Long-Term Fish Monitoring of Lake Macatawa: Results from Year 5

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Introduction

This study was initiated to provide critical information on littoral fish populations that will be used to evaluate the performance of watershed restoration activities that are part of Project Clarity. Although we do not expect the benefits of the restoration activities in the watershed to be expressed in Lake Macatawa immediately, establishing baseline conditions in Lake Macatawa will be critical for evaluating ecological change over time. In autumn 2014, we initiated a long-term monitoring effort of the littoral fish assemblage of Lake Macatawa. Our fish sampling plan for Lake Macatawa is similar to our ongoing, long-term (since 2003) monitoring effort in Muskegon Lake (Bhagat and Ruetz 2011). By using the same monitoring protocols in each water body, Muskegon Lake can serve as a "control" to evaluate temporal changes in Lake Macatawa in an effort to assess how the lake is responding to watershed restoration activities.

Our primary objective in the fifth year of sampling was to continue to characterize the pre-restoration (baseline) littoral fish assemblage. We made preliminary comparisons with our ongoing work in Muskegon Lake (see Bhagat and Ruetz 2011) as well as with six Lake Michigan drowned river mouths for which we have data (see Janetski and Ruetz 2015). However, the true value of this fish monitoring effort will come in future years as we examine how the littoral fish assemblage responds to restoration activities in the watershed.

Methods

Study sites.—Lake Macatawa is a drowned river mouth lake in Holland, Michigan that is located on the eastern shore of Lake Michigan in Ottawa County. Lake Macatawa has an area of 7.20 km^2, mean depth of 3.66 m, and maximum depth of 12.19 m (MDNR 2011). The shoreline has high residential and commercial development, and the watershed consists mainly of agricultural land (MDNR 2011). Fish sampling was conducted at four littoral sites in Lake

Macatawa that represented a gradient from the mouth of the Macatawa River to the connecting channel with Lake Michigan (Figure 1; Table 1). In 2016, much of the riparian vegetation was removed at site #2 for a construction project. The clearing of most trees and woody vegetation that were flooded by high Great Lakes water levels at site #2 (most were cut off at the water level) provided habitat structure for fish that could be more easily accessed by sampling gear (especially with respect to boat electrofishing) than prior to removal.

Fish sampling.—At each study site, we sampled fish via fyke netting and boat electrofishing. Using both sampling gears should better characterize the littoral fish assemblage than either gear by itself because small-bodied fishes are better represented in fyke netting and large-bodied fishes are better represented in nighttime boat electrofishing (Ruetz et al. 2007). Fyke nets were set on 4 September 2018 during daylight hours (i.e., between 1100 and 1600) and fished for about 22.0 h (range = 21.8-22.3 h). Three fyke nets (4-mm mesh) were fished at each site; two fyke nets were set facing each other and parallel to the shoreline, whereas a third fyke net was set perpendicular to the shoreline following the protocol used by Bhagat and Ruetz (2011). A description of the design of the fyke nets is reported in Breen and Ruetz (2006). We conducted nighttime boat electrofishing at each site on 6 September 2018. A 10-min (pedal time) electrofishing transect was conducted parallel to the shoreline at each site with two people at the front of the boat to net fish. The electrofishing boat was equipped with a Smith-Root 5.0 generator-powered pulsator control box (pulsed DC, 220 volts, ~7 amp). For both sampling methods, all fish captured were identified to species, measured (total length), and released in the field; however, some specimens were preserved to confirm identifications in the laboratory.

We measured water quality variables (i.e., temperature, dissolved oxygen, specific conductivity, total dissolved solids, turbidity, pH, oxidation-reduction potential [ORP], and chlorophyll *a*) in the middle of the water column using a YSI 6600 multi-parameter data sonde.

Note that the probe used to measure ORP on our YSI sonde malfunctioned during 2018 sampling, so we do not report that variable in our 2018 data. We made one measurement at each fyke net (n = 12) and one measurement at the beginning of each electrofishing transect (n = 4). We measured the water depth at the mouth of each fyke net and visually estimated the percent macrophyte cover for the length of the lead between the wings of each fyke net (see Bhagat and Ruetz 2011). In previous years, we also visually estimated the percent macrophyte cover for the length of each electrofishing transect during fish sampling; however, we were unable to see the lake bottom during electrofishing transects and were unable to make such an assessment in 2018.

