Muskegon River Veterans Memorial Park Fish and Wildlife Habitat Restoration Project Fisheries and Water Quality Monitoring

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Introduction

Muskegon Lake has a long history of industrial activity on its shoreline (Alexander 2006), and environmental impairment from these activities led to its listing as an Area of Concern (AOC) in 1985 (Carter et al. 2006, Steinman et al. 2008). In particular, shoreline alterations and the filling of shallow-water habitats resulted in the loss, degradation, and fragmentation of littoral and wetland habitats. The overall goal of this restoration project is to improve and reconnect shallow-water habitat by focusing restoration efforts on two ponds adjacent to the North Branch of the Muskegon River at Veterans Memorial Park in Muskegon County. Veterans Memorial Park begins at the mouths of two previously converted wetland ponds on the north and south sides of the Muskegon River, within a parkway at the east end of Muskegon Lake. Excavation and filling of the Muskegon River wetlands occurred in the early 1900s to establish the parkway and park. This construction resulted in the excavation of two ponds, the straightening of the river channel, and the filling of adjacent wetlands. In the late 1900s, installation of a water control structure reduced fish passage from the Muskegon River to the south pond and likely degraded its water quality. Thus, the planned habitat restoration aims to improve habitat in both ponds and re-connect the river with the south pond.

The purpose of the associated monitoring effort is to provide a pre- and post-restoration assessment of the fish community and water quality in response to habitat restoration at Veterans Memorial Park. In this report, we summarize the results of our pre-restoration monitoring, which was conducted during autumn 2015. In autumn 2016, we plan to conduct post-restoration monitoring. Nevertheless, monitoring fish and water quality several years after restoration will likely be needed to better evaluate the effects of habitat restoration on fish assemblages and water quality in the ponds of Veterans Memorial Park.

Methods

Study sites.—Veterans Memorial Park is located on the North Branch of the Muskegon River (Muskegon County, Michigan), which flows into Muskegon Lake and then Lake Michigan, and is located in the Muskegon Lake AOC. The park was created on property that was historically wetlands and contains a north pond and south pond (Figure 1). Fish and water quality sampling were conducted at 11 littoral sites (Table 1). Six sites were sampled at the south pond, three sites were sampled at the north pond, and two sites were sampled in Muskegon Lake near where the North Branch of the Muskegon River enters Muskegon Lake (Figure 1). A stratified random sampling approach was used on the south pond, where the south pond was broken into three main strata (strata #1, 2, and 3 in Figure 1), and a sampling site was randomly selected (among two approximately equal segments) on each side of the south pond in each strata. In the north pond, three sampling sites were randomly selected (i.e., among four shoreline segments). The site locations in Muskegon Lake (Figure 1) were selected in relatively close proximity to Veterans Memorial Park but in areas that would not experience any habitat restoration.

Fish and environmental sampling.—We sampled fish via fyke netting at each study site between 5 and 8 October 2015. Fyke nets were set during daylight hours and fished an average of 23.75 h (range = 22.20-25.18 h). Two fyke nets (4-mm mesh) were fished at each site; the fyke nets were set facing each other and parallel to the shoreline. A description of the design of the fyke nets is reported in Breen and Ruetz (2006), and the type of fyke nets we used tend to select for small-bodied fish (Ruetz et al. 2008). Each fish captured was identified to species, measured (total length), and released in the field; however, some specimens were preserved to confirm identifications in the laboratory. We also created a photo library of each fish species we encountered, and the identifications were confirmed by CRR.

Environmental conditions were measured at each fish sampling site. We measured water temperature, dissolved oxygen concentration, specific conductivity, total dissolved solids, turbidity, pH, oxidation reduction potential, and chlorophyll *a* in the middle of the water column using a YSI 6600 multi-parameter data sonde near the mouth of each fyke net. We measured water depth at the mouth of each fyke net and visually estimated the percent cover of submerged aquatic vegetation (SAV) and emergent aquatic vegetation (EAV) for the length of the lead between the wings of each fyke net. At each site, water was collected by a 1-L grab-sample at mid depth using an acid-washed polyethylene bottles following the protocol of Janetski and Ruetz (2014). Bottles for specific analytes were rinsed with sample water before collection. All samples were stored in the dark, on ice in the field and then processed further upon return to the laboratory. One 250 mL poly bottle was filled with raw water and stored frozen for analysis of total phosphorus (TP). Additionally, 500 mL of water was filtered using a 0.45-µm nitrocellulose filter, and a 20 mL subsample was collected for the analysis of chloride, nitrate, and soluble reactive phosphorus (SRP). Chloride and nitrate concentrations were determined by ion chromatography on a Dionex ICS-2100. SRP and TP concentrations were determined using a SEAL Analytical AQ2 discrete analyzer.

Results and Discussion

Environmental sampling.—Across the 11 fish sampling sites, water depth averaged 88 cm with an average water temperature of 16.0 °C (Table 2). We reported the results of the environmental conditions at each fish sampling site in Tables 2 and 3 (including duplicate samples), and the results of our QA/QC assessment are reported in Appendix 1.

We found differences in environmental conditions among the three sampling locations (Tables 2 and 3). The most apparent differences among the locations were the south pond had high turbidity (Figure 2a), specific conductivity (Figure 2b), TP (Figure 2c), and SRP (Figure 2d) compared with the north pond and Muskegon Lake. In contrast, nitrate concentrations were lower in the north and south ponds compared with Muskegon Lake (Figure 2e), which could be the result of denitrification. Interestingly, the fish sampling sites in the south pond were characterized by the absence of SAV (Figure 3a). The absence of SAV in the south pond was presumably because of insufficient light penetrating to the bottom as a result of high turbidity. Both the south and north ponds had 25% and 32% coverage of EAV, respectively, which was absent at the fish sampling sites in Muskegon Lake (Figure 3b).

