Fish community support in wetlands within protected embayments of Lake Ontario

Marcia S. Meixler, Kristin K. Arend and Mark B. Bain

Center for the Environment

Cornell University

Ithaca, NY 14853

Running title: Fish community support in wetlands within Lake Ontario embayments

ABSTRACT. Fish community data were collected to investigate the role of wetlands in supporting fish communities of protected embayments in Lake Ontario. Wetland and deeper, more open, littoral sites were sampled in five protected embayments using gill nets, fyke nets, minnow traps, and electrofishing gear during the summers of 2001 and 2002. Pooled gear data were used to analyze community composition, size frequency, and species richness. We found that even within protected embayments where community composition of both habitats is similar, wetlands support a community of fish different in species dominance and size structure than littoral embayment habitats. The abundance of young-of-year fish suggests that wetlands support fish populations by providing important nursery habitat. The similarity in fish community composition between wetland and littoral habitats indicates that wetlands remain important in supporting a subset of the embayment fish community. These results demonstrate that both wetlands and littoral areas in embayments are valuable and intensively utilized fish habitats that should receive special consideration in ecosystem management plans for the Great Lakes.

INDEX WORDS: coastal wetlands, littoral habitats, embayments, Great Lakes, fish communities, nursery function, habitat specificity

INTRODUCTION

Currently, the coastal wetland area in the Great Lakes is estimated to be 1,200 km^2 (Herdendorf *et al*. 1981, Mitsch and Gosselink 1993). This reflects a 60-80 percent loss in wetland area since European settlement, due largely to agricultural practices, land filling, and industrial development (Whillans 1982, Jude and Pappas 1992, Comer *et al*. 1995). Despite dramatic losses and ongoing pressures from human influences (Maynard and Wilcox 1997), coastal wetlands serve a valuable function in aquatic ecosystems. They improve water clarity through sediment removal (Jude and Pappas 1992), increase primary and invertebrate productivity (Jude and Pappas 1992), concentrate biodiversity (Randall *et al*. 1996), and provide a diversity of structural habitats (Jude and Pappas 1992, Brazner and Beals 1997).

In particular, coastal wetlands serve a key role for Great Lakes fish species. More than 75 percent of Great Lakes fish species utilize coastal wetlands during some portion of their life cycle (Stephenson 1990, Whillans 1992, Jude and Pappas 1992). Increasing research suggests that coastal wetlands serve as critical spawning and nursery habitats for a variety of species (Jude and Pappas 1992, Brazner and Beals 1997). This is partly due to dense macrophyte stands that increase the presence of invertebrate prey species (Keast and Harker 1977, Keast 1978, Wiley *et al.* 1984), buffer water movements (Engel 1988), and provide a variety of habitats, thereby promoting a diverse fish community (Emery 1978, Eadie and Keast 1984). In addition, high secondary productivity in wetlands provides a source of zooplankton and benthos important as a food source for fish (Jude and Pappas 1992). Clearly, wetland habitats support very unique fish faunas compared to the open water of the Great Lakes (Jude and Pappas 1992); however, their role within embayments has not been explored.

Several calls have been released for research to increase our knowledge of fish community structure, feeding, migratory patterns, and nursery function of Great Lakes wetlands (Busch and Lewis 1982, Liston and Chubb 1986, Smith *et al*. 1991, Jude and Pappas 1992, Krieger *et al*. 1992). Studies were performed to elucidate the relationship of fish faunal composition between wetlands and open water in the Great Lakes (Jude and Pappas 1992), in wetlands and beaches (Brazner and Beals 1997), in wetlands, harbor breakwalls, and exposed shorelines (Randall and Minns 2002), and along the gradient between the macrophyte edge and shore (Cardinale *et al*. 1998). However, questions remain about the role of wetlands in providing fish community support within Lake Ontario embayments. This is of particular interest given that only one percent of the shoreline in Lake Ontario embayments is classified as protected wetlands (Bain and Mills 2004). We examine basic patterns of habitat use through analysis of fish community species composition, size structure, and species richness data in wetland and relatively deeper, more open, nearshore (i.e., littoral) habitats throughout each embayment.