Results and Discussion

We characterized water quality variables at each site during fish sampling (Tables 2 and 3). The mean water depth at fyke nets was 91 cm (Table 2). Mean water temperature was similar during fyke netting (25.5 °C; Table 2) and boat electrofishing (24.2 °C; Table 3). At fyke nets, mean % cover of macrophytes was zero at site #1 and approached zero at site #2 (<1%), whereas mean % cover of macrophytes was 17% and 23% at sites #3 and #4, respectively. Unfortunately, we were unable to estimate macrophyte cover at electrofishing transects because we could not see the lake bottom. The trend is an increase in % macrophyte cover over time, although we observed lower % macrophyte cover during fyke netting in 2018 than in 2017 (Figure 2). We hypothesized that low densities of macrophytes in Lake Macatawa during 2014 and 2015 were caused by insufficient light penetrating the water column to allow submersed plants to grow; both turbidity from inflowing sediment and abundant phytoplankton growth in the lake water column can reduce light penetration.

As stated in past reports, aquatic macrophytes are important habitat for fish (e.g., Radomski and Goeman 2001), and their return is an important goal for the restoration of the fish

community in Lake Macatawa. The presence of macrophyte beds in the vicinity of our fish sampling sites were likely related to the lower turbidity that we observed in the lake (2016-2018) compared with 2014-2015 (Figure 3B). A detailed macrophyte survey, conducted on a 3-5 year interval, would provide useful information for Lake Macatawa's ecological status (see Ogdahl and Steinman 2014).

Compared to six Lake Michigan drowned river mouths, water quality in Lake Macatawa was most similar to Kalamazoo Lake, especially with respect to high turbidity and specific conductivity (Janetski and Ruetz 2015). Turbidity and specific conductivity were higher in Lake Macatawa than Muskegon Lake, the drowned river mouth lake for which we have the longest time series of water quality observations (Bhagat and Ruetz 2011). High levels of turbidity and specific conductivity often are associated with relatively high anthropogenic disturbance in Great Lakes coastal wetlands (Uzarski et al. 2005). Thus, the water quality we measured in Lake Macatawa appears on the degraded side of the spectrum among Lake Michigan drowned river mouths (see Uzarski et al. 2005, Janetski and Ruetz 2015). Nevertheless, turbidity and specific conductivity were lower in 2018 than in 2014 and 2015 (Figure 3). Within the lake itself, there was a gradient in specific conductivity and turbidity, with higher levels closer at the east end and lower levels closer to Lake Michigan (Tables 2 and 3). This is to be expected given that most of the sediment entering the lake comes from the Macatawa River, which runs off largely agricultural land and through urbanized Holland.

We captured 1,503 fish comprising 28 species in Lake Macatawa during 2018 sampling surveys (Table 4), which was similar to most years (Figure 4). The most abundant fishes in the combined catch (i.e., fyke netting and boat electrofishing in 2018) were bluegill (34%), gizzard shad (32%), and yellow perch (6%), which composed 72% of the total catch (Figure 5A). Four of the 28 species captured during 2018 were non-native to the Great Lakes basin (Bailey et al.

2004)—alewife, common carp, white perch, and round goby—which composed 9% of the total catch (Table 4).

In fyke netting, bluegill (41%), gizzard shad (34%), spotfin shiner (5%), and alewife (4%) were the most abundant fishes in the catch, composing 84% of all fish captured (Figure 5B). Bluegill was the most abundant or second most abundant species in the catch at all sites (Table 5). Gizzard shad was most abundant in the catch at site #2 (Table 5). Although not the most abundant species in the catch, alewife was the next most abundant species at site #3, and spotfin shiner was the next most abundant species at site #4 (Table 5). The number of fish captured also varied among sites, with the most fish captured at sites #2 and #1 (Table 5; Figure 6A). Compared with the previous fyke netting surveys, the most abundant species in the catch varied among years (Figure 7) as did the patterns in total catch among sites (Figure 6A). The main differences in the relative abundance (i.e., percentage of a fish species in the total catch for a given year) were that we captured more bluegill in 2018 than previous years (Figure 7). The relative abundance of gizzard shad and alewife in 2018 also was high compared with most other years, whereas brook silverside was much lower than in 2017 (Figure 7). As we continue monitoring Lake Macatawa, we will be better able to assess spatiotemporal patterns and whether these observed patterns are associated with other environmental variables.

In boat electrofishing, the most abundant fishes captured were gizzard shad (24%), yellow perch (22%), white perch (13%), largemouth bass (12%), pumpkinseed (8%), and bluegill (7%), which composed 86% of the total catch (Figure 5C). Yellow perch was most abundant in the catch at sites #2 and #4, and gizzard shad was most abundant in the catch at sites #1 and #3 (Table 6). The next most abundant species in the catch was gizzard shad at site #2, largemouth bass at site #4, and white perch at sites #1 and #3 (Table 6). Total catch also varied among sites in 2018, with the higher catch at sites #2 and #4 and lower catch at sites #3 and #1 (Figure 6B).

