of ≤0.2 (Clarke and Warwick 2001). Differences in community structure between creek and mosquito-ditch samples were tested using the Analysis of Similarity (ANOSIM) routine from PRIMER, a non-parametric test analogous to Analysis of Variance (ANOVA).

Results and Discussion

Wetland-habitat characterization

Physical characteristics of wetland sample sites at Weedon Island and Feather Sound differed between creek and mosquito-ditched habitats. In general, creek sites were wider, with deeper water and greater current velocity than mosquito-ditch sites (Table 1). Mosquito-ditch sites, on average, had greater substrate deposition (0.13 m substrate depth) than creek sites (0.04 m). Total area sampled was relatively similar between creek (503.1 m^2) and mosquito-ditched habitats (413.1 m^2). However, because there were more mosquito-ditch sites than creek sites, the mean area of Grassy Creek sample sites (83.8 m^2) was twice that of the mosquito-ditch sites (41.3 m^2). Sample sites within Grassy Creek varied in mean width and relative water depth though all sites received noticeable current from both tides and upstream freshwater discharge. Freshwater may also enter the creek through one or more of the mosquito ditches, which intersect the creek along its length.

Habitat conditions in both wetland ponds at Weedon Island were comparable (Table 1), despite the noticeably larger size of East Pond (Fig. 3). The red-mangrove-dominated shorelines, patchy distribution of widgeon grass (*Ruppia maritima*) and mud-sand substrate provided similar habitat characteristics in both ponds. East Pond was connected to Tampa Bay via several mosquito ditches to the east and to West Pond by a mosquito ditch maintained for canoe-trail access to the west. A series of mosquito ditches (also maintained for canoe-trail access) connected West Pond with Bayou Grande to the west (Fig. 3). Tidal exchange with Tampa Bay was observed in East Pond through several mosquito ditches. Similar exchange (based on current velocity in adjoining ditches) in West Pond seemed to be more limited. Water depths in East Pond were consistently greater relative to West Pond by up to 0.2 m.

Table 1. Physical characteristics of wetland sample sites at Weedon Island and Feather Sound at time of sampling. Sample size (n) is equal to the number of sites sampled each season. Ranges are in parentheses below mean values.

	Site type			
	Creek	Ditches	Ponds	
Measure	Grassy Creek (n=6)	Mosquito Ditches (n=10)	East Pond (n=3)	West Pond (n=3)
Mean area (m^2)	83.8 (60.4-119.5)	41.3 (23.6-50.9)	60.6 (60.6)	60.6 (60.6)
Mean width (m)	9.2 (6.6-13.1)	4.5 (2.6-5.6)	-	-
Mean water depth (m)	0.64 (0.2-1.0)	0.44 (0.0-0.7)	0.76 (0.4-1.0)	0.64 (0.5-0.8)
Mean current velocity (m/s)	0.12 (0.00-0.33)	0.07 (0.00-0.22)	-	-
Mean substrate depth (m)	0.04 (0.0-0.2)	0.13 (0.0-0.4)	0.04 (0.00-0.10)	0.03 (0.00-0.05)

Water-quality characterization

Mean water-quality parameters varied between seasonal sampling events (Table 2). Mean water temperature was similar between Grassy Creek and the mosquito ditches at Weedon Island, though warmer water temperatures were frequently recorded in the mosquito ditches. Salinity was notably higher in the mosquito ditches, due to limited freshwater influx there. Maximum salinities at Grassy Creek were often less than or similar to minimum salinities in the mosquito ditches. Spring salinity measurements at Grassy Creek ranged from 0.2 to 26.4 ppt. Freshwater pulses from a mosquito ditch which connects the creek to an upstream freshwater retention pond may have been responsible for the observed salinities of 0.2, 0.4, and 1.7 ppt at C01-1, C01-2, and C01-4, respectively.

Water-quality conditions were similar between East and West Ponds (Table 2), except during the summer season, when the ponds were sampled a week apart. Low-salinity values measured during spring in East Pond (1.7 ppt) and West Pond (0.2 ppt) were considerably lower than concurrent salinity measurements of 26-27 ppt at sites within 20 m. Groundwater intrusion may explain these observations. Mean water temperatures were similar between ponds during each season, although temperatures were higher during the spring and summer (28.6ºC) compared to the fall and winter (22.0ºC).

Nekton assemblages at Weedon Island and Feather Sound

Year-one sampling yielded data from 24 Grassy Creek samples, 39 mosquito-ditch samples (one fall sample not taken) and 24 pond samples. In all, 39,023 fishes, pink shrimp, and blue crabs were collected from 36 different taxa (Tables 3 and 4). The 10 most abundant species accounted for 94% of the total number of fishes collected. Abundant residents from the family Cyprinodontidae (seven species of killifishes) and Poeciliidae (two species of livebearers), composed 78% of the overall community (Table 3, life-history strategies after Nordlie 2003 except for *Gambusia holbrooki*). Silverside (*Menidia* spp.), a common nursery transient, and two species of economic value, spot (*Leiostomus xanthurus*) and blue crab (*Callinectes sapidus*), accounted for the additional 16% of the catch. Twelve transient species of recreational or commercial importance were collected, composing 7% of the total catch. Three species contributed the largest proportion of the recreational assemblage (81%), including *L. xanthurus*, *C. sapidus*, and red drum (*Sciaenops ocellatus)*. Several other important recreational species were also collected, including (in order of decreasing abundance) pink shrimp (*Farfantepenaeus duorarum*), mullet

Table 2. Mean water quality by habitat type at Weedon Island and Feather Sound, Tampa Bay, FL (2004). Sample size (n) is equal to the number of sites sampled each season. Values were averaged across sites within each habitat. Ranges are in parentheses following mean values.