METHODS

Study Site Descriptions

This study was conducted in five embayments across two regional areas along the southeast coast of Lake Ontario (Fig. 1). The embayments vary in four main physical factors: surface area, watershed size, wetland density, and connectedness to Lake Ontario. The eastern regional area (43°39.34'N, 76°10.93'W), consisting of Floodwood, South Colwell, and North Sandy ponds, all have extensive wetlands and are separated from Lake Ontario by barriers composed mainly of sand. Floodwood and North Sandy ponds are classified as sand-spit embayments, while South Colwell Pond has a barrier beach lagoon only open to the lake part of the year (Maynard and Wilcox 1997, Minc and Albert 1998, Chow-Fraser and Albert 1998, Keough *et al.* 1999). Little Sodus and Blind Sodus bays, located in the western regional area (43°20.08'N, 76°42.55'W), have fewer wetlands and are separated from Lake Ontario by sand and gravel barriers, some of which are reinforced and paved. Both are classified as protected embayments (Maynard and Wilcox 1997, Minc and Albert 1998, Chow-Fraser and Albert 1998, Keough *et al.* 1999). Embayment surface area ranges from 0.078 km^2 at Floodwood Pond to 9.73 km^2 at North Sandy Pond, and drainage areas range from 1.38 km^2 at South Colwell Pond to 658 km^2 at Floodwood Pond. The shorelines of North Sandy Pond, Blind Sodus Bay, and Little Sodus Bay are somewhat developed for seasonal and occasional residences, while those of Floodwood and South Colwell ponds are largely intact.

All embayments have wetlands with broad-leaved emergent, narrow-leaved emergent, and free-floating vegetation, including *Sparganium eurycarpum* (giant bur reed), *Typha x* *glauca* (hybrid cattail) and *Hydrocharis morsus-ranae* (European Frog's bit). Littoral sites were randomly chosen to provide coverage of the entire embayment. Though off-shore, these sites often were located near residential development, sandy beaches, or the opening to Lake Ontario; therefore, these sites were exposed to higher wind and wave action, lower macrophyte coverage, less diverse substrate, and increased human influences. The dominant macrophytes were *Vallisneria americana* and *Myriophyllum spicatum* in Floodwood Pond and *Ceratophyllum demersum* and *M. spicatum* in Little Sodus Bay and South Colwell Pond. The spatial extents of macrophyte coverage in the embayments were 29% in Little Sodus Bay, 46% in Floodwood Pond, and 100% in South Colwell Pond (R. L. Johnson, Cornell University, Ithaca, NY, 2004, personal communication). The remaining embayments have not been surveyed specifically for macrophytes.

Sampling Methods

We sampled fish assemblages at 38 sites (17 wetland and 21 littoral) between 30 May 2001 and 20 August 2002 using four methods. Gill netting and electrofishing were performed in both the summer of 2001 and 2002, while fyke nets and minnow traps were used only in the summer of 2002. Each embayment was sampled fifty or more times to ensure good coverage of wetland and littoral areas. Shallow wetland sites were sampled with large and small fyke nets, minnow traps, and electrofishing gear. All wetland sites were sampled at the edge of the emergent vegetation based on findings of higher abundance and richness in these locations (Cardinale *et al.* 1998). Littoral sites were characterized by deeper water (1.5 – 4.5 m) and were sampled with gill nets and electrofishing gear only. The gear types employed in each habitat type were chosen to cover the size range of resident fish and ultimately to provide a pooled sample with all species in relative proportions approximating those of the local assemblage.

Gill netting was performed using 9.1 x 1.8 m, 22.9 x 1.8 m, 32 x 1.8 m, and 45.7 x 1.8 m nets with stretched-mesh sizes of 2.5 cm, 5.1 cm, and 10.2 cm. Gill nets were deployed in 1.2 to 11.0 m of water and were set for approximately two hours. Both large (0.9 m x 1.8 m opening, 1.3 cm stretched-mesh, two throats in the crib, 15.2 m leader, two 6.1 m wings) and small (0.9 m x 0.45 m opening, 1.3 cm stretched-mesh, two throats and five hoop frames, 15.0 m leader, two 3.6 m wings) fyke nets were set with the opening facing the emergent vegetation. The two wings were set at 45 degree angles to the net opening and the leader was extended into the emergent vegetation to optimize fish community sampling in those areas. Fyke nets were set for a period of 24 hours in water at least 25-75 cm deep for the small nets and at least 75-125 cm deep for the large nets, ensuring all funnels were under water. Minnow traps (0.4 m long, 0.6 cm mesh, 2.5 cm opening) were used to sample fish in areas too shallow for fyke nets. Each trap was set near the edge of the emergent vegetation for 24 hours with no bait. Electrofishing was performed using a 4.9 m boat with booms for 15 minutes in each location. A 5,000 Watt generator was used with a Smith Root type VIA transformer unit set at 120 pulses per second DC with 354 volts. The pulse width varied between 3-5 milliseconds. A circular pattern was followed in water less than 4.0 m deep around a central buoy. All fish were identified, enumerated, and measured (mm total length, TL) before release.