Compared with previous boat electrofishing surveys, the most abundant species in the catch varied among years, although the pattern was more similar among recent years (i.e., 2016-2018; Figure 8). Overall, there appears to be less variability in species composition for boat electrofishing surveys compared with fyke netting surveys (see Figure 8 vs. Figure 7). The main difference in the littoral fish assemblage among annual electrofishing surveys was that gizzard shad, largemouth bass, and bluegill were more common and spottail shiner and pumpkinseed were less common in 2016-2018 compared with 2014-2015 (Figure 8).

In conclusion, the observations reported here are the fifth year of an effort to characterize the littoral fish assemblage of Lake Macatawa. This monitoring effort will provide a baseline to assess how the fish assemblage responds to restoration activities in the Lake Macatawa watershed. Although we have completed only 5 years of fish monitoring, we observed differences in total catch (Figure 6) and relative abundance among years (Figures 7 and 8). As we continue to build our time series of observations, we will be able to make more robust inferences about the littoral fish assemblage of Lake Macatawa (in terms of assessing the baseline, evaluating change over time, and comparing abiotic and biotic variables with other drowned river mouth lakes in the region) and better identify likely underlying mechanisms driving spatiotemporal patterns.

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Table 1. Locations (latitude and longitude) for each 2018 fish sampling site; coordinates are the mean of the three fyke nets and the start and end of each boat electrofishing transect. Site locations are depicted in Figure 1.

			Electrofishing			
	Fyke netting		Start		End	
Site	Lat (°)	Long (°)	Lat (°)	Long (°)	Lat (°)	Long (°)
1	42.79559	-86.12270	42.79578	-86.12104	42.79568	-86.12351
2	42.78843	-86.14423	42.78807	-86.14469	42.79000	-86.14377
3	42.78651	-86.17490	42.78402	-86.17302	42.78671	-86.17510
4	42.77990	-86.19661	42.77902	-86.19801	42.78053	-86.19601

Table 2. Mean ± 1 standard error (n = 3) of water quality variables at fish sampling sites in Lake Macatawa. Measurements were made during fyke netting on 4 September 2018 with a YSI sonde.

Site	Depth (cm)	Water Temperature (°C)	Dissolved Oxygen (mg/L)	% Dissolved Oxygen	Specific Conductivity (µS/cm)	Total Dissolved Solids (g/L)	Turbidity (NTU)	pH	Oxidation Reduction Potential	Chlorophyll *a* (µg/L)
1	95±1	26.49±0.10	13.50±0.15	168.0±0.7	504±1	0.33±0.00	14.8±1.5	8.67±0.04	--	77.8±2.7
2	93±17	25.72±0.01	13.43±0.59	164.9±7.2	482±0	0.31±0.00	11.8±0.4	8.71±0.00	--	103.7±4.4
3	96±1	24.96±0.04	11.69±0.23	141.5±2.7	410±1	0.27±0.00	12.5±3.3	8.89±0.01	--	50.7±3.6
4	83±5	24.72±0.05	12.49±0.18	150.5±2.0	406±0	0.26±0.00	11.1±3.6	8.96±0.00	--	44.8±7.0

Table 3. Water quality variables at fish sampling sites in Lake Macatawa. Measurements were made during nighttime boat electrofishing on 6 September 2018 with a YSI sonde.

Site	Water Temperature (°C)	Dissolved Oxygen (mg/L)	% Dissolved Oxygen	Specific Conductivity (µS/cm)	Total Dissolved Solids (g/L)	Turbidity (NTU)	pH	Oxidation Reduction Potential (mV)	Chlorophyll *a* (µg/L)
1	24.59	8.88	106.8	530	0.345	15.6	7.92	--	80.3
2	24.30	8.99	107.5	493	0.320	12.9	8.22	--	76.6
3	24.02	10.27	122.2	430	0.280	11.6	8.71	--	74.2
4	23.82	10.73	127.2	415	0.270	5.9	8.81	--	44.8

Table 4. Number and mean total length (TL; ranges reported parenthetically) of fish captured by fyke netting (n = 12 nets) on 5 September 2018 and boat electrofishing (n = 4 transects) on 6 September 2018 at four sites in Lake Macatawa. Total catch combined both gears.