		Season								Annual
Habitat type	**Mean**	**Winter**		**Spring**		**Summer**		**Fall**		**2004**
Creek										
Grassy Creek	Temperature (°C)	**22.0**	(19.5-25.1)	**24.6**	(23.8-25.5)	**29.3**	(27.2-33.1)	**20.1**	(18.9-21.1)	**24.0**
(n=6)	Salinity (ppt)	**21.5**	(21.3-21.7)	**14.0**	(0.2-26.4)	**14.9**	(13.7-16.4)	**16.7**	(16.3-17.7)	**16.8**
	Dissolved oxygen (mg/L)	**4.41**	(1.53-12.30)	**1.50**	(1.14-1.83)	**2.21**	(1.20-4.30)	**6.91**	(3.06-16.23)	**3.76**
Ditches										
Mosquito ditches	Temperature (°C)	**20.9**	(16.6-27.4)	**25.2**	(22.4-31.5)	**30.2**	(26.8-35.3)	**22.6**	(21.2-25.5)	**24.7**
(n=10)	Salinity (ppt)	**24.4**	(22.1-25.6)	**27.4**	(26.2-28.5)	**19.0**	(14.7-21.8)	**21.1**	(19.8-22.6)	**23.0**
	Dissolved oxygen (mg/L)	**8.49**	(1.70-16.13)	**2.91**	(0.88-6.17)	**3.19**	(0.71-8.46)	**2.62**	(1.40-4.68)	**4.30**
Ponds										
East Pond	Temperature (°C)	**23.2**	(23.0-23.3)	**27.6**	(27.3-28.0)	**29.1**	(28.8-29.4)	**20.5**	(20.2-20.8)	**25.1**
(n=3)	Salinity (ppt)	**25.0**	(25.0-25.0)	**18.8**	(1.7-27.5)	**21.0**	(20.8-21.1)	**20.0**	(19.9-20.1)	**21.2**
	Dissolved oxygen (mg/L)	**10.25**	(10.24-10.26)	**2.42**	(1.82-3.10)	**3.90**	(2.70-4.95)	**5.51**	(5.32-5.80)	**5.52**
West Pond	Temperature (°C)	**22.9**	(22.9-23.0)	**29.0**	(28.7-29.1)	**28.4**	(27.7-29.1)	**21.7**	(21.5-21.8)	**25.5**
(n=3)	Salinity (ppt)	**25.1**	(25.0-25.1)	**17.7**	(0.2-26.5)	**11.1**	(10.7-11.8)	**20.0**	(19.9-20.0)	**18.5**
	Dissolved oxygen (mg/L)	**12.77**	(10.55-13.95)	**4.39**	(3.62-5.41)	**2.21**	(1.84-2.86)	**5.29**	(5.04-5.58)	**6.16**

Table 3. Comparison of mean ± Standard Error (S.E.) species density (nekton/100 m^2) in a tidal creek and mosquito-ditched wetland at Weedon Island, Tampa Bay, FL (2004). Abundance values were averaged across four sample seasons. Sample size (n) is equal to the number of sites sampled each season.

Species				Habitat		
Family	**Scientific name**	**Common name**	**Strategy***	**Creek (n=6)**	**Ditch (n=10)**	**Annual 2004**
Achiridae	*Achirus lineatus*	Lined sole	Marine nursery	2.9±1.0	2.9±1.0	2.9±0.7
	Trinectes maculatus	Hogchoker	Marine nursery	3.0±1.2	0	1.1±0.5
Atherinidae	*Menidia* spp.	Silverside	Marine nursery	71.0±33.4	42.7±13.4	53.3±15.0
Batrachoididae	*Opsanus beta*	Gulf toadfish	Marine transient	1.7±0.8	4.6±2.3	3.5±1.5
Blenniidae	*Blenniidae*	Unidentified blenny	Marine transient	0	<0.1	0
Centropomidae	*Centropomus undecimalis*	Common snook	Marine nursery	0.8±0.5	0.6±0.4	0.7±0.3
Cichlidae	Cichlidae	Unidentified cichlid	Freshwater transient	<0.1	<0.1	<0.1
Cyprinodontidae	*Adinia xenica*	Diamond killifish	Permanent resident	48.8±16.9	57.1±21.6	54.0±14.9
	Cyprinodon variegatus	Sheepshead minnow	Permanent resident	8.8±4.6	90.0±42.8	59.6±27.1
	Floridichthys carpio	Goldspotted killifish	Permanent resident	1.1±0.4	2.0±0.9	1.7±0.6
	Fundulus confluentus	Marsh killifish	Permanent resident	5.2±1.3	4.4±1.4	4.7±1.0
	Fundulus grandis	Gulf killifish	Permanent resident	14.3±4.7	26.4±7.5	21.9±5.0
	Fundulus majalis	Striped killifish	Permanent resident	0.3±0.2	12.3±4.8	7.8±3.0
	Fundulus spp.	Killifish	Permanent resident	3.2±1.0	17.5±11.6	12.1±7.3
	Lucania parva	Rainwater killifish	Permanent resident	186.8±76.0	192.9±54.3	190.6±44.0
Gerreidae	*Diapterus plumieri*	Striped mojarra	Marine nursery	0.9±0.7	2.4±1.7	1.9±1.1
	Eucinostomus harengulus	Tidewater mojarra	Marine transient	0.3±0.2	1.6±0.8	1.1±0.5
	Eucinostomus spp.	Mojarra	Marine transient	0.7±0.5	0.8±0.4	0.8±0.3
Gobiidae	*Gobiosoma* spp.	Goby	Marine transient	7.9±4.2	0.4±0.3	3.2±1.6
	Microgobius gulosus	Clown goby	Permanent resident	5.0±2.3	4.0±1.4	4.4±1.2
Lutjanidae	*Lutjanus griseus*	Gray snapper	Marine transient	1.2±0.6	0.3±0.2	0.6±0.3
Mugilidae	*Mugil* spp.	Mullet	Marine nursery	0.2±0.2	4.5±2.6	2.9±1.6
Penaeidae	*Farfantepenaeus duorarum*	Pink shrimp	Marine nursery	4.1±1.8	3.4±1.5	3.7±1.1
Poeciliidae	*Gambusia holbrooki*	Eastern mosquitofish	Permanent resident	82.9±31.2	184.3±32.4	146.3±24.0
	Poecilia latipinna	Sailfin molly	Permanent resident	72.9±27.0	301.4±71.6	215.7±47.7
Portunidae	*Callinectes sapidus*	Blue crab	Marine nursery	10.1±2.3	10.4±2.6	10.3±1.8
Rivulidae	*Rivulus marmoratus*	Mangrove rivulus	Permanent resident	0	<0.1	0.1±0.1
Sciaenidae	*Cynoscion nebulosus*	Spotted seatrout	Marine nursery	0.4±0.1	0	0.1±0.1
	Leiostomus xanthurus	Spot	Marine nursery	51.5±22.7	23.0±13.6	33.7±12.0
	Pogonias cromis	Black drum	Marine nursery	0.3±0.2	1.4±0.9	1.0±0.6
	Sciaenops ocellatus	Red drum	Marine nursery	3.2±1.0	4.4±1.6	4.0±1.1
Sparidae	*Archosargus probatocephalus*	Sheepshead	Marine transient	0.4±0.2	0.2±0.1	0.2±0.1
	Lagodon rhomboides	Pinfish	Marine transient	13.0±5.6	1.4±0.8	5.7±2.2
Syngnathidae	*Syngnathus scovelli*	Gulf pipefish	Marine transient	0.4±0.3	0	0.1±0.1

Species in gray are of recreational and/or commercial fishery value in Florida.

*Life history strategies are based on Nordlie 2003

Table 4. Mean ± S.E. nekton abundance (number/100 m^2) in wetland ponds at Weedon Island, Tampa Bay, FL. Sample size (n) is equal to the number of samples taken during 2004. Three random samples were collected in each pond during four seasons.