Statistical Analysis

Spatial variation was analyzed by partitioning data by habitat type (wetland and littoral) and by embayment. The density and number of fish species collected by each of the four gears were not compared statistically due to differences in catchability and species vulnerability for each gear type. Instead, we used a set of gears considered effective for each habitat and sampled intensively to obtain representative collections of fish present in those habitats. Data from all gears were pooled based on the assumption that the diversity of methods employed produced a more complete representation of the fish species available for collection in each habitat. Differences between abundance in fish catches in 2001 and 2002 were examined using an Analysis of Variance (ANOVA) and found to be insignificant at the 0.05 level. Therefore, we determined that it was acceptable to pool samples from both years.

Sites in each habitat type were not sampled equally using all methods; therefore, we summed all the individual samples into site totals and converted species' numerical counts into fractional abundances such that fewer strong systematic biases would be incorporated into our estimates of species' relative abundances and spatial distributions (Winemiller and Leslie 1992).

A paired t-test was used to investigate differences in species richness of fishes between wetland and littoral habitats. Significance was indicated at $\alpha = 0.05$. We compared fish community composition pooled by habitat across embayments using a Chi Square test of independence at an $\alpha = 0.05$ level of significance. A nonparametric Wilcoxon signed-rank test was used to determine whether fish sizes were significantly different between wetland and littoral habitats. Significance was accepted at the $\alpha = 0.1$ level for this test due to sample size constraints.

RESULTS

Species Richness

A total of 7,015 individual fish were collected in this study: 3,174 from wetlands and 3,841 from littoral sites. Forty-one species were identified from both littoral and wetland sites in the five embayments (Table 1). Twenty-five species from nine families were collected from wetlands, while 34 species from 14 families were found in littoral habitats. Seven species were found only in wetlands, 16 species were caught only in littoral sites, and 18 species were common between the two habitats (Table 1). With the exception of *Luxilus cornutus*, the additional species in littoral sites were all present in small numbers. Likewise, species found only in wetlands were uncommon, except for *Umbra limi*.

Species richness was marginally lower ($t = 2.15$, $p = 0.098$) in wetland compared to littoral habitats with all embayments paired (Table 1). In each embayment, the number of species present in wetlands compared with littoral sites varied considerably, from a difference of three in highly vegetated South Colwell and Floodwood ponds to eleven in highly developed North Sandy Pond. Only one embayment, South Colwell Pond, had a greater number of fish species in wetlands than in littoral habitats.

Community Composition

Fish communities in wetland and littoral habitats of pooled embayments were similar in species composition but differed in species dominance (Fig. 2). *Ameiurus nebulosus* was dominant in pooled wetlands (53%) but much less so in littoral habitats (3%). Conversely, *Perca flavescens* comprised 58% of the total catch in pooled littoral sites but only 7% of the community in wetlands. Species dominant in both habitats were *P. flavescens, Lepomis macrochirus, Lepomis gibbosus*, and *Micropterus salmoides*, all of which comprised 5% or more of the total. In addition, littoral habitats maintained sizeable populations of the less tolerant *L. cornutus* (4%) and *Notemigonus crysoleucas* (3%). Fish species in wetland and littoral habitats across embayments appear distinct ($\chi^2 = 3{,}392$, $p < 0.001$), suggesting there is little chance a common pattern of composition fits both habitat types.

The same trends were observed between wetland and littoral sites of individual embayments: species composition was similar, while dominant species varied between the two habitat types. *P. flavescens* was the dominant species in littoral sites in all embayments (Table 1). The dominant species in wetlands varied by embayment, with *L. macrochirus* dominant in Floodwood Pond, South Colwell Pond, and Little Sodus Bay; *A. nebulosus* dominant in Blind Sodus Bay; and *M. salmoides* dominant in North Sandy Pond. Although both wetland and littoral sites had a similar number of species comprising 3% or more of the community, percent composition was spread more evenly among the species in wetlands compared to littoral habitats.