		Total	Fyke netting		Electrofishing	
Common name	Scientific name	Catch	Catch	TL (cm)	Catch	TL (cm)
alewife	*Alosa pseudoharengus*	51	51	6.7 (4.8-10.0)	0	--
bowfin	*Amia calva*	4	3	52.9 (41.9-64.1)	1	37.5
freshwater drum	*Aplodinotus grunniens*	3	0	--	3	18.5 (9.9-23.0)
white sucker	*Catostomus commersonii*	26	13	41.1 (27.5-47.7)	13	41.6 (36.2-48.0)
spotfin shiner	*Cyprinella spiloptera*	63	63	7.2 (3.5-9.8)	0	--
common carp	*Cyprinus carpio*	4	0	--	4	58.3 (55.4-60.3)
gizzard shad	*Dorosoma cepedianum*	475	401	8.2 (4-14.9)	74	11.7 (7.4-18.2)
muskellunge	*Esox masquinongy*	1	1	13.1	0	--
banded killifish	*Fundulus diaphanus*	3	2	6.5 (6.3-6.7)	1	9.4
channel catfish	*Ictalurus punctatus*	10	9	45.2 (39.4-51.2)	1	54.9
brook silverside	*Labidesthes sicculus*	13	12	5.9 (5.0-7.0)	1	5.1
pumpkinseed	*Lepomis gibbosus*	53	29	11.2 (4.3-16.8)	24	14.3 (5.9-16.5)
bluegill	*Lepomis macrochirus*	505	482	3.8 (2.1-18.6)	23	15.5 (5.9-19.5)
largemouth bass	*Micropterus salmoides*	49	11	19.7 (4.7-45.1)	38	19.6 (5.7-48.8)
white perch	*Morone americana*	64	23	12.0 (9.0-21.1)	41	10.3 (8.9-17.8)
white bass	*Morone chrysops*	1	0	--	1	16.3
silver redhorse	*Moxostoma anisurum*	2	0	--	2	63.9 (63.9-63.9)
shorhead redhorse	*Moxostoma macrolepidotum*	1	1	47.5	0	--
round goby	*Neogobius melanostomus*	11	11	5.8 (3.7-12.1)	0	--
golden shiner	*Notemigonus crysoleucas*	16	13	5.2 (3.7-9.4)	3	16.9 (14.0-21.3)
emerald shiner	*Notropis atherinoides*	4	3	9.1 (8.9-9.5)	1	5.1
spottail shiner	*Notropis hudsonius*	16	7	7.1 (3.7-10.6)	9	9.6 (8.1-11.9)
mimic shiner	*Notropis volucellus*	1	1	4.3	0	--
yellow perch	*Perca falvescens*	97	27	15.0 (8.2-20.3)	70	14.4 (8.4-19.5)
bluntnose minnow	*Pimephales notatus*	26	26	5.7 (4.2-8.9)	0	--
black crappie	*Pomoxis nigromaculatus*	1	1	9.2	0	--
flathead catfish	*Pylodictis olivaris*	1	1	86.0	0	--
walleye	*Sander vitreus*	2	0	--	2	53.3 (47.3-59.3)
	Total	**1503**	**1191**		**312**	

Table 5. Number and mean total length (TL; range reported parenthetically) of fish captured by fyke netting (n = 3 nets per site) at four sites in Lake Macatawa on 5 September 2018. Site locations are depicted in Figure 1.

