Muskegon Lake Area of Concern Habitat Restoration Project: 2012 Fish Assessment

Carl R. Ruetz III
Annis Water Resources Institute, Grand Valley State University
740 W. Shoreline Dr., Muskegon, MI 49441
Office: 616-331-3946; E-mail: ruetzc@gvsu.edu

Final Report
15 January 2013

Introduction

Fish are indicators of freshwater ecosystems (Uzarski et al. 2005). As such, monitoring fish populations and communities can provide valuable information for assessing the effects of restoration activities. The purpose of this study was to assess fish populations in conjunction with on-going macrophyte monitoring (see Ogdahl and Steinman 2012) in Muskegon Lake. Specifically, my goal was to compare patterns in the fish assemblage with the measures of the macrophyte community. In this study, I used a different approach to sample fish than I had used in previous years of this study (2009-2011; see Ruetz 2011) in an effort to better relate the fish surveys to the on-going macrophyte surveys. A drawback of this approach is that I was unable to directly compare the response of fish to the shoreline restoration activities that occurred in Muskegon Lake during 2010 and 2011 (see Ogdahl and Steinman 2012). Nevertheless, this study takes advantage of a unique opportunity to coordinate fish surveys with intensive macrophyte surveys to assess the response of fish to habitat in littoral areas of lakes. Moreover, if restoration activities affect macrophyte communities, then this data will be useful for inferring how those changes in may affect fish populations. Therefore, my specific objectives were to compare fish communities among six sites in Muskegon Lake and assess whether features of the habitat affected fish populations.

Methods

Site description. Muskegon Lake is a large drowned river mouth lake that connects the Muskegon River to Lake Michigan (Steinman et al. 2008). Fish surveys were conducted at four restoration sites along the south shore of the lake (Ogdahl and Steinman 2012), which included Grand Trunk, Amoco, Kirksey, and Heritage Landing (Table 1). Two reference sites were selected along the north shore of the lake to represent more natural shoreline (Ogdahl and Steinman 2012), which included Northwest Reference and Northeast Reference (Table 1).

Field protocols. Fish were sampled with two types of gear: minnow traps (Hubert 1996) and boat electrofisher (Reynolds 1996). Fish sampling was conducted on the same transects (perpendicular to shore) that were established for macrophyte surveys (Ogdahl and Steinman 2012) during summer 2012.

Minnow trapping was conducted at each site 13-24 August 2012. A minnow trap was set at each transect point with sufficient water (i.e., depth of water was greater than trap) in conjunction with macrophyte surveys (Ogdahl and Steinman 2012). Transects were established perpendicular to shore. Transect points were located every 5 m from 0-10 from shore, every 25 m from 100-300 m from shore, and every 50 m thereafter. Each transect extended to the further point of macrophyte growth, which was defined as two consecutive points on a transect without macrophytes or the absence of macrophytes at a point along the transect with a depth greater than 4.5 m (Ogdahl and Steinman 2012). The number points along a transect where minnow traps were set ranged from 8 at the Amoco site to 19 at the Grand Trunk site (Table 1).

Boat electrofishing was conducted during daylight hours on 5 and 26 September 2012. The electrofishing boat had a Smith-Root 5.0 GPP control box. Pulsed (120 pulses/s) direct current (about 7 amps) was used to sample fish. Two people netted fish on the front of the boat. Electrofishing was begun at the outer most transect point, and the boat was driven toward shore (which was the zero point for the macrophyte transect). The electrofishing transect was ceased when the water became too shallow to operate the boat. Fish data from the 5 September sampling event at the Kirksey site are excluded from this report because the electrofishing survey did not match the macrophyte survey. All sites were correctly sampled during the 26 September electrofishing survey. The electrofishing transects ranged from 80 m at the Amoco site to 575 m at the Northwest Reference site (Table 2). The amount of pedal time (i.e., actual time electricity is put into the water) was proportional to the length of a transect (Table 2). For both sampling methods, all fish were identified to species and measured for total length before being released.

I examined whether catch (i.e., number of fish captured by a given gear) was associated with habitat features by performing Pearson's correlations between the number of fish captured and three habitat variables (only two variables were assessed for electrofishing surveys). The habitat variables were distance from shore (only assessed for minnow-trap surveys), water depth, and macrophyte cover. The index for macrophyte cover (termed cover index) was measured by Ogdahl and Steinman (2012). The cover index ranged from 0 to 5, with 0 = bare substrate, 1 = 1-25% macrophyte, 2 = 26-50% macrophyte, 3 = 51-75% macrophyte, and 4 = 76-100% macrophyte cover.