Size Frequency

Fish in littoral sites were greater in size ($p = 0.10$) than those in wetlands for paired wetland and littoral habitats within embayments (Table 2). Median length values of pooled littoral fish were approximately twice that of pooled wetland fish. The median lengths of the five most common species, *P. flavescens* (21 mm), *M. salmoides* (26 mm), *L. gibbosus* (26 mm), *L. macrochirus* (45 mm), and *A. nebulosus* (231 mm), were greater in littoral habitats than in wetlands. Similarly, individual fish in the 25-75 interquartile ranges were consistently larger in littoral habitats than in wetlands and did not overlap in size between the two habitats in Floodwood and South Colwell ponds (Table 2). Littoral sites harbored larger sized and a wider range of fish.

DISCUSSION

Enclosed and protected embayments of the Great Lakes provide some of the same habitat attributes and fish community support functions as coastal wetlands. However, we found distinct differences between fish assemblages of wetland and littoral habitats within these productive embayments. Similar numbers of fish were recorded in each type of habitat with greater species richness (34 versus 25 species) in littoral habitats than in wetlands. Overall, similar fish species were caught in both littoral and wetland habitats, but the habitats differed sharply in dominant species and size structure. *P. flavescens* strongly dominated littoral habitats in each embayment, whereas the dominant species in wetland habitats varied by embayment (*L. macrochirus*, *M. salmoides*, and *A. nebulosus)*.

For many embayment fish species, spawning occurs in late spring and the young grow to approximately 50 mm by the end of summer (Smith 1985). Thus, a large proportion of the individuals captured in our wetlands, and in particular in Blind Sodus Bay, were young-of-the-year fish. The dominance of very young fish in wetland sites supports the important role wetlands play as nursery habitats (Stephenson 1990, Jude and Pappas 1992, Brazner 1997, Brazner and Beals 1997). The size distribution of fish captured in littoral habitats was considerably larger than that of fish captured in wetland habitats indicating that multiple habitats within embayments are important to support fishes in varying life stages.

The dominance of *P. flavescens* in littoral habitats may be due to their highly generalized feeding and habitat requirements and use of planktonic food resources in pelagic habitats

(Smith 1985). We also recorded a wide size range of *P. flavescens* in littoral sites, indicating that the embayment waters serve as productive regions for multiple year classes. The higher species richness in littoral sites could result from transient use of these habitats by fish from open waters of Lake Ontario. Jude and Pappas (1992) and Cardinale (1998) found that connectedness between the Great Lakes and more protected habitats was important to maintain community structure via fish movements. In our sites, the embayments are situated between the Great Lakes and wetlands. Therefore, the embayments may act as transition zones between these two habitats. Jude and Pappas (1992) observed clear differences in fish community structure between wetlands and open, nearshore waters of the Great Lakes. Differences in our study were much less striking, most likely because wetland and littoral habitats of embayments are similarly protected, productive, and complex. Nevertheless, our results indicate that wetland habitats remain important in supporting a subset of the embayment fish community and in providing a clear nursery function. When combined with the protected and productive littoral habitats in embayments, the total fish diversity and habitat support function is even greater. These results demonstrate that both wetlands and littoral areas in embayments are valuable and intensely utilized fish habitats that should receive special consideration in ecosystem management plans for the Great Lakes.