		Site #1		Site #2		Site #3		Site #4	
Common name	Scientific name	Catch	TL (cm)	Catch	TL (cm)	Catch	TL (cm)	Catch	TL (cm)
alewife	*Alosa pseudoharengus*	0	--	0	--	50	6.7 (4.8-10.0)	1	6.4
bowfin	*Amia calva*	0	--	0	--	2	58.5 (52.8-64.1)	1	41.9
white sucker	*Catostomus commersonii*	4	38.2 (27.5-44.0)	1	42.3	4	41.0 (35.6-47.7)	4	43.8
spotfin shiner	*Cyprinella spiloptera*	1	8.1	17	6.8 (3.5-8.9)	5	8.4 (6.8-9.8)	40	7.1 (4.4-9.0)
gizzard shad	*Dorosoma cepedianum*	9	11.0 (7.1-14.4)	386	8.2 (6.1-13.6)	5	9.1 (4.0-11.0)	1	14.9
muskellunge	*Esox masquinongy*	1	13.1	0	--	0	--	0	--
banded killifish	*Fundulus diaphanus*	0	--	0	--	0	--	2	6.5 (6.3-6.7)
channel catfish	*Ictalurus punctatus*	3	41.2 (39.4-42.5)	3	48.9 (47.6-51.2)	1	44.6	2	45.9 (45.6-46.2)
brook silverside	*Labidesthes sicculus*	2	6.2 (6.1-6.3)	0	--	0	--	10	5.8 (5.0-7.0)
pumpkinseed	*Lepomis gibbosus*	10	11.3 (5.7-15.4)	5	14.8 (11.2-16.8)	4	13.0 (5.4-16.0)	10	8.5 (4.3-15.3)
bluegill	*Lepomis macrochirus*	209	3.9 (2.1-18.6)	96	3.8 (2.6-17.7)	92	3.6 (2.7-5.6)	85	4.0 (2.8-15.9)
largemouth bass	*Micropterus salmoides*	3	33.3 (12.8-45.1)	0	--	3	19.9 (4.7-44.1)	5	11.3 (7.2-24.3)
white perch	*Morone americana*	4	10.3 (9.7-11.2)	12	13.9 (9.1-21.1)	2	10.3 (9.8-10.7)	5	9.7 (9.0-10.7)
shorhead redhorse	*Moxostoma macrolepidotum*	1	47.5	0	--	0	--	0	--
round goby	*Neogobius melanostomus*	1	5.4	2	6.6 (6.6-6.6)	1	4.0	7	5.9 (3.7-12.1)
golden shiner	*Notemigonus crysoleucas*	9	4.8 (3.7-9.4)	0	--	1	4.1	3	6.9 (4.6-8.5)
emerald shiner	*Notropis atherinoides*	1	8.9	0	--	1	9.5	1	9.0
spottail shiner	*Notropis hudsonius*	1	7.7	2	3.7 (3.7-3.7)	3	9.8 (8.3-10.6)	1	5.3
mimic shiner	*Notropis volucellus*	0	--	0	--	0	--	1	4.3
yellow perch	*Perca falvescens*	9	13.4 (8.6-19.6)	6	15.7 (9.7-18.4)	8	15.4 (8.2-20.3)	4	46.8 (14.9-19.1)
bluntnose minnow	*Pimephales notatus*	4	7.5 (6.2-8.7)	0	--	0	--	22	5.4 (4.2-8.9)
black crappie	*Pomoxis nigromaculatus*	1	9.2	0	--	0	--	0	--
flathead catfish	*Pylodictis olivaris*	1	86.0	0	--	0	--	0	--
	Total	**274**		**530**		**182**		**205**	

Table 6. Number and mean total length (TL; range reported parenthetically) of fish captured by nighttime boat electrofishing (n = 1 transect per site) at four sites in Lake Macatawa on 6 September 2018. Site locations are depicted in Figure 1.

		Site #1		Site #2		Site #3		Site #4	
Common name	Scientific name	Catch	TL (cm)	Catch	TL (cm)	Catch	TL (cm)	Catch	TL (cm)
bowfin	*Amia calva*	0	--	0	--	0	--	1	37.5
freshwater drum	*Aplodinotus grunniens*	0	--	1	9.9	0	--	2	22.9 (22.7-23.0)
white sucker	*Catostomus commersonii*	0	--	2	40.9 (38.0-43.8)	2	40.9 (39.7-42.0)	9	42.0 (36.2-48.0)
common carp	*Cyprinus carpio*	1	55.4	1	57.4	2	60.3 (60.2-60.3)	0	--
gizzard shad	*Dorosoma cepedianum*	10	9.1 (7.4-12.0)	25	11.5 (10.3-17.8)	33	12.7 (8.6-18.2)	6	11.8 (9.3-13.2)
banded killifish	*Fundulus diaphanus*	0	--	0	--	0	--	1	9.4
channel catfish	*Ictalurus punctatus*	0	--	0	--	0	--	1	54.9
brook silverside	*Labidesthes sicculus*	0	--	1	5.1	0	--	0	--
pumpkinseed	*Lepomis gibbosus*	3	13.2 (10.6-16.0)	13	14.5 (11.0-16.5)	1	14.7	7	14.2 (5.9-16.2)
bluegill	*Lepomis macrochirus*	3	16.4 (16.0-16.6)	17	15.5 (5.9-19.5)	1	13.2	2	15.8 (15.0-16.6)
largemouth bass	*Micropterus salmoides*	7	23.1 (14.0-48.8)	15	24.4 (14.9-33.8)	0	--	16	13.7 (5.7-34.0)
white perch	*Morone americana*	8	12.0 (9.5-17.8)	17	9.8 (8.9-10.3)	4	9.5 (9.2-9.8)	12	10.2 (9.0-16.7)
white bass	*Morone chrysops*	0	--	0	--	1	16.3	0	--
silver redhorse	*Moxostoma anisurum*	1	63.9	0	--	0	--	1	63.9
golden shiner	*Notemigonus crysoleucas*	0	--	0	--	1	14	2	18.4 (15.5-21.3)
emerald shiner	*Notropis atherinoides*	1	5.1	0	--	0	--	0	--
spottail shiner	*Notropis hudsonius*	0	--	4	8.7 (8.2-9.1)	2	9.1 (8.1-10.1)	3	11.2 (10.8-11.9)
yellow perch	*Perca flavescens*	3	17.6 (16.7-19.1)	26	14.7 (9.1-17.6)	2	17.3 (16.1-18.4)	39	13.7 (8.4-19.5)
walleye	*Sander vitreus*	0	--	0	--	2	53.3 (47.3-59.3)	0	--
	Total	**37**		**122**		**51**		**102**	