Results & Discussion

I captured 198 fish in minnow trap surveys, 157 fish during electrofishing surveys on 5 September, and 271 fish during electrofishing surveys on 26 September. In these surveys, I captured 8 species in minnow traps, 15 species during electrofishing on 5 September, and 16 species electrofishing on 26 September (Table 3). In total, 18 fish species were captured during fish surveys. The three most abundant species each gear were pumpkinseed, largemouth bass, and banded killifish in minnow traps; largemouth bass, bluegill, and yellow perch in electrofishing on 5 September; and largemouth bass, yellow perch, and bluegill in electrofishing on 26 September (Table 3). These species have previously been found to be common in littoral habitats of Muskegon Lake (Bhagat and Ruetz 2011). Additionally, as expected (see Ruetz et al. 2007), minnow traps targeted smaller individuals than boat electrofishing (Table 3).

In minnow-trap surveys (Figure 1), the most fish were captured at the Grand Trunk and Northeast Reference sites. At both of those sites, the catch was dominated by pumpkinseed. Catch at the Kirksey site was dominated by bluegill. During the electrofishing survey on 5 September (Figure 2), catch was more consistent among sites, although the most fish were captured at the Northwest Reference site. Largemouth bass were common at each sampling site. Bluegill was most common in the catch at the Grand Trunk, Heritage Landing, and Northeast Reference sites, whereas bluntnose minnow were common at the Amoco site (Figure 2). During the electrofishing survey on 26 September (Figure 3), catch was consistently higher at all of the sites expect Amoco compared with the electrofishing survey on 5 September. Note that sampling effort (measured as pedal time) also was higher during the 26 September sampling event (Table 2). Again, largemouth bass dominated the catch at all of the sites, although yellow perch co-dominated the catch at the Grand Trunk and Heritage Landing sites (Figure 2). A noticeable difference was that brook silverside were more common in the catch at the Kirksey site compared with the other sites (Figure 2). In terms of water quality differences between the two electrofishing surveys, water temperature was warmer on 5 September compared with 26 September, whereas differences in dissolved oxygen concentration, specific conductivity, turbidity, and pH were less obvious (Table 4).

I assess whether catch in minnow traps was associated with distance from shore, water depth, and macrophyte cover. Although there was no evidence of a strong relationship between minnow-trap catch and distance from shore (Figure 4A) or between minnow-trap catch and water depth (Figure 4B), I detected a significant, positive association between minnow-trap catch and macrophyte cover (Figure 4C). The relationship between minnow-trap catch and macrophyte cover showed that more fish were captured in areas of Muskegon Lake were macrophytes were abundant, which may suggest that fish are more abundant in littoral habitats that have abundant macrophytes. However, minnow traps may also be more efficient at capturing fish when macrophytes are more abundant. Additionally, I did not detect a significant association between macrophyte cover and distance from shore (Figure 4D) or between macrophyte cover and water depth (Figure 4E), although there was a significant positive association between water depth and distance from shore (Figure 4F). Thus, the association between minnow-trap catch and macrophyte cover does not appear to be confounded with water depth or distance from shore.

Finally, for boat electrofishing on 26 September, I assess whether catch per unit effort (CPUE) or catch (i.e., all individuals captured during an electrofishing survey at a site) were associated with water depth or macrophyte cover. In both cases, I did not detect any significant trends between CPUE and water depth (Figure 5A), between CPUE and macrophyte cover (Figure 5B), between catch and water depth (Figure 5C), or between catch and macrophyte cover (Figure 5D). These comparison are based on mean values of water depth and macrophyte cover along a transect at a site, so there is aggregating of observation that could make detecting trends more difficult, especially given the number of sites that were sampled (i.e., $n = 6$; see Figure 5). Note that there was not a significant association between mean macrophyte cover (measured as the cover index) and mean water depth (data not shown; $r = 0.38$, $P > 0.4$, $n = 6$).