Fish sampling.—We captured 1285 fish comprising 23 species (excluding the unknown sunfish that was likely a hybrid) at the three (north pond, south pond, and Muskegon Lake) sampling locations (Table 4). The most abundant fishes across all sites were pumpkinseed (32%), yellow perch (27%), bluegill (13%), brown bullhead (8%), and largemouth bass (8%), which composed 86% of the total catch (Table 4). Three of the 24 species captured were non-native to the Great Lakes basin (Bailey et al. 2004)—goldfish (2%), common carp (0.2%), and round goby (0.5%)—which composed 2% of the total catch (Table 4). The goldfish and common carp only were captured in the south pond, whereas the round goby was only captured in Muskegon Lake. Although not an abundant species in the catch, we captured warmouth—a native sunfish (Becker 1983)—in both the north and south ponds (Table 4), which was not commonly captured when fyke netting in littoral habitats of Muskegon Lake (Bhagat and Ruetz 2011, Janetski and Ruetz 2015).

We captured the majority of the fish (91%) and fish species in the south pond compared with sites in the north pond and Muskegon Lake (Table 4). The catch at each site is reported in Appendix 2. When standardized by sampling effort (i.e., number of fyke nets), the catch per unit effort (CPUE) in the south pond was about seven times higher than the north pond and nine times higher than the sites in Muskegon Lake (Figure 4a). Similarly, as expected given the much higher catch, more fish species were captured in the south pond (16 species) than the north pond (9 species) or Muskegon Lake (12 species). We captured the most unique fish species (i.e., species only captured at a given location) in the south pond (8 species), followed by the sites in Muskegon Lake (5 species) and the north pond (1 species; Table 4).

There were clear differences in the fish assemblages between the three sampling locations (Figure 4b). In the south pond, pumpkinseed (33%), yellow perch (29%), bluegill (12%), brown bullhead (9%), and largemouth bass (8%) were the most abundant fishes captured, which composed 92% of the total fish captured (Table 4). In the north pond, the most abundant fishes captured were bluegill (35%), pumpkinseed (19%), warmouth (17%), and largemouth bass (11%), which composed 83% of the total catch (Table 4). In the Muskegon Lake, the most abundant fishes captured were pumpkinseed (27%), rock bass (17%), and round goby (10%), which composed 54% of the total catch (Table 4). Thus, species that tended to be representative of a sampling location were yellow perch and brown bullhead in the south pond, bluegill and warmouth in the north pond, and rock bass and round goby in Muskegon Lake (Figure 4b). In contrast, pumpkinseed and largemouth bass were well represented across sampling locations (Figure 4b).

In conclusion, the observations reported here provide the pre-restoration assessment of the fish assemblage and water quality of ponds at Veterans Memorial Park as well as baseline conditions in nearby sites in Muskegon Lake. During the pre-restoration monitoring reported here, we found evidence of degraded water quality (see Uzarski et al. [2005] for comparison with Great Lakes coastal wetlands and Janetski and Ruetz [2015] for comparison with other drowned river mouth lakes) in the south pond at Veterans Memorial Park, which could be important for explaining differences in CPUE and the fish assemblages among the three sampling locations.

This monitoring effort will provide a baseline to assess how the fish assemblage and water quality respond to habitat restoration activities at Veterans Memorial Park.

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Table 1. Latitude and longitude for each fish sampling site in 2015. Coordinates are the mean of the two nets at each site. Site locations are depicted in Figure 1.

Location	Site	Lat (°)	Long (°)
Muskegon Lake	1	43.25666	86.25440
Muskegon Lake	2	43.25478	86.25063
North pond	B	43.26365	86.24769
North pond	C	43.26426	86.24669
North pond	D	43.26362	86.24648
South pond	1-B	43.26162	86.24448
South pond	2-B	43.26000	86.24223
South pond	1-D	43.26194	86.24522
South pond	2-D	43.26037	86.24376
South pond	3-A	43.25913	86.24117
South pond	3-D	43.25887	86.24184

Table 2. Mean ± 1 standard error (*n* = 2) of environmental conditions measured during fyke netting in October 2015. Site duplicates (dup) are single samples highlighted in gray. SAV is submerged aquatic vegetation and EAV is emergent aquatic vegetation. Water quality variables where measured with a YSI sonde.