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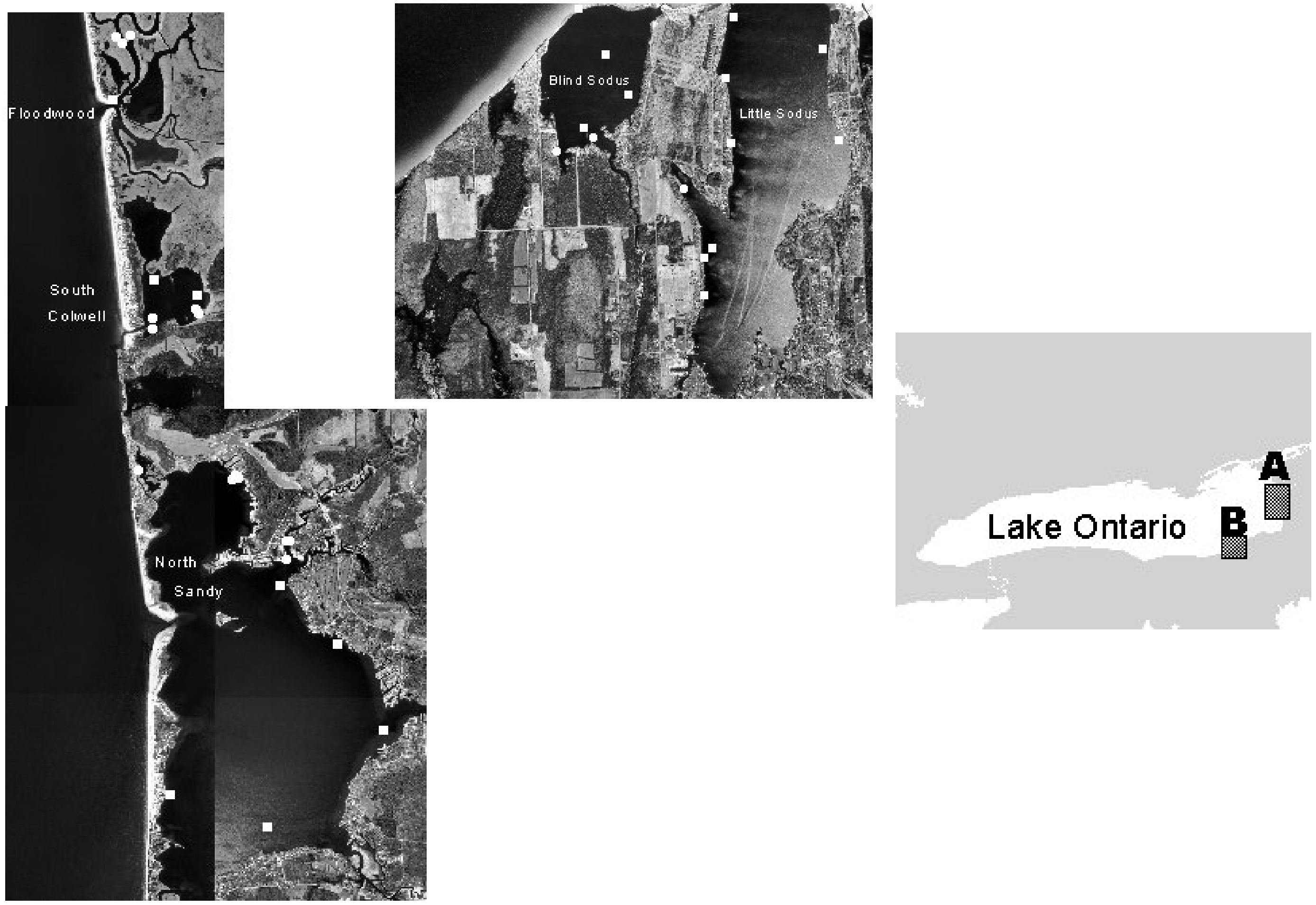
FIG. 1. Map of Lake Ontario showing the relative position of the eastern and western regional areas encompassing the five study embayments. Locational information is provided for all wetland and littoral sites sampled during the study period (eastern region, A; western region, B; wetland sites, ●; littoral sites, ■).

FIG. 2. Overall fish community composition in wetland and littoral habitats from pooled gear data collected during the summers of 2001 and 2002.

FIG. 1.



A. Eastern sites

B. Western sites

FIG. 2.