Ogdahl and Steinman (2012) reported that the macrophyte community had recovered to at least pre-restoration biomass levels and species richness in 2012 following restoration activities in preceding years. The present study on fish showed that high macrophyte cover was associated with the capture of more fish in minnow traps, but this pattern was not detectable in electrofishing surveys. Nevertheless, macrophyte cover likely provides important habitat for fish, and restoration activities that aspire for restoring littoral habitats with healthy macrophyte communities likely benefit fish populations.

Acknowledgments

Financial support was provided by the National Oceanic and Atmospheric Administration. Project partners were the West Michigan Shoreline Regional Development Commission, Muskegon Lake Watershed Partnership, Muskegon River Watershed Assembly, and the Great Lakes Commission. I thank Mary Ogdahl, Maggie Weinert, James Smit, Dave Janetski, Jessica Wesolek, Brandon Harris, Jared Homola, and Amanda Chambers for their assistance in the field and with data entry.

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Table 1. Macrophyte transects (see Ogdahl and Steinman 2012) where fish surveys were conducted with minnow traps in Muskegon Lake during August 2012. Latitude (lat) and longitude (long) are reported for each transect at shore to the outer most point in the lake where a minnow trap was set (transects run perpendicular from shore). Latitude and longitude are reported in decimal degrees. The portion of a macrophyte transect where minnow traps were fished is noted for the first point where a trap was set and the outer most point a trap is set (e.g., if the first location was 5 m and the outermost location was 80 m, then minnow traps were set along a 75-m transect for fish surveys at that site). Finally, the number of points for each transect refers to the number of minnow traps that were set at a site (i.e., one minnow trap was set at each point along a transect with sufficient water).

	Location				Location along transect (m)		No. of transect points
	Shore		Outer				
Site	Lat (N)	Long (W)	Lat (N)	Long (W)	First	Outer	
Amoco	43.22206	86.28417	43.22261	86.28471	5	80	8
Grand Trunk	43.21598	86.29733	43.22024	86.29742	30	450	19
Heritage Landing	43.23315	86.26212	43.23424	86.26259	5	125	12
Kirksey	43.23241	86.27596	43.23372	86.27733	5	175	14
Northeast Reference	43.24656	86.28090	43.24466	86.27869	5	275	18
Northwest Reference	43.24711	86.316231	43.24031	86.31584	125	750	17

Table 2. The portion of a macrophyte transect (Ogdahl and Steinman 2012) where an electrofishing survey was conducted to sample fish in Muskegon Lake during September 2012. Pedal time refers to the duration for which electricity was put into the water to sample fish during an electrofishing survey at a site. The Kirksey site was not sampled during the 5 September sampling event.

	Location along transect (m)					
	5 Sept		26 Sept		Pedal time (s)	
Site	Inner	Outer	Inner	Outer	5 Sept	26 Sept
Amoco	10	90	10	90	180	255
Grand Trunk	250	500	225	500	524	965
Heritage Landing	20	175	20	175	458	663
Kirksey	--	--	80	200	--	512
Northeast Reference	60	350	80	350	701	724
Northwest Reference	225	800	225	800	853	1670

Table 3. Number and size (total length, TL) of fish captured by minnow traps and boat electrofisher (two sampling events) at six sites in Muskegon Lake. Note that data for the Kirksey site was not included for the 5 September boat electrofishing survey.