Location	Site	Depth (cm)	Water Temperature %	Dissolved Oxygen (mg/L)	% Dissolved Oxygen	Specific Conductivity (uS/cm)	Total Dissolved Solids (g/L)	Turbidity (NTU)	pH	Oxidation Reduction Potential	Chlorophyll *a* (ug/L)	SAV (%)	EAV (%)
Muskegon Lake	1	74±7	17.58±0.24	8.40±0.45	88.1±4.5	432±1	0.285±0.003	1.1±0.9	7.98±0.06	373±0	3.4±0.1	50±10	0±0
Muskegon Lake	1 dup	--	17.81	8.29	87.1	431	0.280	0.1	7.91	370.8	3.7	--	--
Muskegon Lake	2	78±5	16.05±0.01	9.14±0.06	92.8±0.6	432±0	0.281±0.000	1.3±0.5	8.15±0.02	373±1	3.4±0.1	40±10	0±0
North pond	B	98±4	14.62±0.00	6.57±0.13	65.0±1.5	502±0	0.327±0.001	0.8±1.2	7.50±0.00	371±1	3.8±0.4	53±3	45±5
North pond	C	95±6	14.64±0.03	5.63±0.21	55.6±2.1	520±0	0.338±0.000	-0.6±0.2	7.46±0.01	376±1	7.0±1.6	20±0	25±0
North pond	D	96±2	14.67±0.00	6.11±0.13	60.3±1.3	496±1	0.323±0.001	-0.7±0.0	7.58±0.01	359±5	5.2±0.6	15±5	25±0
North pond	D dup	--	14.67	6.01	59.2	497	0.323	-0.4	7.62	352	4.9	--	--
South pond	1-B	81±8	16.58±0.60	12.38±0.07	127.3±1.4	544±1	0.354±0.001	26.9±1.6	8.15±0.04	382±4	18.3±0.3	0±0	50±0
South pond	1-D	90±4	15.80±0.18	10.12±0.71	102.4±7.6	558±6	0.363±0.004	22.8±0.3	7.75±0.02	368±1	16.3±0.9	0±0	20±0
South pond	1-D dup	--	15.57	9.55	95.8	562	0.365	23.6	7.72	369	15.6	--	--
South pond	2-B	92±13	16.57±0.23	13.97±0.06	142.7±1.2	540±0	0.351±0.000	29.7±0.8	8.47±0.02	358±0	19.3±0.9	0±0	0±0
South pond	2-D	87±0	16.17±0.03	11.75±0.17	120.0±1.1	547±3	0.356±0.001	28.9±5.1	8.00±0.01	370±2	16.9±1.2	0±0	48±3
South pond	3-A	87±3	16.78±0.06	14.58±0.26	149.5±3.4	536±0	0.348±0.000	25.3±1.4	8.54±0.01	361±1	14.6±2.0	0±0	0±0
South pond	3-A dup	--	16.71	14.94	154.0	536	0.348	27.1	8.55	362	16.3	--	--
South pond	3-D	93±4	16.60±0.11	15.51±0.65	153.5±0.7	536±0	0.349±0.001	28.9±1.0	8.53±0.00	361±5	17.8±1.0	0±0	33±3

Note : Negatigve turbidity values should be interpreted as zero.

Table 3. Nutrients concentrations of water samples collected during fyke netting in 2015. Site duplicates (dup) are highlighted in gray.

Location	Site	Cl (mg/L)	NO_3-N (mg/L)	SRP-P (mg/L)	TP-P (mg/L)
Muskegon Lake	1	26	0.34	0.007	0.02
Muskegon Lake	1 dup	25	0.33	0.005	0.02
Muskegon Lake	2	26	0.49	<0.005	0.02
North pond	B	40	0.07	0.006	0.03
North pond	C	34	0.06	0.007	0.03
North pond	D	21	0.04	0.005	0.03
North pond	D dup	36	0.07	0.005	0.03
South pond	1-B	35	<0.01	0.008	0.12
South pond	2-B	34	<0.01	0.005	0.14
South pond	1-D	36	<0.01	0.016	0.12
South pond	1-D dup	38	0.05	0.018	0.12
South pond	2-D	35	0.05	0.017	0.14
South pond	3-A	34	<0.01	0.005	0.12
South pond	3-A dup	34	<0.01	0.005	0.12
South pond	3-D	35	<0.01	0.009	0.13

Note : values denoted as < are below the detection limit.

Table 4. Number and mean total length (TL; ranges reported parenthetically) of fish captured by fyke netting (n = 22 nets) at three locations in October 2015. The locations were Muskegon Lake (n = 4 nets), north pond (n = 6 nets), and south pond (n = 12 nets).

		Total	Lake		North		South	
Common name	Scientific name	Catch	Catch	TL (cm)	Catch	TL (cm)	Catch	TL (cm)
rock bass	*Ambloplites rupestris*	10	10	9.0 (4.9-10.7)	0	--	0	--
black bullhead	*Ameiurus melas*	3	0	--	0	--	3	25.8 (21.1-29.0)
yellow bullhead	*Ameiurus natalis*	11	0	--	0	--	11	15.7 (6.9-24.1)
brown bullhead	*Ameiurus nebulosus*	106	0	--	0	--	106	10.4 (7.5-28.8)
bowfin	*Amia calva*	8	0	--	2	45.5 (45.1-45.9)	6	38.9 (35.0-41.4)
goldfish	*Carrassius auratus*	22	0	--	0	--	22	16.0 (12.8-30.1)
white sucker	*Catostomus commersonii*	2	0	--	0	--	2	27.8 (26.2-29.4)
common carp	*Cyprinus carpio*	2	0	--	0	--	2	40.1 (24.6-55.5)
gizzard shad	*Dorosoma cepedianum*	20	5	10.0 (9.5-10.4)	0	--	15	10.4 (8.6-11.3)
northern pike	*Esox lucius*	2	0	--	2	22.4 (12.1-32.6)	0	--
brook silverside	*Labidesthes sicculus*	3	3	7.0 (6.3-8.2)	0	--	0	--
pumpkinseed	*Lepomis gibbosus*	417	16	6.0 (4.0-12.2)	12	13.1 (6.5-16.9)	389	9.4 (5.5-17.3)
warmouth	*Lepomis gulosus*	13	0	--	11	14.9 (4.0-20.5)	2	13.4 (10.0-16.7)
bluegill	*Lepomis macrochirus*	165	2	11.0 (4.8-17.2)	22	12.0 (4.6-16.5)	141	9.7 (3.5-22.9)
unknown sunfish	*Lepomis* spp.*	6	0	--	4	18.1 (16.3-19.5)	2	14.6 (12.0-17.2)
largemouth bass	*Micropterus salmoides*	102	5	12.9 (6.9-26.8)	7	9.9 (6.7-17.6)	90	10.6 (5.6-25.5)
silver redhorse	*Moxostoma anisurum*	1	1	45.8	0	--	0	--
round goby	*Neogobius melanostomus*	6	6	5.2 (3.0-7.4)	0	--	0	--
golden shiner	*Notemigonus crysoleucas*	10	0	--	0	--	10	12.4 (10.6-14.7)
spottail shiner	*Notropis hudsonius*	1	0	--	0	--	1	6.7
mimic shiner	*Notropis volucellus*	4	4	4.5 (4.0-5.3)	0	--	0	--
yellow perch	*Perca falvescens*	348	3	14.0 (13.0-14.6)	2	18.1 (13.6-22.5)	343	10.7 (7.7-30.3)
bluntnose minnow	*Pimephales notatus*	2	2	4.3 (3.7-4.8)	0	--	0	--
black crappie	*Pomxsis nigromaculatus*	21	2	17.4 (16.3-18.5)	1	22.3	18	16.8 (14.2-18.6)
	Total	**1285**	**59**		**63**		**1163**	