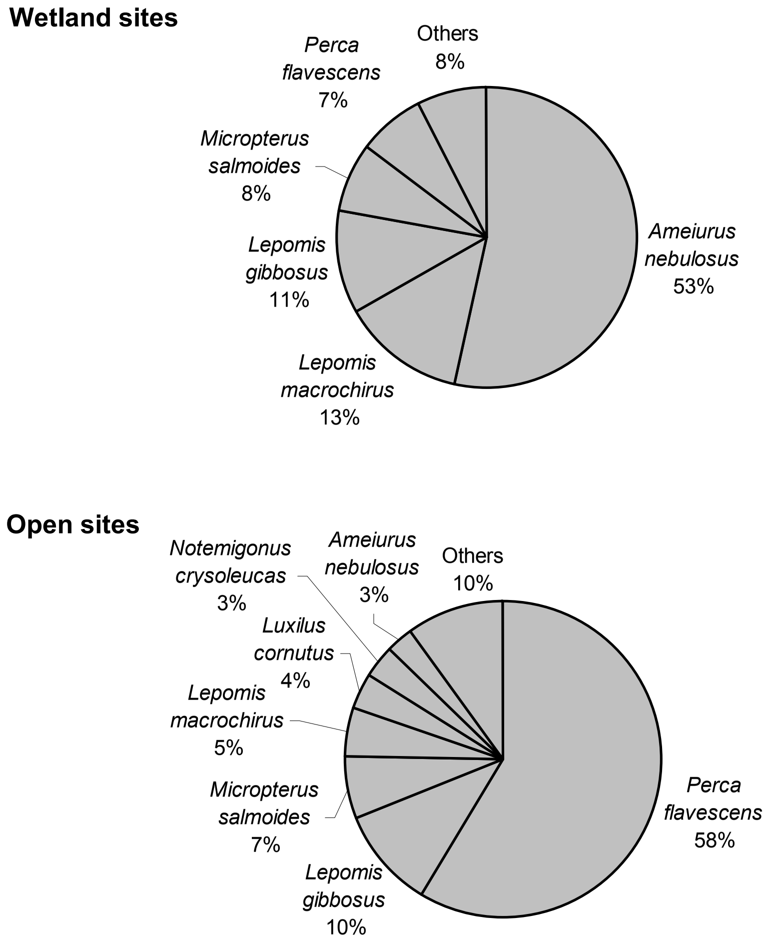

Wetland sites
Others 8%
Perca flavescens 7%
Micropterus salmoides 8%
Lepomis gibbosus 11%
Lepomis macrochirus 13%
Ameiurus nebulosus 53%
Open sites
Notemigonus crysoleucas 3%
Ameiurus nebulosus 3%
Others 10%
Luxilus cornutus 4%
Lepomis macrochirus 5%
Micropterus salmoides 7%
Lepomis gibbosus 10%
Perca flavescens 58%

TABLE 1. Total and relative abundances of the species contributing to the total catch in littoral and wetland nearshore habitats using pooled electrofishing, gill netting, fyke netting, and minnow trapping data from summers 2001-2002. Percentages refer to the contribution to the total catch of each species.

		Blind Sodus				**Little Sodus**				**Floodwood**				**North Sandy**				**South Colwell**			
		Littoral		**Wetland**		**Littoral**		**Wetland**		**Littoral**		**Wetland**		**Littoral**		**Wetland**		**Littoral**		**Wetland**	
Scientific Name	**Common Name**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Amiidae																					
Amia calva	Bowfin	2	0	12	1	13	2	0	0	6	1	4	1	11	1	7	1	5	1	3	1
Anguillidae																					
Anguilla rostrata	American eel	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Atherinidae																					
Labidesthes sicculus	Brook silverside	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Catostomidae																					
Catostomus commersoni	White sucker	3	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Centrarchidae																					
Ambloplites rupestris	Rock bass	3	0	0	0	4	1	1	1	0	0	1	0	4	0	21	3	0	0	0	0
Lepomis cyanellus	Green sunfish	0	0	5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Lepomis gibbosus	Pumpkinseed	70	7	63	4	93	12	32	22	72	12	99	33	126	12	125	17	33	9	32	15
Lepomis macrochirus	Bluegill	25	2	46	3	28	4	47	32	50	8	103	34	42	4	174	24	34	9	39	18
Micropterus dolomieu	Smallmouth bass	6	1	0	0	2	0	0	0	6	1	0	0	1	0	0	0	0	0	5	2
Micropterus salmoides	Largemouth bass	22	2	8	0	59	8	10	7	44	7	26	9	27	2	222	30	43	12	31	14
Pomoxis nigromaculatus	Black crappie	7	1	1	0	0	0	1	1	2	0	3	1	7	1	2	0	8	2	1	0
Clupeidae																					
Alosa pseudoharengus	Alewife	1	0	0	0	12	2	0	0	7	1	0	0	6	1	0	0	1	0	0	0
Dorosoma cepedianum	Gizzard shad	12	1	0	0	9	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0

TABLE 1. Continued.