			Boat electrofishing			
	Minnow trapping		5 Sept.		26 Sept.	
Name	Catch	TL (cm)	Catch	TL (cm)	Catch	TL (cm)
Banded killifish, *Fundulus diaphanus*	19	6.2 (4.0-7.4)	5	7.4 (6.7-8.0)	10	7.2 (6.1-9.3)
Bluegill, *Lepomis macrochirus*	17	4.8 (3.0-9.0)	31	11.3 (4.4-18.8)	20	12.5 (4.4-19.2)
Bluntnose minnow, *Pimephales notatus*	0	--	12	8.4 (6.6-9.1)	9	7.5 (5.4-9.2)
Bowfin, *Amia calva*	0	--	1	61.0	4	55.5 (33.9-70.0)
Brook silverside, *Labidesthes sicculus*	0	--	0	--	13	8.1 (6.7-10.3)
Common carp, *Cyprinus carpio*	1	10.3	0	--	1	19.6
Gizzard shad, *Dorosoma cepedianum*	0	--	2	30.3 (29.0-31.5)	4	35.9 (32.9-38.1)
Largemouth bass, *Micropterus salmoides*	31	7.3 (5.0-9.7)	53	9.6 (5.9-46.8)	131	10.5 (5.6-41.8)
Longnose gar, *Lepisosteus osseus*	0	--	1	45.8	1	38.9
Northern pike, *Esox lucius*	0	--	1	43.7	2	61.8 (57.7-65.8)
Pumpkinseed, *Lepomis gibbosus*	104	5.3 (3.6-9.5)	16	11.6 (5.6-17.9)	19	12.3 (5.8-18.4)
Smallmouth bass, *Micropterus dolomieu*	2	6.8 (6.0-7.5)	0	--	0	--
Rock bass, *Ambloplites rupestris*	12	5.0 (3.0-9.2)	1	9.3	4	10.9 (6.8-14.3)
Round goby, *Neogobius melanostomus*	12	6.9 (4.5-11.5)	3	10.3 (9.0-11.3)	4	10.8 (7.5-13.5)
Silver redhorse, *Moxostoma anisurum*	0	--	2	56.4 (55.4-57.4)	1	51.0
Yellow perch, *Perca flavescens*	0	--	25	14.4 (11.6-25.7)	44	14.1 (10.0-17.3)
Walleye, *Sander vitreus*	0	--	1	13.4	0	--
White sucker, *Catostomus commersonii*	0	--	3	46.2 (36.9-52.5)	4	45.1 (33.6-53.0)

Table 4. Water quality variables measured at the surface of Muskegon Lake in conjunction with boat electrofishing surveys on 5 and 26 September 2012. Variables were water temperature (temp), dissolved oxygen concentration (DO), specific conductivity (SPC), turbidity (turb), and pH; each was measured with a YSI data sonde (Model 6600).

	Temp (ºC)		DO (mg/L)		SPC (µS/cm)		Turb (NTU)		pH	
Site	9/5	9/26	9/5	9/26	9/5	9/26	9/5	9/26	9/5	9/26
Amoco	25.25	17.37	10.56	10.15	373	382	2.3	1.9	8.74	8.52
Grand Trunk	24.99	16.22	10.23	8.12	372	454	2.7	0.0	8.73	8.15
Heritage Landing	25.44	17.27	10.64	10.60	383	399	1.9	0.4	8.70	8.55
Kirksey	25.33	17.98	10.48	11.23	375	385	2.4	1.5	8.73	8.56
Northeast Reference	25.12	15.99	9.67	9.65	390	387	1.4	0.3	8.60	8.48
Northwest Reference	24.20	16.59	8.96	9.92	374	371	2.4	0.2	8.62	8.44

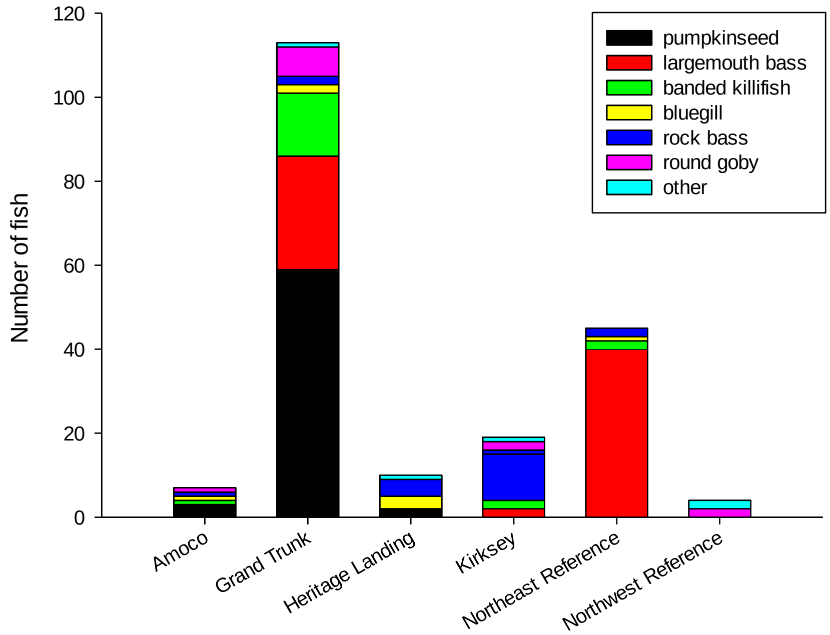

Figure 1. Fish species composition of catch based on minnow trapping at the six sampling sites in Muskegon Lake during August 2012.