*Unknown sunfish was likely a hybrid between a pumpkinseed (*Lepomis gibbosus*) and a warmouth (*Lepomis gulosus*).

Figure 1. Map of Veterans Memorial Park ponds (Muskegon County, Michigan) showing study sites in north pond, south pond, and Muskegon Lake. The latitude and longitude for each site is reported in Table 1.

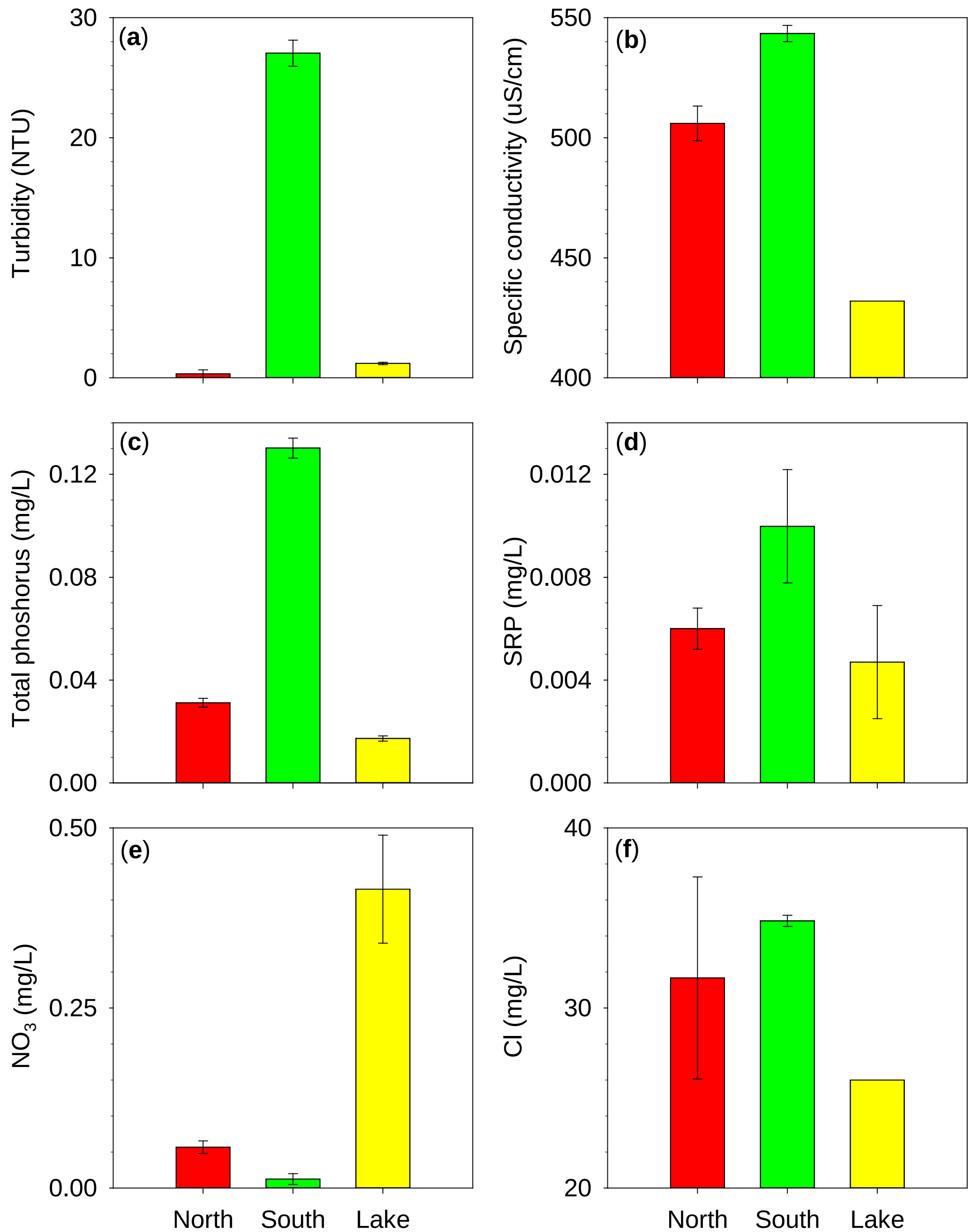

Figure 2. Mean (±1 SE) (**a**) turbidity, (**b**) specific conductivity, (**c**) total phosphorus (TP), (**d**) soluble reactive phosphorus (SRP), (**e**) nitrate (NO_3), and (**f**) chloride (Cl) in the north pond (n = 3 sites), south pond (n = 6 sites), and Muskegon Lake (n = 2 sites). Note that negative values of turbidity were assumed to be zero (see Table 2). If values were less than the detection limit for NO_3 or SRP, then a value of 0.5×detection limit was used to calculate means and SE.