Species			Pond		Annual
Family	Scientific name	Common name	West (P01) (n=12)	East (P02) (n=12)	2004.0 (n=24)
Achiridae	Achirus lineatus	Lined sole	0	<0.1	<0.1
Atherinidae	*Menidia* spp.	Silverside	255.0±64.1	106.6±66.8	180.8
Cyprinodontidae	*Cyprinodon variegatus*	Sheepshead minnow	25.2±16.2	0	11.9
	Fundulus grandis	Gulf killifish	2.8±2.2	<0.1	1.4
	Fundulus majalis	Longnose killifish	1.1±1.1	0	0.6
	Lucania parva	Rainwater killifish	403.7±137.9	25.4±15.0	214.3
Engraulidae	*Anchoa mitchilli*	Bay anchovy	0.3±0.3	<0.1	0.2
Gerreidae	*Diapterus plumieri*	Striped mojarra	0	0.4±0.4	0.2
	Eucinostomus harengulus	Tidewater mojarra	1.0±0.5	1.4±1.4	1.2
	Eucinostomus spp.	Mojarra	0.6±0.4	18.8±9.1	9.7
Gobiidae	*Microgobius gulosus*	Clown goby	5.2±1.8	13.2±5.5	9.2
Mugilidae	*Mugil* spp.	Mullet	10.2±8.7	0.4±0.4	5.3
	Mugil cephalus	Striped mullet	5.0±5.0	0	2.5
Penaeidae	*Farfantepenaeus duorarum*	Pink shrimp	0	<0.1	<0.1
Poeciliidae	*Gambusia holbrooki*	Eastern mosquitofish	25.7±14.3	2.5±2.3	14.1
	Poecilia latipinna	Sailfin molly	388.2±265.4	0.3±0.3	194.2
Portunidae	*Callinectes sapidus*	Blue crab	0.3±0.2	2.8±1.9	1.5
Sciaenidae	*Leiostomus xanthurus*	Spot	22.6±13.3	42.6±21.5	32.6
	Pogonias cromis	Black drum	0	0.3±0.3	0.1
	Sciaenops ocellatus	Red drum	12.4±9.5	4.0±3.3	8.2
Sparidae	*Archosargus probatocephalus*	Sheepshead	0.3±0.3	0.3±0.2	0.3
	Lagodon rhomboides	Pinfish	0.3±0.2	0.6±0.6	0.4
Syngnathidae	*Syngnathus scovelli*	Gulf pipefish	0	1.1±0.6	0.4

Species in gray are of recreational and/or commercial fishery value in Florida.

(*Mugil* spp., *M. cephalus*), black drum (*Pogonias cromis*), snook (*Centropomus undecimalis*), gray snapper (*Lutjanus griseus*), sheepshead (*Archosargus probatocephalus*), and spotted seatrout (*Cynoscion nebulosus*). However, these latter species contributed a lesser combined percentage (16%) to the recreational assemblage.

Comparison of nekton assemblages in creek versus ditch habitats

Although we expected differences in the composition of nekton assemblages between natural tidal creek and mosquito-ditched wetland habitats, nekton structure was similar in Weedon Island ditches and Grassy Creek in a number of respects, including number of taxa, dominant species, species richness, and species diversity. Thirty-two taxa of nekton were collected in creek sites, and 31 taxa were collected in ditch sites (Table 3). Only four taxa were unique to a habitat, and those four were rarely collected. Species composition was similar as eight of the 10 most abundant species appeared in both habitats with rank differences (Fig. 4). Three of the four most abundant species in both habitats were rainwater killifish (*Lucania parva*), sailfin molly (*Poecilia latipinna*), and mosquitofish (*Gambusia holbrooki*), accounting for 68% of the creek assemblage and 57% of the ditch assemblage. *Menidia* spp., the second most abundant species of the creek assemblage, was in much lower abundance in the mosquito-ditch sites. Although annual nekton density was greater in ditch sites, species richness and diversity were similar between the two habitats (Table 5). Furthermore, community structure did not differ statistically between creek and ditch habitats (ANOSIM; p=0.068), although nekton assemblages in some ditch sites (i.e., D02, D09, D10, and D11) were considerably more similar to the creek assemblage (Fig. 5) than those of other ditch sites (i.e. D01, D03, D04, D07, and D12). Similarities between nekton in creek and ditch habitats may be related to the direct connection between Grassy Creek and the complex of mosquito-control ditches that surrounds it. Nekton at Grassy Creek are undoubtedly moving between creek and ditch habitats, thus explaining the similarities in species composition between habitats. The recreational assemblage was similar between creek and ditch habitats since 10 of 11 recreationally important taxa were collected in both habitats. Five species, including *C. sapidus*, *S. ocellatus*, *F. duorarum*, *C. undecimalis*, and *A. probatocephalus,* were equally abundant in samples from both habitats, while *Mugil spp*., *Diapterus plumieri,* and *P. cromis* were typically more abundant in the mosquito ditches (Table 3). *Callinectes sapidus* and *L. xanthurus* dominated the recreational assemblage in both habitats.