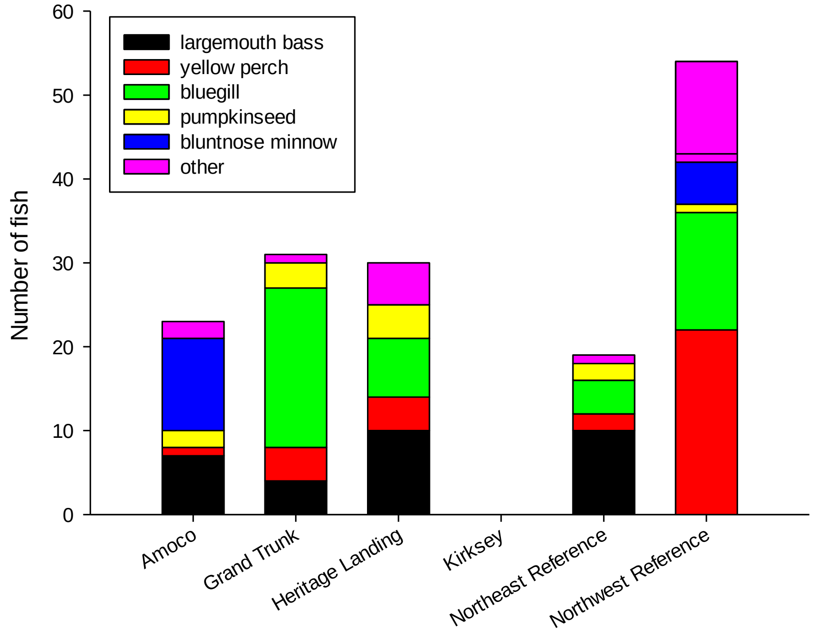

Figure 2. Fish species composition of catch based on boat electrofishing at the six sampling sites in Muskegon Lake during 5 September 2012. Note that the Kirksey site was not sampled.

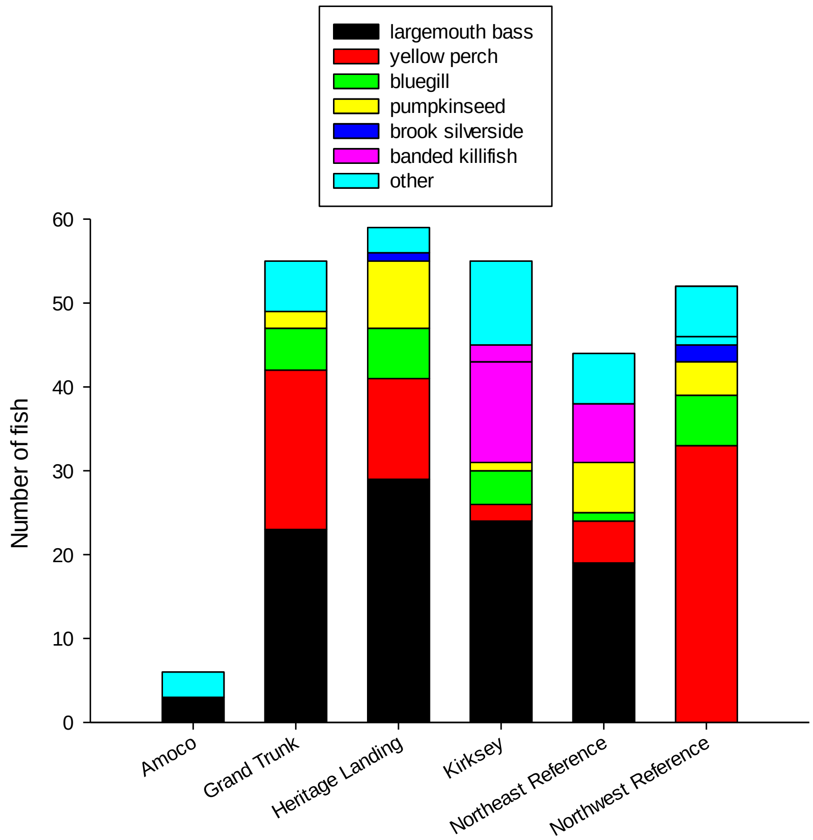

Figure 3. Fish species composition of catch based on boat electrofishing at the six sampling sites in Muskegon Lake during 26 September 2012.