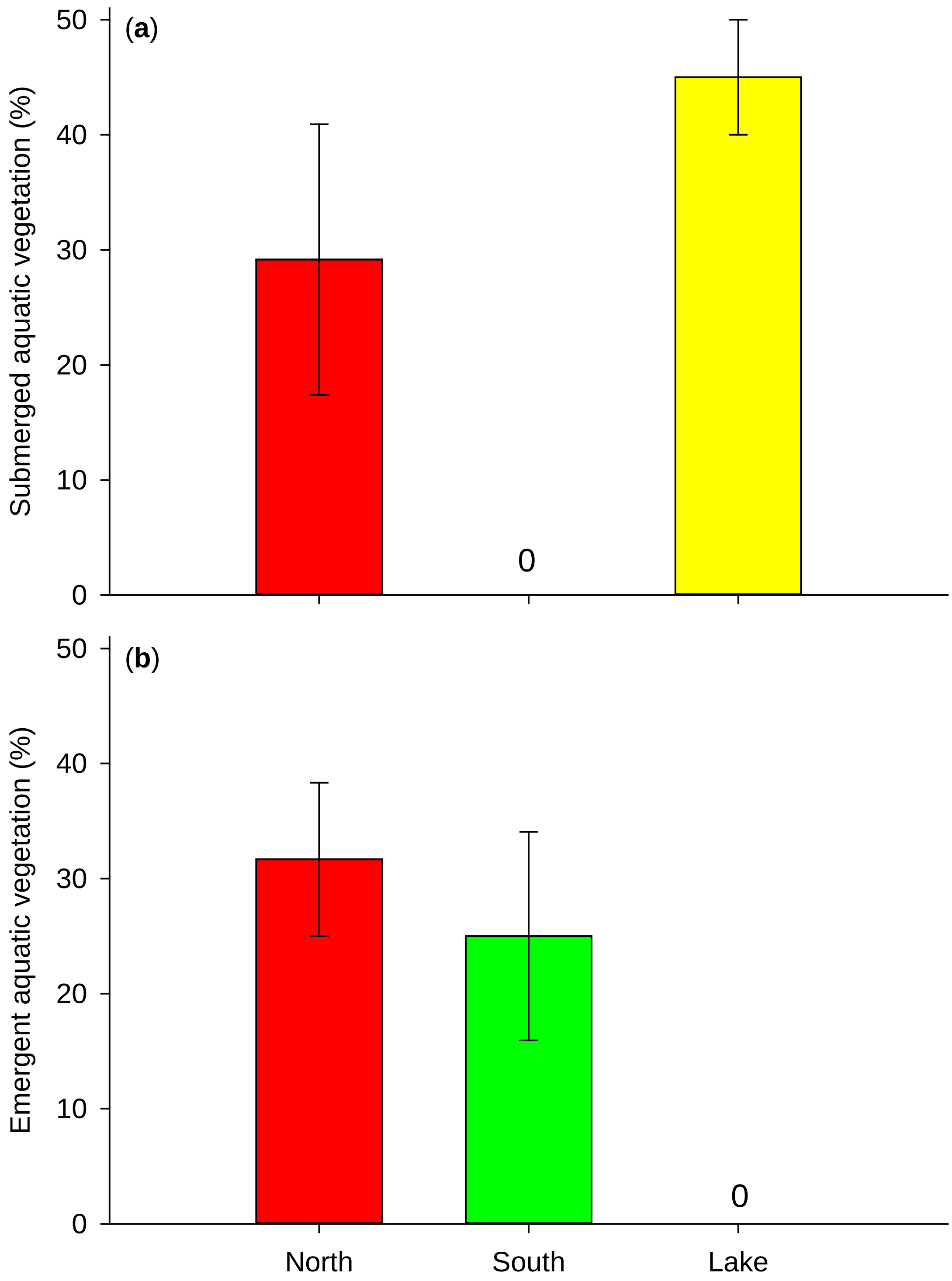

Figure 3. Mean (±1 SE) percent coverage of (**a**) submerged aquatic vegetation (SAV) and (**b**) emergent aquatic vegetation (EAV) in the north pond (*n* = 3 sites), south pond (*n* = 6 sites), and Muskegon Lake (*n* = 2 sites). Zeros indicate the absence of SAV or EAV at a sampling location.