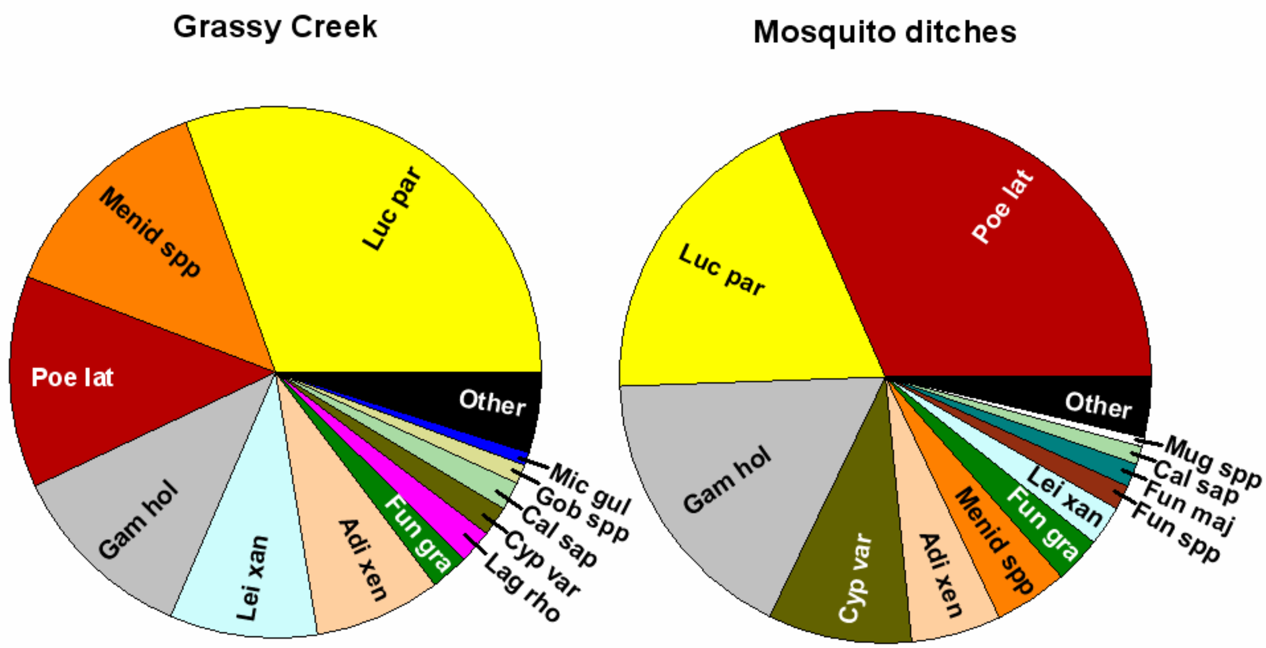

Figure 4. Species composition of nekton assemblages in a tidal-creek and mosquito-ditched wetland in Tampa Bay. Grassy Creek (n=6) and the mosquito ditches at Weedon Island (n=10) were sampled seasonally (i.e., winter-February, spring-May, summer-August, fall-November) during 2004.

Luc par=*Lucania parva*
Menid spp=*Menidia* spp
Poe lat=*Poecilia latipinna*
Gam hol=*Gambusia holbrooki*
Lei xan=*Leiostomus xanthurus*
Adi xen=*Adinia xenica*
Fun gra=*Fundulus grandis*
Lag rho=*Lagodon rhomboides*
Cyp var=*Cyprinodon variegatus*
Cal sap=*Callinectes sapidus*
Gob spp=*Gobiosoma* spp
Mic gul=*Microgobius gulosus*
Fun spp=*Fundulus* spp
Fun maj=*Fundulus majalis*
Mug spp=*Mugil* spp
Other=20, 19 taxa

Table 5. Measures of nekton community structure by season and wetland habitat at Weedon Island and Feather Sound, Tampa Bay, FL (2004).

		Season				Annual
Habitat	**Measure**	**Winter**	**Spring**	**Summer**	**Fall**	**2004**
Grassy Creek	Density (fish/100m^2)	431.77	185.58	1316.52	479.87	**603.44**
	Richness*	7.45	7.43	4.19	6.13	**8.06**
	Diversity**	0.79	0.81	0.69	0.70	**0.84**
Mosquito Ditches	Density (fish/100m^2)	822.97	531.18	1829.25	813.19	**999.15**
	Richness*	6.83	6.91	4.37	6.21	**7.82**
	Diversity**	0.87	0.81	0.78	0.77	**0.82**
Ponds	Density (fish/100m^2)	490.92	1455.72	654.84	159.79	**690.32**
	Richness*	4.61	4.30	3.26	1.81	**5.50**
	Diversity**	0.78	0.63	0.51	0.30	**0.75**

*** Margalef's Index of Species Richness**
**** Simpson Diversity Index**

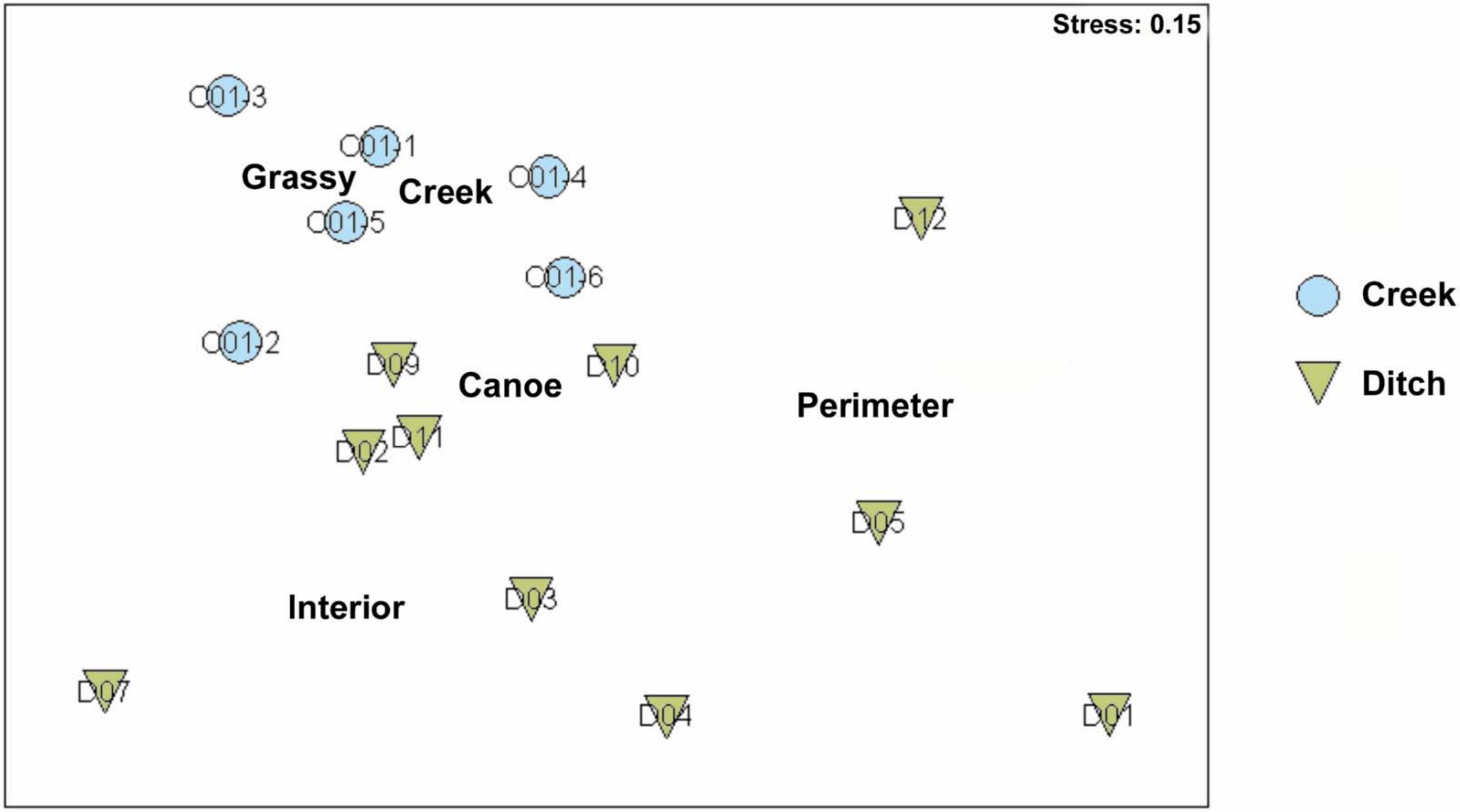

Figure 5. MDS plot showing the similarity of tidal-creek and mosquito-ditch sample sites based on species composition and abundance of nekton at Weedon Island County Preserve, 2004. Each point represents the average of four seasonal samples. Grassy Creek = creek sites; Canoe = sites on or similar to the canoe trail; Perimeter = sites along the perimeter ditch that separates the upland and wetland; Interior = sites not along the perimeter ditch or canoe trail.