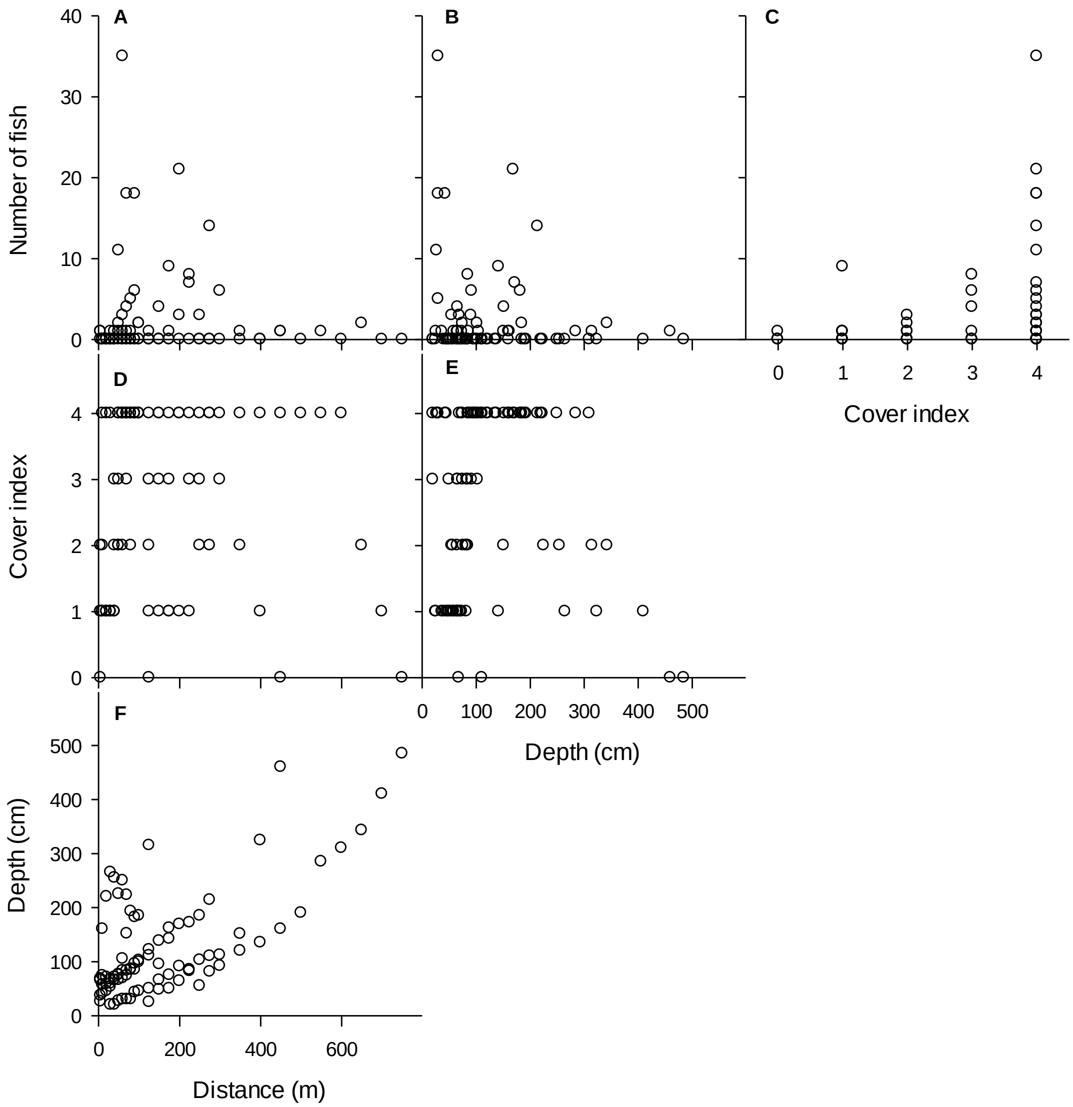

Figure 4. Relationship between (A) catch (number of fish) and distance from shore (r = -0.05, P > 0.6), (B) catch and water depth (r = -0.12, P > 0.2), (C) catch and cover index (r = 0.27, P < 0.02), (D) cover index and distance from shore (r = 0.01, P > 0.9), (E) cover index and water depth (r = -0.06, P > 0.5), and (F) water depth and distance from shore (r = 0.67, P < 0.01). Fish were captured via minnow traps in Muskegon Lake during August 2012. Each point represents the number of fish captured in one minnow trap and/or the habitat variables measured at that point on the transect. Note that the cover index values correspond to 0 = bare substrate, 1 = 1-25% macrophyte, 2 = 26-50% macrophyte, 3 = 51-75% macrophyte, and 4 = 76-100% macrophyte cover.