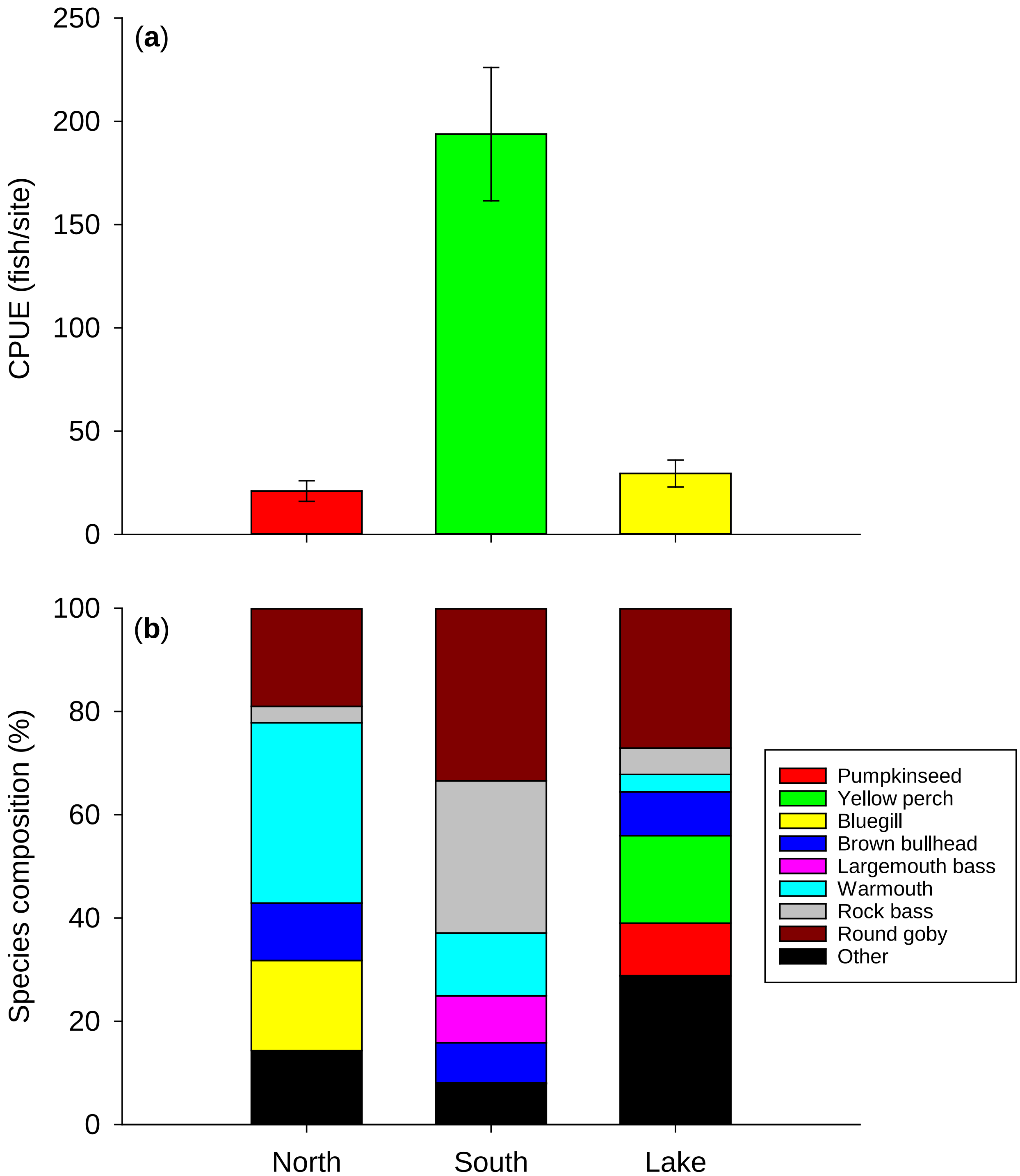

Figure 4. (**a**) Mean (±1 SE) total catch per unit effort (CPUE) and (**b**) fish species composition in the north pond (*n* = 3 sites), south pond (*n* = 6 sites), and Muskegon Lake (*n* = 2 sites). Two fyke nets were fished at each site. The legend only applies to panel (b); "other" includes all species not listed in the legend (see Table 4).

Appendix 1

Accuracy.—Accuracy is the agreement between an observed measurement and a true value. We used two approaches to evaluate accuracy. First, for SRP and TP, we calculated the percent recovery of two matrix spikes as $(C_s - C_u)/C_a \times 100$, where C_s is the measured concentration of a spiked sample, C_u is the measured concentration of the unspiked sample, and C_a is the actual concentration of the spike added. Using this approach, mean recovery was 96% (range = 92-99%) for SRP ($n = 4$ including a duplicate of each spike) and 102% (range = 98-106%) for TP ($n = 6$ including a duplicate of each spike). Note that C_a was 0.1 mg/L for both SRP and TP. Second, we calculated percent recovery of a standard for SRP (standard = 0.25 mg/L), TP (standard = 0.25 mg/L), NO_3 (standard = 5.0 or 2.5 mg/L), and Cl (standard = 50 or 25 mg/L). Using this approach, mean recovery of the standard was 96% (range = 95-97%) for SRP ($n = 3$), 96% (range = 95-98%) for TP ($n = 3$), 98% for a standard of 5 mg/L ($n = 2$) and 99% for a standard of 2.5 mg/L ($n = 2$) for NO_3, and 99% for a standard of 50 mg/L ($n = 2$) and 99% for a standard of 25 mg/L for Cl ($n = 2$). Therefore, we found evidence of high accuracy for our measurements of SRP, TP, NO_3, and Cl.