Seasonal species composition and abundance varied by habitat type (Table 6). In both habitats, the highest mean densities were observed during the summer season as a result of large catches of the dominant estuarine residents (Table 5). Lowest mean densities were observed during the spring season in Grassy Creek and in the mosquito ditches. Seasonal recruitment was observed in both habitats for several of the more abundant recreational species. Juvenile *F. duorarum*, *C. undecimalis*, and *D. plumieri* were most abundant during the summer and fall, while *L. xanthurus*, *C. sapidus*, *P. cromis*, *L. griseus*, and *A. probatocephalus* were most abundant during the winter and spring sample seasons. *Sciaenops ocellatus* were most abundant during the fall and winter. The nekton assemblage at Grassy Creek differed seasonally (Fig. 6; ANOSIM; p=0.001) since pairwise comparison of species composition during each of the four seasons differed statistically (Table 7). Despite statistical differences (p=0.001), seasonality of nekton structure in ditches was not as clearly defined as that observed in Grassy Creek (Table 7 and Fig. 7). During a given season, the nekton assemblage found in Grassy Creek did not differ from that of the mosquito ditches ($p \geq 0.08$), with the exception of the spring season (p=0.01) when large differences were observed in the abundances of *P. latipinna*, *F. grandis*, and *L. rhomboides* between the two habitats.

Nekton assemblages in Weedon Island wetland ponds

Twenty-three taxa were collected in ponds at Weedon Island, including nine taxa of recreational importance (Table 4). Despite similarities between East Pond and West Pond in species composition (five of the top eight species were similar; Fig. 8) and species diversity (0.71 and 0.72, respectively), the overall nekton assemblages differed between the two ponds (p=0.002) based on mean nekton abundance. West Pond contained a dense assemblage of fishes (1159.52 nekton/100 m^2), with relatively low species richness (2.69) and a dominance of forage species, particularly *L. parva*, *P. latipinna*, and *Menidia* spp., which contributed 90% of the West Pond assemblage. In contrast, East Pond contained a much lower density of fishes (221.12 fish/100 m^2), a greater species richness (3.71), and was characterized by *Menidia* spp., *L. xanthurus*, *L. parva*, *Eucinostomus* spp., and *Microgobius gulosus*, which contributed to 88% of the pond's nekton assemblage. Submerged aquatic vegetation (SAV) seemed to be a primary habitat feature that differentiated the fish assemblages of the ponds, because a significant difference was observed between sites that contained SAV and those that did not (p=0.001). More fish were collected in West

Table 6. Comparison of mean ±S.E. seasonal nekton abundance (number/100 m^2) in a tidal creek and mosquito-ditched wetland at Weedon Island, Tampa Bay, FL (2004).

Species			Season							
			Winter		Spring		Summer		Fall	
Family	Scientific name	Common name	Creek (n=6)	Ditch (n=10)	Creek (n=6)	Ditch (n=10)	Creek (n=6)	Ditch (n=10)	Creek (n=6)	Ditch (n=9)
Achiridae	*Achirus lineatus*	Lined sole	6.2±3.5	4.9±2.7	1.9±0.8	3.4±1.9	1.7±1.4	0.5±0.3	1.9±0.9	2.8±2.1
	Trinectes maculatus	Hogchoker	10.5±2.9	0	1.7±1.0	0	0	0	0	0
Atherinidae	*Menidia* spp.	Silverside	12.3±10.6	10.8±6.6	56.3±33.2	9.4±3.4	12.7±11.1	78.6±33	202.6±119.7	71.8±38.5
Batrachoididae	*Opsanus beta*	Gulf toadfish	2.1±1.3	6.7±6.5	0.6±0.6	7.8±6.5	3.6±2.8	3.6±2.1	0.4±0.2	0.2±0.2
Blenniidae	Blenniidae	Unidentifed blenny	0	0.2±0.2	0	0	0	0	0	0
Centropomidae	*Centropomus undecimalis*	Common snook	0	0	0	0	3.1±1.7	0	0	2.4±1.5
Cichlidae	Cichlidae	Unidentified cichlid	0	0	0	0	0	0	0.4±0.3	0.2±0.2
Cyprinodontidae	*Adinia xenica*	Diamond killifish	30.4±17.2	82.6±38.9	0.7±0.3	26.7±14.2	158.1±40.8	115.9±74.3	6.0±2.2	3.3±2.2
	Cyprinodon variegatus	Sheepshead minnow	7.3±6.6	176.1±169.8	0.7±0.2	32.3±14.2	21.8±17.0	107.5±52.7	5.3±2.2	50.2±25.5
	Floridichthys carpio	Goldspotted killifish	0.9±0.5	2.8±2.2	0.6±0.4	1.8±1.8	2.7±1.3	1.6±1.2	0.3±0.3	1.8±1.8
	Fundulus confluentus	Marsh killifish	3.3±1.7	9.3±4.4	0.8±0.6	2.2±1.0	10.6±3.6	5.7±2.7	5.9±2.4	0.5±0.3
	Fundulus grandis	Gulf killifish	6.1±4.3	22.0±12.1	7.2±2.6	31.0±14.4	39.5±14.6	46.1±22.9	4.6±2.8	6.6±2.6
	Fundulus majalis	Striped killifish	0.6±0.6	2.3±1	0	17.2±8.9	0.4±0.3	24.5±16.1	0	5.2±4.1
	Fundulus spp.	Killifish	7.6±3.0	53.0±44.5	2.5±1.1	14.3±12.3	2.4±1.1	2.6±2.1	0.2±0.2	0
	Lucania parva	Rainwater killifish	11.6±4.4	31.2±21.7	4.4±2.4	40.9±19.7	649.1±216.6	521.7±157.2	82.1±39.9	177.9±89.6
Gerreidae	*Diapterus plumieri*	Striped mojarra	0	0	0	0	0	6.8±6.8	3.8±2.5	2.9±1.9
	Eucinostomus spp.	Mojarra	0	0	0	0.2±0.2	0	0	3.8±2.4	9.8±4.0
Gobiidae	*Gobiosoma* spp.	Goby	29.0±14.1	1.8±1.3	2.1±1.2	0	0.5±0.5	0	0	0
	Microgobius gulosus	Clown goby	17.0±7.4	7.8±4.1	1.0±0.4	0.2±0.2	0	0.2±0.2	2.0±1.0	7.8±3.2
Lutjanidae	*Lutjanus griseus*	Gray snapper	3.1±2.0	0.8±0.8	1.5±1.3	0.4±0.4	0	0	0	0
Mugilidae	*Mugil* spp.	Mullet	1.0±0.6	0.6±0.3	0	17.5±9.6	0	0	0	0
Penaeidae	*Farfantepenaeus duorarum*	Pink shrimp	0	0	0	0	0.9±0.6	3.9±2.7	15.4±4.9	9.9±4.7
Poeciliidae	*Gambusia holbrooki*	Eastern mosquitofish	64.1±22.6	177.0±49.8	5.2±2.8	81.3±34.6	187.0±113.4	321.5±81.4	75.4±32.7	157.3±67.0
	Poecilia latipinna	Sailfin molly	11.3±4.3	119.2±42.4	3.4±1.3	211.8±88.3	219.7±81.8	583.4±208.8	57.2±25.4	291.1±148.9
Portunidae	*Callinectes sapidus*	Blue crab	23.3±4.2	19.1±8.8	9.9±4.5	12.8±3.7	2.8±1.0	5.0±2.3	4.4±1.8	4.5±1.9
Rivulidae	*Rivulus marmoratus*	Mangrove rivulus	0	0	0	0.3±0.3	0	0.2±0.3	0	0
Sciaenidae	*Cynoscion nebulosus*	Spotted seatrout	0	0	0.7±0.4	0	0	0	0.7±0.4	0
	Leiostomus xanthurus	Spot	173.4±71.2	83.9±51.2	32.8±17.8	7.9±3.5	0	0	0	0
	Pogonias cromis	Black drum	0	0.3±0.3	1.3±0.6	5.1±3.3	0	0	0	0
	Sciaenops ocellatus	Red drum	5.3±2.6	9.8±5.6	0.7±0.4	1.0±0.6	0	0	6.8±2.2	6.9±2.7
Sparidae	*Archosargus probatocephalus*	Sheepshead	0.3±0.3	0	1.4±0.7	0.6±0.6	0	0	0	0
	Lagodon rhomboides	Pinfish	3.2±1.8	0.4±0.3	48.2±15.4	4.8±3.1	0	0	0.8±0.4	0.2±0.2
Syngnathidae	*Syngnathus scovelli*	Gulf pipefish	1.6±1.0	0	0	0	0	0	0	0