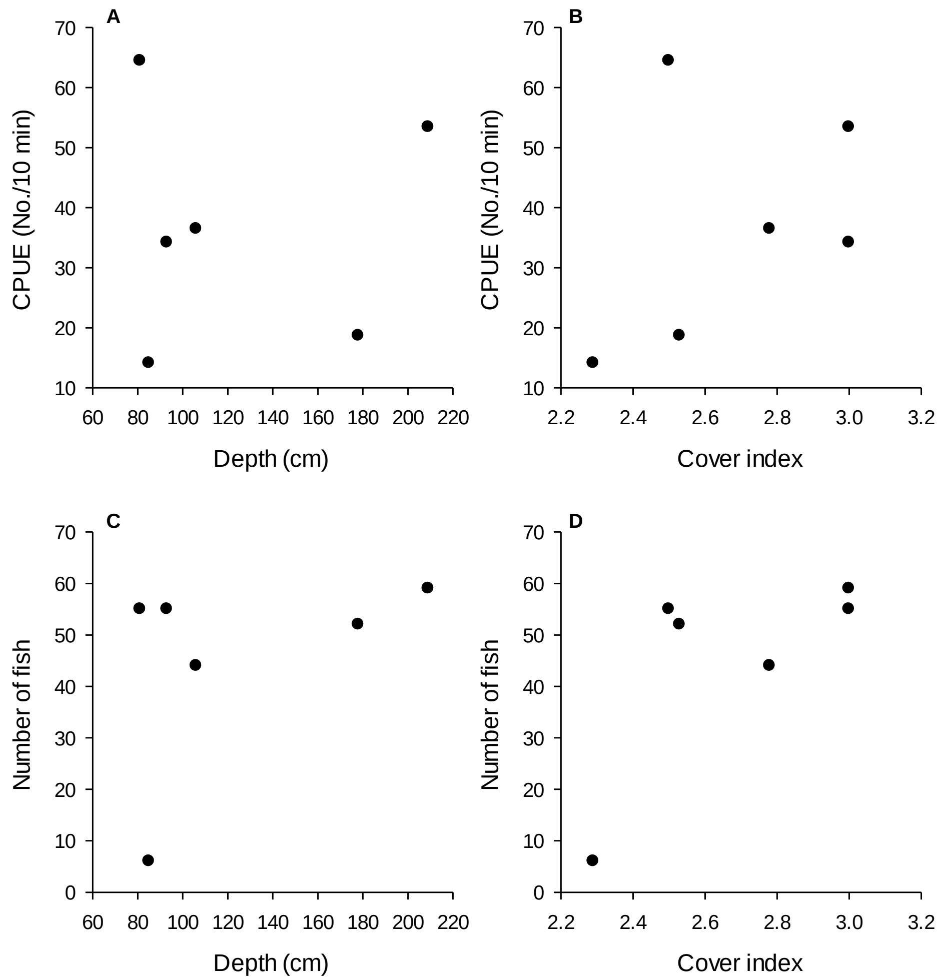

Figure 5. Relationship between (A) catch per unit effort (CPUE; number of fish/10 min of electrofishing pedal time) and water depth (r = 0.04, P > 0.9), (B) CPUE and cover index (r = 0.39, P > 0.4), (C) catch (number of fish) and water depth (r = 0.44, P > 0.3), and (D) catch and cover index (r = 0.69, P > 0.1). Fish were captured via boat electrofishing surveys in Muskegon Lake during 26 September 2012. Each point represents an electrofishing transect at one site. Water depth and cover index are mean values for the portion of the transect where fish were sampled. Note that the cover index values correspond to 0 = bare substrate, 1 = 1-25% macrophyte, 2 = 26-50% macrophyte, 3 = 51-75% macrophyte, and 4 = 76-100% macrophyte cover.