Precision.—Precision is the agreement between multiple measurements. For water quality measurements, we assessed precision by calculating the relative percent difference (RPD) as:

$$\mathrm{RPD} = \frac{(V_s - V_d)}{(V_s + V_d)/2}(100),$$

where V_s is the measured variable for the site, and V_d is the measured variable for the duplicate sample (see Tables 2 and 3). We reported the mean RPD for each variable ($n = 4$). All but two of the water quality variables met the precision target of RPD $\leq$ 20% (Table A1.1). In both cases, the high RPD was primarily the result of variability among values near zero (turbidity; Table 2) or the detection limit (NO_3; Table 3), which is further supported by the modest values of standard error relative to the mean for turbidity (Figure 2a) and NO_3 (Figure 2e).

Table A1.1. The mean relative percent difference (RPD) between each water quality variable (n = 4). Values greater than 20% are shown in bold, which did not meet the precision target of RPD ≤ 20%.

Variable	RPD (%)
Temperature	0.1
Dissolve oxygen	1.5
% dissolve oxygen	1.6
Specific conductivity	-0.2
Total dissolve solids	0.2
Turbidity	**52.6**
pH	0.1
Oxidation reduction potential	0.5
Chlorophyll *a*	-3.0
Cl	-13.5
NO_3[a]	**-53.8**
SRP	3.0
TP	-4.4

[a]For NO_3, if value was < detection limit (see Table 3), then a value of 0.5 × detection limit (i.e., 0.005 mg/L) was used to calculate RPD.

For fish sampling, we calculated RPD for the north pond, south pond, and Muskegon Lake based on the fyke net with the largest catch (C_s) and the smallest catch (C_d). The RPD at each location was 86% at Muskegon Lake (minimum catch in a fyke net was 8 fish and maximum catch was 20), 78% at the north pond (minimum catch in a fyke net was 7 fish and maximum catch was 16), and 124% at the south pond (minimum catch in a fyke net was 42 fish and maximum catch was 179). Thus, RPD was greater for fyke net catch compared with measurements of environmental variables, which is expected given the distribution of fish in a water body is often much more heterogeneously distributed across space relative to environmental variables (at least at the spatial scale we are considering). Nevertheless, we conclude that the observed precision was acceptable for both fish and environmental sampling.

Completeness.—Completeness is the amount of valid data obtained from sampling compared with the amount expected. The percent completeness (C) was calculated as $C = M_v/M_p \times 100$, where M_v is the number of valid measurements or samples and M_p is the number of planned measurements or samples. The completeness was 100% for fish and environmental sampling during 2015 (Table A1.2).

Table A1.2. The number of samples (*N*), number of field duplicates, number of valid measurements or samples (M_v), number of planned measurements or samples (M_p), and the percent completeness (*C*) for each method. The YSI sonde was used to measure water temperature, dissolved oxygen concentration, percent dissolved oxygen, specific conductivity, total dissolved solids, turbidity, pH, oxidation reduction potential, and chlorophyll *a*. Fyke netting was used to sample fish. Water grabs were used to analyze Cl, NO_3, SRP, and TP.

Method	*N*	Duplicates	M_v	M_p	*C* (%)
YSI sonde	22	4	26	26	100
Fyke netting	22	0	22	22	100
Water grabs	11	4	15	15	100

Note: *N* refers to the number of fish measurements for the YSI sonde (one measurement at the mouth of each fyke net), number of nets fished for one night for fyke netting (two nets were fished at each site), and number of samples collected for water grabs (one water sample was collected per site).

Appendix 2

The catch of fish by site in fyke netting during October 2015 at Muskegon Lake (Table A2.1), north pond (Table A2.2), and south pond (Table A2.3). Aggregate fish data were reported in Table 4 and Figure 4.

Table A2.1. Number and mean total length (TL; ranges reported parenthetically) of fish captured by fyke netting (*n* = 2 nets per site) at two sites in Muskegon Lake (see Figure 1). Fyke nets were retrieved on 6 October 2015.

		Site 1		Site 2	
Common name	Scientific name	Catch	TL (cm)	Catch	TL (cm)
rock bass	*Ambloplites rupestris*	6	10.0 (9.3-10.7)	4	7.6 (4.9-10.2)
gizzard shad	*Dorosoma cepedianum*	0	--	5	10.0 (9.5-10.4)
brook silverside	*Labidesthes sicculus*	2	7.4 (6.5-8.2)	1	6.3
pumpkinseed	*Lepomis gibbosus*	5	8.0 (4.5-12.2)	11	5.1 (4.0-5.7)
bluegill	*Lepomis macrochirus*	2	11.0 (4.8-17.2)	0	--
largemouth bass	*Micropterus salmoides*	3	10.3 (8.1-12.1)	2	16.9 (6.9-26.8)
silver redhorse	*Moxostoma anisurum*	1	45.8	0	--
round goby	*Neogobius melanostomus*	0	--	6	5.2 (3.0-7.4)
mimic shiner	*Notropis volucellus*	0	--	4	4.5 (4.0-5.3)
yellow perch	*Perca falvescens*	2	13.8 (13.0-14.6)	1	14.5
bluntnose minnow	*Pimephales notatus*	0	--	2	4.3 (3.7-4.8)
black crappie	*Pomxsis nigromaculatus*	2	17.4 (16.3-18.5)	0	--
	Total	**23**		**36**	

Table A2.2. Number and mean total length (TL; ranges reported parenthetically) of fish captured by fyke netting (*n* = 2 nets per site) at three sites in the north pond of Veterans Memorial Park (see Figure 1). Fyke nets were retrieved on 6 October 2015.