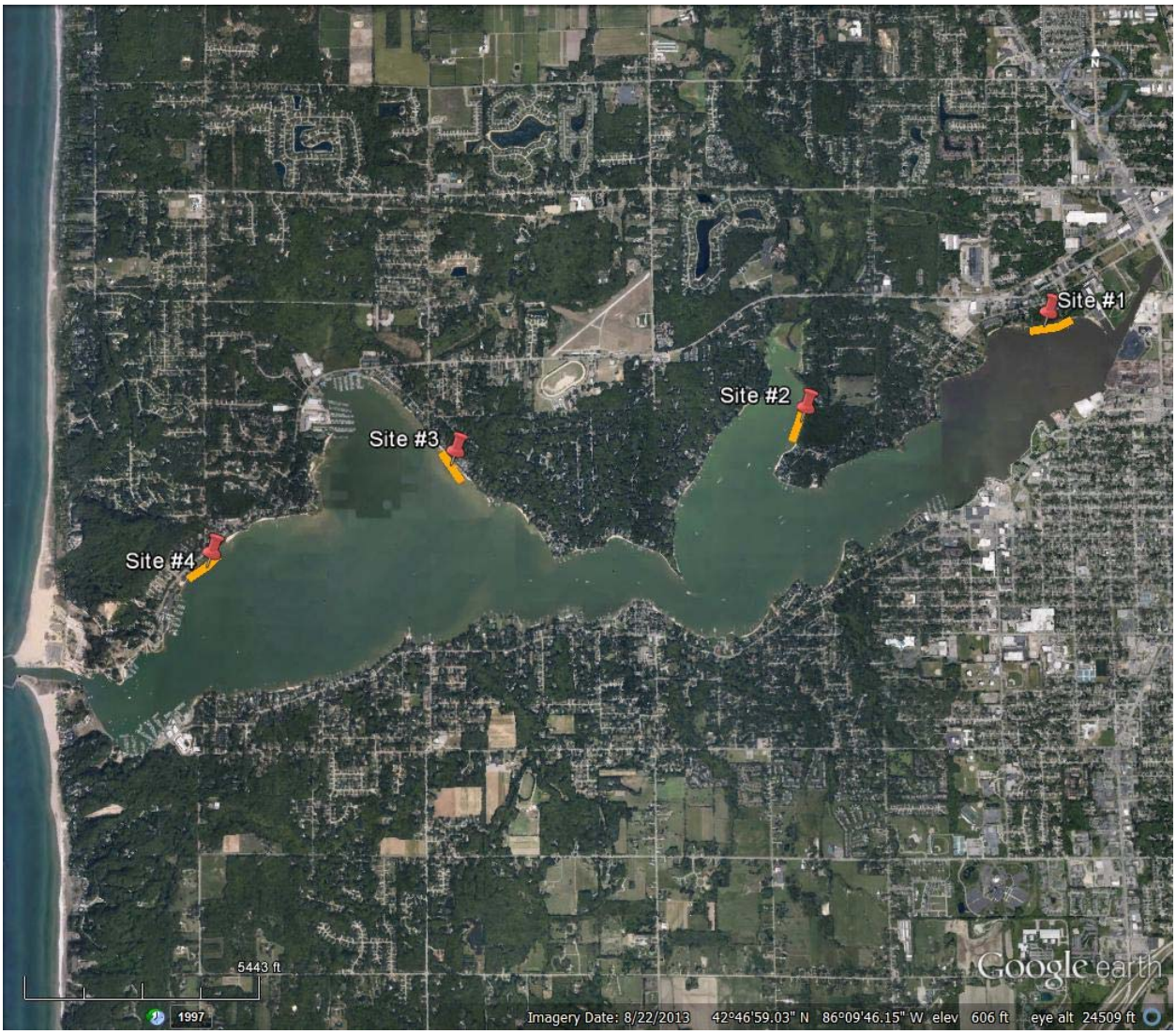

Figure 1. Map of Lake Macatawa (Ottawa County, Michigan) showing fish sampling sites. The orange transects depict approximately where boat electrofishing was conducted at each site. Site #1 is closest to the Macatawa River and site #4 is closest to Lake Michigan.