Species in gray are of recreational and/or commercial fishery value in Florida.

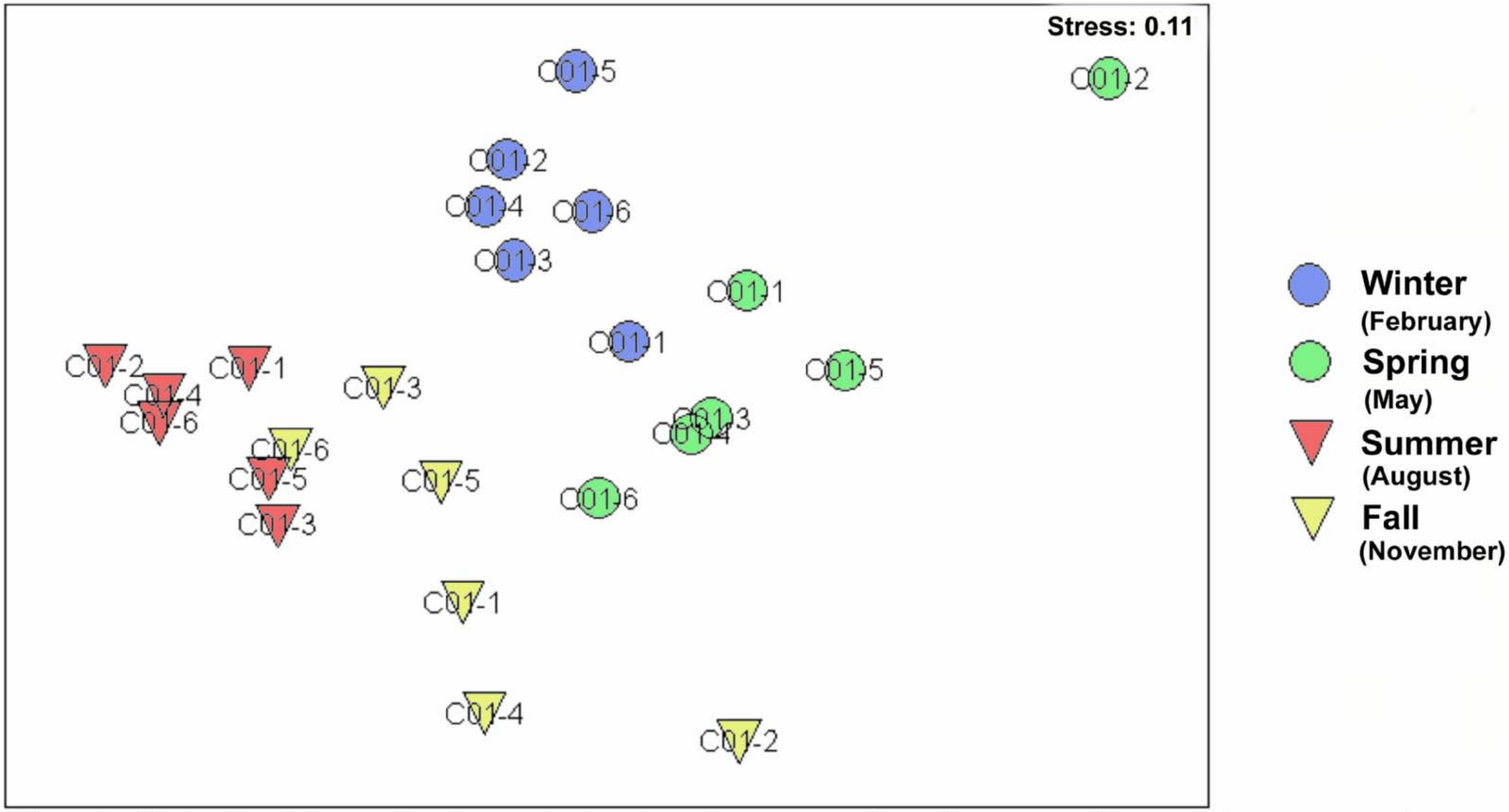

Figure 6. Similarity of Grassy Creek sample sites based on seasonal species composition and abundance during 2004. Nekton assemblages differed seasonally at Grassy Creek (p=0.001). Dry-season assemblages (February and May) seem to be more similar to one another than wet-season assemblages (August and November).

Table 7. Pairwise-comparison results (reported as p values) of seasonal species composition in Grassy Creek at Feather Sound and the mosquito ditches at Weedon Island, Tampa Bay, FL (2004).