		Site B		Site C		Site D	
Common name	Scientific name	Catch	TL (cm)	Catch	TL (cm)	Catch	TL (cm)
bowfin	*Amia calva*	1	45.9	0	--	1	45.1
northern pike	*Esox lucius*	1	12.1	1	32.6	0	--
pumpkinseed	*Lepomis gibbosus*	2	11.8 (11.5-12.0)	9	14.2 (9.1-16.9)	1	6.5
warmouth	*Lepomis gulosus*	4	15.6 (12.7-17.7)	4	14.0 (4.0-20.5)	3	15.2 (12.0-19.8)
bluegill	*Lepomis macrochirus*	6	9.5 (4.6-14.6)	12	14.1 (11.9-16.5)	4	9.6 (4.6-14.5)
unknown sunfish	*Lepomis* spp.*	0	--	1	18.6	3	17.9 (16.3-19.5)
largemouth bass	*Micropterus salmoides*	2	12.2 (6.7-17.6)	2	8.6 (7.4-9.8)	3	9.3 (6.7-14.4)
yellow perch	*Perca falvescens*	0	--	1	13.6 (13.6-13.6)	1	22.5
black crappie	*Pomxsis nigromaculatus*	0	--	1	22.3	0	--
	Total	**16**		**31**		**16**	

*Unknown sunfish was likely a hybrid between a pumpkinseed (*Lepomis gibbosus*) and a warmouth (*Lepomis gulosus*).

Table A2.3. Number and mean total length (TL; ranges reported parenthetically) of fish captured by fyke netting (*n* = 2 nets per site) at six sites in the south pond of Veterans Memorial Park (see Figure 1). Fyke nets were retrieved on 8 October 2015.

		Site 1-B		Site 1-D		Site 2-B		Site 2-D		Site 3-A		Site 3-D	
Common name	Scientific name	Catch	TL (cm)	Catch	TL (cm)	Catch	TL (cm)	Catch	TL (cm)	Catch	TL (cm)	Catch	TL (cm)
black bullhead	*Ameiurus melas*	0	--	0	--	0	--	3	25.8 (20.1-29.0)	0	--	0	--
yellow bullhead	*Ameiurus natalis*	1	18.5	6	17.0 (8.9-24.1)	1	6.9	3	15.1 (12.2-18.0)	0	--	0	--
brown bullhead	*Ameiurus nebulosus*	18	14.3 (7.5-28.5)	13	8.5 (8.0-9.4)	20	10.7 (8.0-28.8)	36	9.2 (8.4-10.8)	15	9.4 (8.3-10.8)	4	10.5 (10.0-11.2)
bowfin	*Amia calva*	3	37.0 (35.0-40.5)	1	41.4	1	39.8	0	--	1	26.2	0	--
goldfish	*Carrassius auratus*	2	17.3 (15.0-19.5)	4	17.5 (13.1-30.1)	3	16.4 (15.0-17.6)	9	15.4 (13.5-17.4)	3	15.2 (12.8-17.2)	1	13.8
white sucker	*Catostomus commersonii*	0	--	1	29.4	0	--	0	--	1	26.2	0	--
common carp	*Cyprinus carpio*	2	40.1 (24.6-55.5)	0	--	0	--	0	--	0	--	0	--
gizzard shad	*Dorosoma cepedianum*	5	10.5 (9.5-11.3)	2	10.8 (10.3-11.2)	0	--	0	--	2	9.8 (8.9-10.6)	6	10.4 (8.6-11.0)
pumpkinseed	*Lepomis gibbosus*	109	9.5 (5.7-17.3)	81	9.3 (5.6-13.5)	24	10.0 (9.0-12.2)	89	9.3 (6.4-13.0)	53	9.5 (5.5-15.1)	33	9.5 (7.8-12.0)
warmouth	*Lepomis gulosus*	0	--	0	--	0	--	2	13.4 (10.0-16.7)	0	--	0	--
bluegill	*Lepomis macrochirus*	28	10.0 (4.2-12.8)	42	9.7 (3.7-19.3)	14	9.3 (4.6-13.2)	38	9.8 (3.5-22.9)	12	9.3 (4.6-14.3)	7	10.3 (8.6-12.1)
unknown sunfish	*Lepomis* spp.*	0	--	0	--	0	--	2	14.6 (12.0-17.2)	0	--	0	--
largemouth bass	*Micropterus salmoides*	14	11.2 (6.5-25.5)	23	9.8 (5.6-25.2	9	9.0 (7.4-11.4)	17	12.9 (7.5-25.0)	17	10.5 (7.3-24.5)	10	8.9 (7.5-17.1)
golden shiner	*Notemigonus crysoleucas*	0	--	3	13.0 (11.6-13.8)	4	11.7 (10.6-13.5)	1	11.9	2	13.3 (11.9-14.7)	0	--
spottail shiner	*Notropis hudsonius*	0	--	0	--	1	6.7	0	--	0	--	0	--
yellow perch	*Perca falvescens*	90	11.2 (8.0-30.3)	68	10.1 (8.0-15.8)	30	11.0 (8.3-23.3)	66	10.2 (7.7-25.9)	37	10.3 (8.0-26.4)	52	11.3 (8.1-26.4)
black crappie	*Pomxsis nigromaculatus*	9	16.5 (14.2-18.6)	0	--	5	16.9 (16.4-17.8)	2	17.1 (17.1-17.1)	2	17.3 (16.9-17.6)	0	--
	Total	**281**		**244**		**112**		**268**		**145**		**113**	

*Unknown sunfish was likely a hybrid between a pumpkinseed (*Lepomis gibbosus*) and a warmouth (*Lepomis gulosus*).