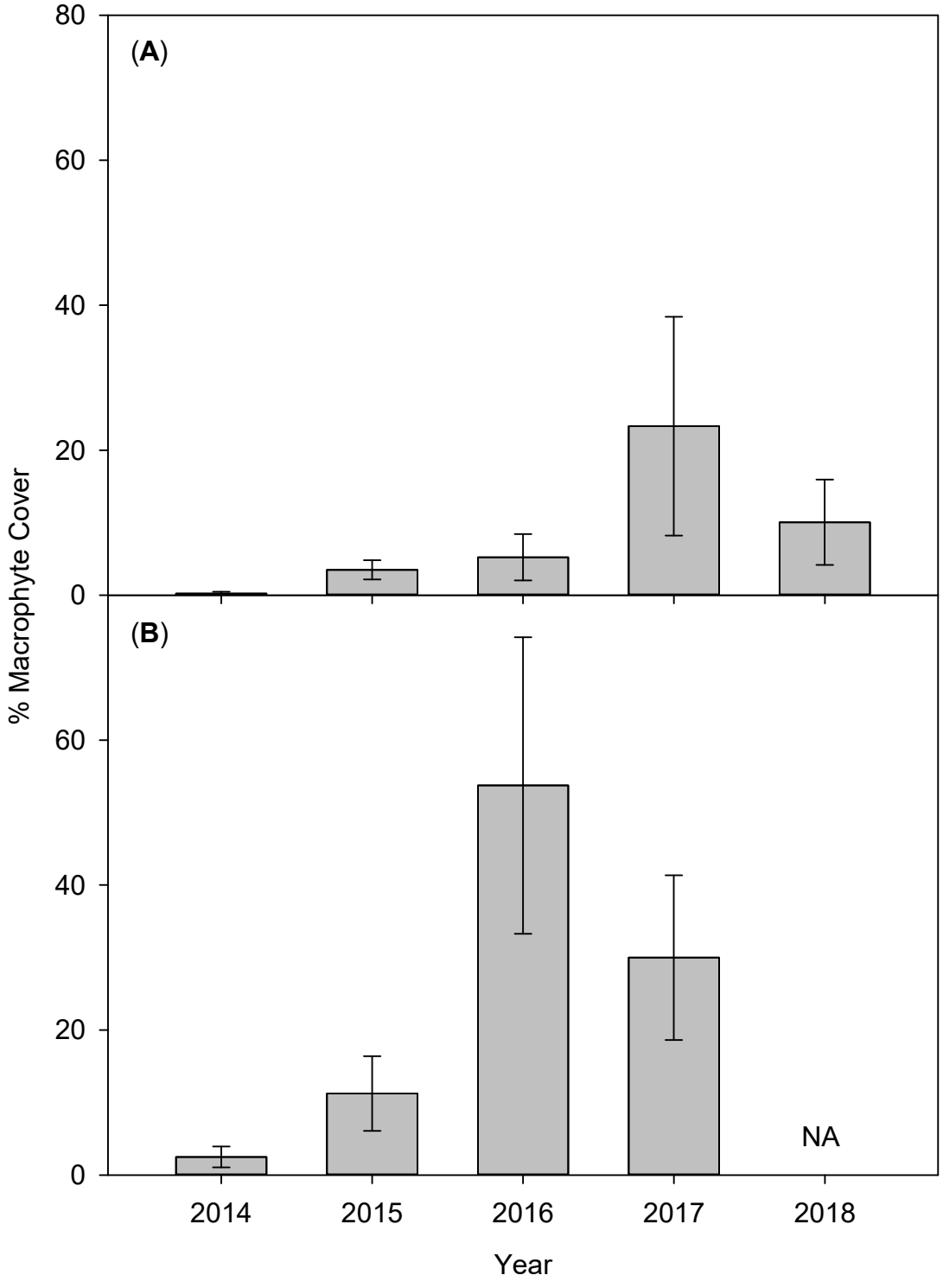

Figure 2. Mean (±1 standard error) % macrophyte cover visually estimated at (**A**) fyke net locations and (**B**) boat electrofishing transects in Lake Macatawa (n = 4 sites per year). Note that the area where macrophyte cover is assessed during fyke netting is much less compared with a boat electrofishing transect. NA means data were not available.