		Season		
Habitat		**Winter**	**Spring**	**Summer**
Grassy Creek	**Winter**	·	·	·
	Spring	0.002	·	·
	Summer	0.002	0.002	·
	Fall	0.002	0.004	0.002
Mosquito Ditches	**Winter**	·	·	·
	Spring	0.206	·	·
	Summer	0.001	0.002	·
	Fall	0.001	0.081	0.076

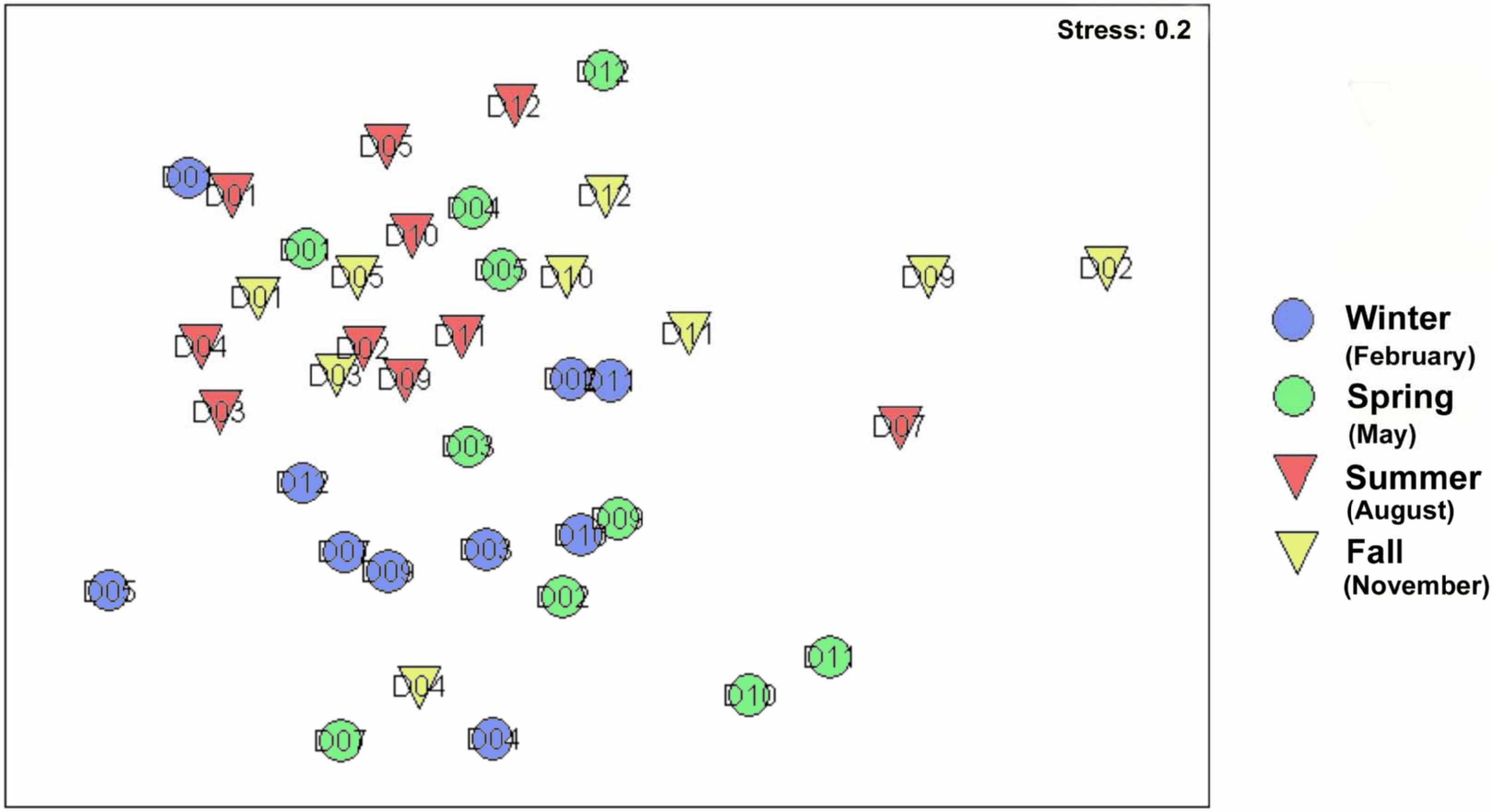

Figure 7. **Similarity of Weedon Island mosquito-ditch sample sites based on seasonal species composition and abundance during 2004. Though seasonal differences in ditch-nekton structure are not as obvious as those observed at Grassy Creek, summer structure differed from winter (p=0.001) and spring (p=0.004) and winter structurediffered from fall (p=0.005).**