		Blind Sodus				Little Sodus				Floodwood				North Sandy				South Colwell			
		Littoral		Wetland		Littoral		Wetland		Littoral		Wetland		Littoral		Wetland		Littoral		Wetland	
Scientific Name	**Common Name**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Cyprinidae																					
Cyprinella spiloptera	Spotfin shiner	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprinus carpio	Common carp	7	1	2	0	14	2	0	0	9	1	3	1	1	0	0	0	0	0	0	0
Hybognathus regius	Eastern silvery minnow	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxilus cornutus	Common shiner	12	1	0	0	0	0	0	0	129	21	0	0	2	0	0	0	4	1	0	0
Notemigonus crysoleucas	Golden shiner	59	6	5	0	35	5	1	1	12	2	0	0	10	1	2	0	12	3	3	1
Notropis amoenus	Comely shiner	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Notropis heterodon	Blackchin shiner	0	0	0	0	0	0	0	0	0	0	0	0	9	1	0	0	1	0	22	10
Notropis hudsonius	Spottail shiner	7	1	0	0	9	1	0	0	4	1	0	0	11	1	0	0	6	2	0	0
Notropis rubellus	Rosyface shiner	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pimephales notatus	Bluntnose minnow	0	0	0	0	0	0	0	0	0	0	1	0	2	0	2	0	0	0	0	0
Pimephales promelas	Fathead minnow	0	0	0	0	0	0	4	3	0	0	0	0	0	0	1	0	0	0	0	0
Semotilus atromaculatus	Creek chub	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Esocidae																					
Esox americanus vermiculatus	Grass pickerel	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	3	4	2
Esox lucius	Northern pike	21	2	3	0	2	0	0	0	6	1	1	0	5	0	2	0	3	1	3	1
Esox niger	Chain pickerel	0	0	2	0	0	0	0	0	0	0	0	0	0	0	10	1	0	0	1	0
Fundulidae																					
Fundulus diaphanus	Banded killifish	0	0	0	0	2	0	0	0	0	0	0	0	8	1	62	8	0	0	2	1

TABLE 1. Continued.

		Blind Sodus				Little Sodus				Floodwood				North Sandy				South Colwell			
		Littoral		Wetland		Littoral		Wetland		Littoral		Wetland		Littoral		Wetland		Littoral		Wetland	
Scientific Name	**Common Name**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	No	%	No	%
Ictaluridae																					
Ameiurus natalis	Yellow bullhead	0	0	1	0	0	0	1	1	0	0	0	0	0	0	3	0	0	0	1	0
Noturus gyrinus	Tadpole madtom	0	0	2	0	0	0	0	0	0	0	2	1	0	0	1	0	0	0	5	2
Ameiurus nebulosus	Brown bullhead	11	1	1467	83	34	4	33	22	9	1	4	1	49	4	21	3	5	1	17	8
Lepisosteidae																					
Lepisosteus osseus	Longnose gar	0	0	0	0	8	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Moronidae																					
Morone americana	White perch	3	0	0	0	0	0	0	0	0	0	0	0	17	2	0	0	0	0	0	0
Morone chrysops	White bass	0	0	0	0	0	0	0	0	0	0	0	0	10	1	0	0	0	0	0	0
Percidae																					
Etheostoma olmstedi	Tessellated darter	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0
Perca flavescens	Yellow perch	712	71	155	9	430	57	16	11	259	42	26	9	733	67	58	8	201	55	37	17
Percina caprodes	Logperch	9	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Sander vitreus	Walleye	5	0	0	0	0	0	0	0	1	0	0	0	4	0	0	0	0	0	0	0
Sciaenidae																					
Aplodinotus grunniens	Freshwater drum	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Umbridae																					
Umbra limi	Central mudminnow	0	0	0	0	0	0	0	0	0	0	30	10	0	0	21	3	0	0	9	4
Total individuals		1002		1774		758		147		618		304		1095		734		368		215	
Total richness		24		16		18		11		17		14		28		17		14		17	
Total number of samples		23		66		30		28		19		31		35		62		21		32	
Catch per sample (Cs)		43.6		26.9		25.3		5.3		32.5		9.8		31.3		11.8		17.5		6.7	

TABLE 2. Summary statistics on the total length distribution of fish captured in littoral and wetland habitats in the five bays using pooled sampling techniques and years. Coefficient of variation = (standard deviation /mean)X100.

Habitat and site	Median total length (mm)	Interquartile 25-75 range (mm)	Total length range (mm)	CV (%)
<u>Littoral</u>				
Blind Sodus	74	48-129	34-862	100
Little Sodus	127	110-152	11-850	69
Floodwood	111	100-120	22-805	84
North Sandy	104	88-117	26-925	67
South Colwell	113	96-125	16-659	63
<u>Wetland</u>				
Blind Sodus	48	45-51	33-680	77
Little Sodus	66	55-89	24-560	86
Floodwood	65	53-95	29-581	65
North Sandy	67	57-94	29-700	57
South Colwell	66	52-95	34-680	93