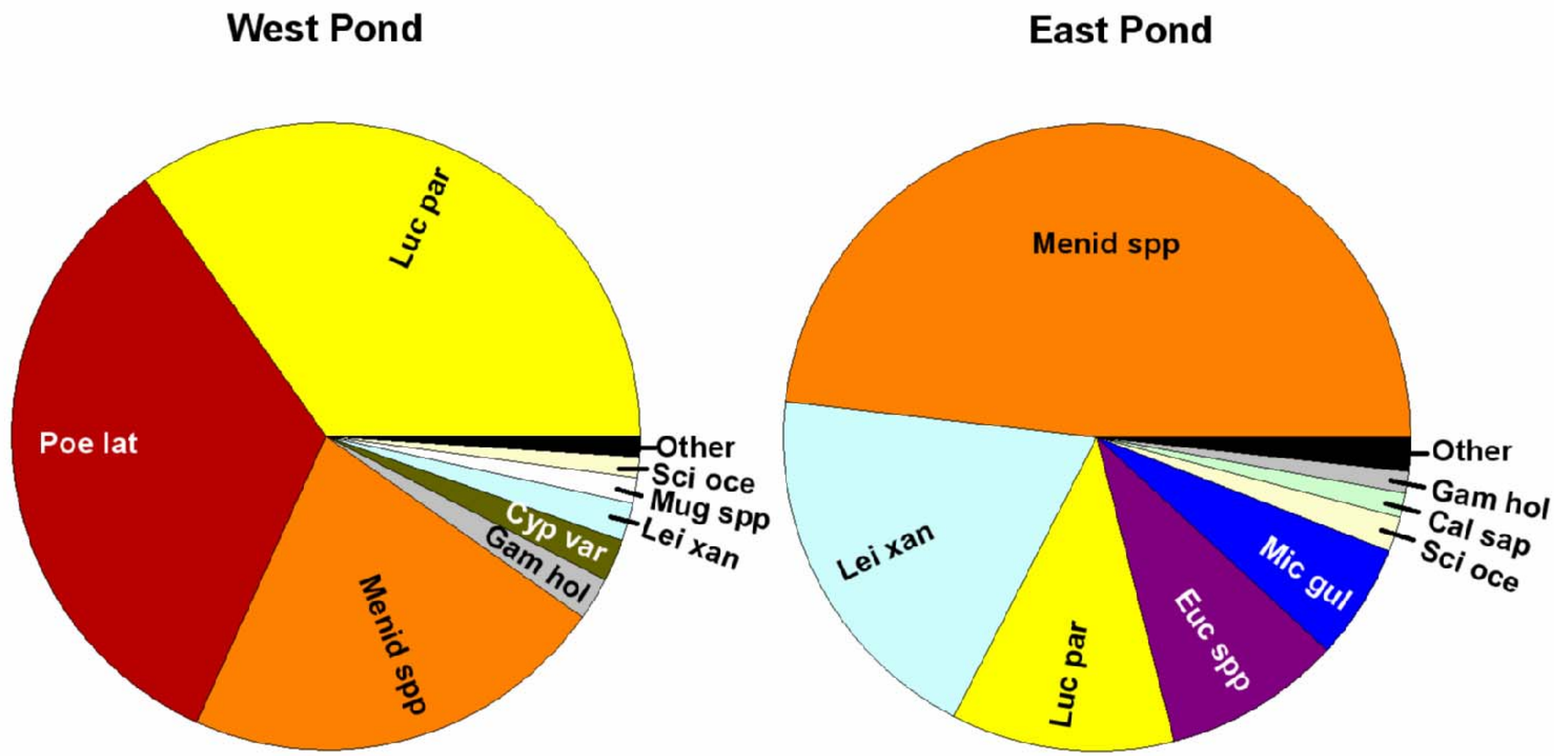

Figure 8. Species composition of nekton assemblages in two wetland ponds at Weedon Island County Preserve, Tampa Bay. West Pond (n=3) and East Pond (n=3) were sampled seasonally (i.e., winter-February, spring-May, summer-August, fall-November) during 2004.

Luc par=*Lucania parva*
Poe lat=*Poecilia latipinna*
Menid spp=*Menidia* spp
Gam hol=*Gambusia holbrooki*

Cyp var=*Cyprinodon variegatus*
Lei xan=*Leiostomus xanthurus*
Mug spp=*Mugil* spp
Sci oce=*Sciaenops ocellatus*

Euc spp=*Eucinostomus* spp
Mic gul=*Microgobius gulosus*
Cal sap=*Callinectes sapidus*
Other=10, 12 taxa

Pond, where 92% of samples were collected over *R. maritima*. In direct contrast, only 42% of East Pond sites contained bottom vegetation (four sites with *R. maritima* and one with *Caulerpa* spp.), possibly contributing to the lower density of fish collected there. Seasonally, many residents were most abundant during the spring season (Table 8). Seasonal influx of transient juveniles was observed with the recruitment of *Mugil* spp., *C. sapidus*, *L. xanthurus*, *S. ocellatus* and *L. rhomboides* during the winter season.

Conclusions

Nekton assemblages differed little between Grassy Creek in Feather Sound and the mosquito ditches at Weedon Island. Wetland-associated killifishes, livebearers, and silversides dominated the overall nekton assemblages of both habitat types with minor proportional differences. Both habitats had lesser abundances of gobies and seasonal transients, including spot, red drum, pinfish, and blue crabs. Seasonally, nekton assemblages differed only in spring between the two habitats. Although there was little difference in terms of species composition and relative abundance between creek and ditch habitats, there was an obvious seasonal pattern of nekton at Grassy Creek, whereas a seasonal pattern was less apparent in the ditches at Weedon Island. Several of the mosquito-ditch sites provided similar habitat to sites in Grassy Creek relative to mean water depth and current velocity. These sites exhibited similarities in species composition and abundance that were not observed at less “creek-like” ditch habitats. In contrast, the narrower, shallower, more lotic mosquito-ditch sites tended to be most dissimilar to creek sites in terms of available habitat and nekton use. Generally, specific habitat features such as depth, current velocity, and site width, rather than the origin of the habitat (i.e., natural creek or man-made ditch), seem to dictate nekton-assemblage structure.

Although the ponds were relatively similar in size, connectivity, and spatial location on the Weedon Island peninsula, the nekton assemblages differed. West Pond, which contained large amounts of submerged aquatic vegetation, had a much higher nekton density than East Pond, which contained less vegetation. This finding indicates that submerged aquatic vegetation may be a key characteristic in determining the nekton assemblages of these open-water habitats.

Table 8. Mean ± S.E. nekton abundance (number/100 m^2) in wetland ponds at Weedon Island, Tampa Bay, FL (2004). Three random samples were collected from each pond during four seasons.

Species			Season			
Family	Scientific name	Common name	Winter (n=6)	Spring (n=6)	Summer (n=6)	Fall (n=6)
Achiridae	*Achirus lineatus*	Lined sole	0.3±0.3	0	0	0
Atherinidae	*Menidia* spp.	Silverside	46.2±20.5	228.5±96.3	316.6±113.1	131.7±106.7
Cyprinodontidae	*Cyprinodon variegatus*	Sheepshead minnow	11.8±5.8	35.5±32.6	0.3±0.3	0
	Fundulus grandis	Gulf killifish	0.3±0.3	4.4±4.4	1.1±0.6	0
	Fundulus majalis	Striped killifish	0	2.2±2.2	0	0
	Lucania parva	Rainwater killifish	180.1±79.6	347.9±218.1	328.4±209.4	0.8±0.8
Engraulidae	*Anchoa mitchilli*	Bay anchovy	0	0.3±0.3	0.6±0.6	0
Gerreidae	*Diapterus plumieri*	Striped mojarra	0	0	0.8±0.8	0
	Eucinostomus harengulus	Tidewater mojarra	0	0.6±0.6	0	4.1±2.6
	Eucinostomus spp.	Mojarra	17.1±12.4	0.3±0.3	0	21.5±14.3
Gobiidae	*Microgobius gulosus*	Clown goby	11.8±2.2	23.1±9.2	0.6±0.6	1.4±0.5
Mugilidae	*Mugil* spp.	Mullet	17.6±17.6	3.6±2.1	0	0
	Mugil cephalus	Striped mullet	9.9±9.9	0	0	0
Penaeidae	*Farfantepenaeus duorarum*	Pink shrimp	0	0	0.3±0.3	0
Poeciliidae	*Gambusia holbrooki*	Eastern mosquitofish	27.5±20.8	24.2±21.6	4.7±4.7	0
	Poecilia latipinna	Sailfin molly	0.6±0.6	775.6±499.9	0.8±0.6	0
Portunidae	*Callinectes sapidus*	Blue crab	5.0±3.7	0.6±0.3	0.3±0.3	0.3±0.3
Sciaenidae	*Leiostomus xanthurus*	Spot	124.3±24.9	6.1±4.5	0	0
	Pogonias cromis	Black drum	0	0	0.6±0.6	0
	Sciaenops ocellatus	Red drum	32.7±17.2	0	0	0
Sparidae	*Archosargus probatocephalus*	Sheepshead	0	1.1±0.6	0	0
	Lagodon rhomboides	Pinfish	1.4±1.1	0.3±0.3	0	0
Syngnathidae	*Syngnathus scovelli*	Gulf pipefish	0.6±0.6	1.1±1.1	0	0

Species in gray are of recreational and/or commercial fishery value in Florida.

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