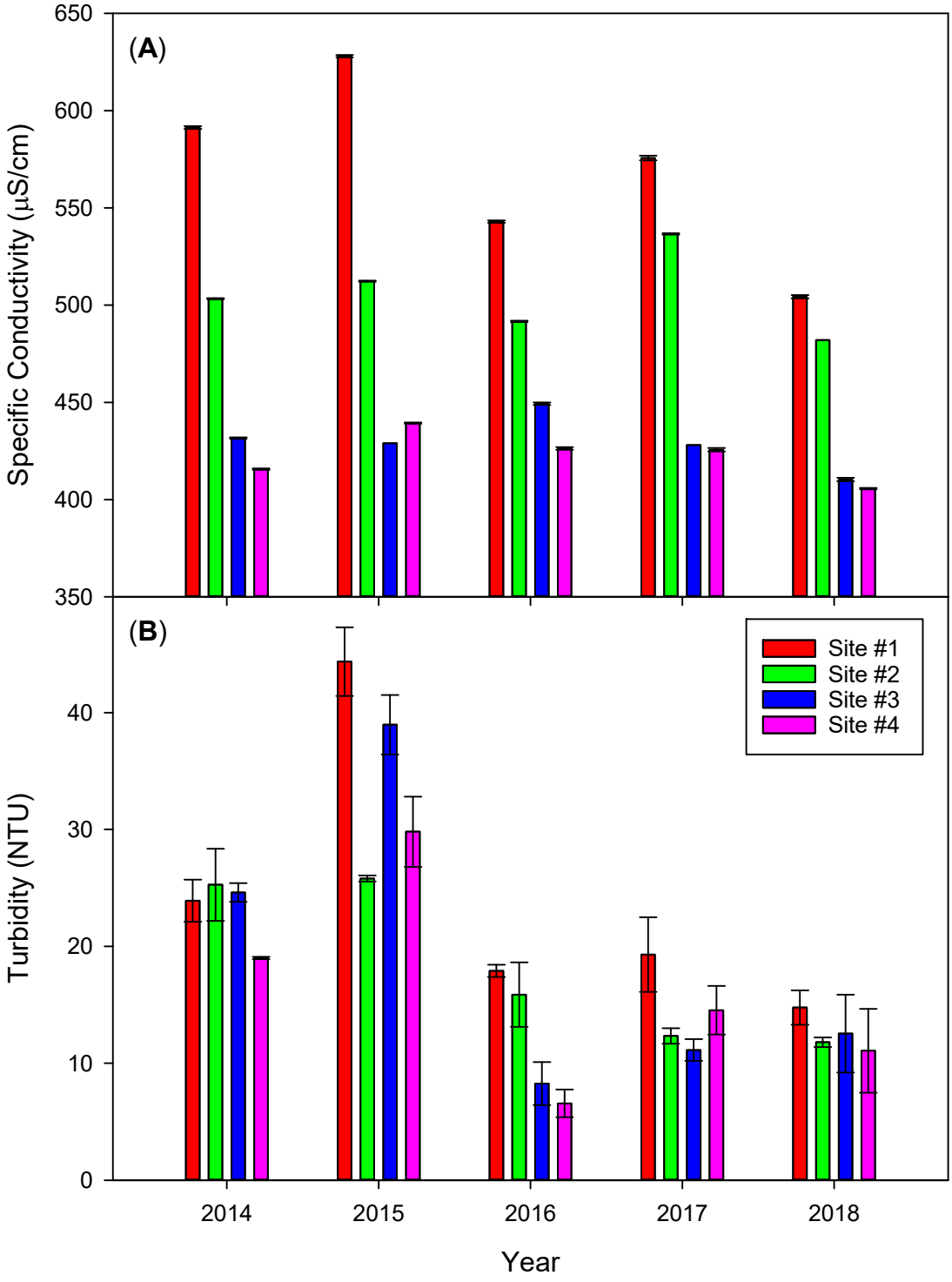

Figure 3. Mean (**A**) specific conductivity and (**B**) turbidity measured during fyke netting in Lake Macatawa. Error bars represent ±1 standard error (n = 3 nets per site), although they may be too small to be visible for some means.

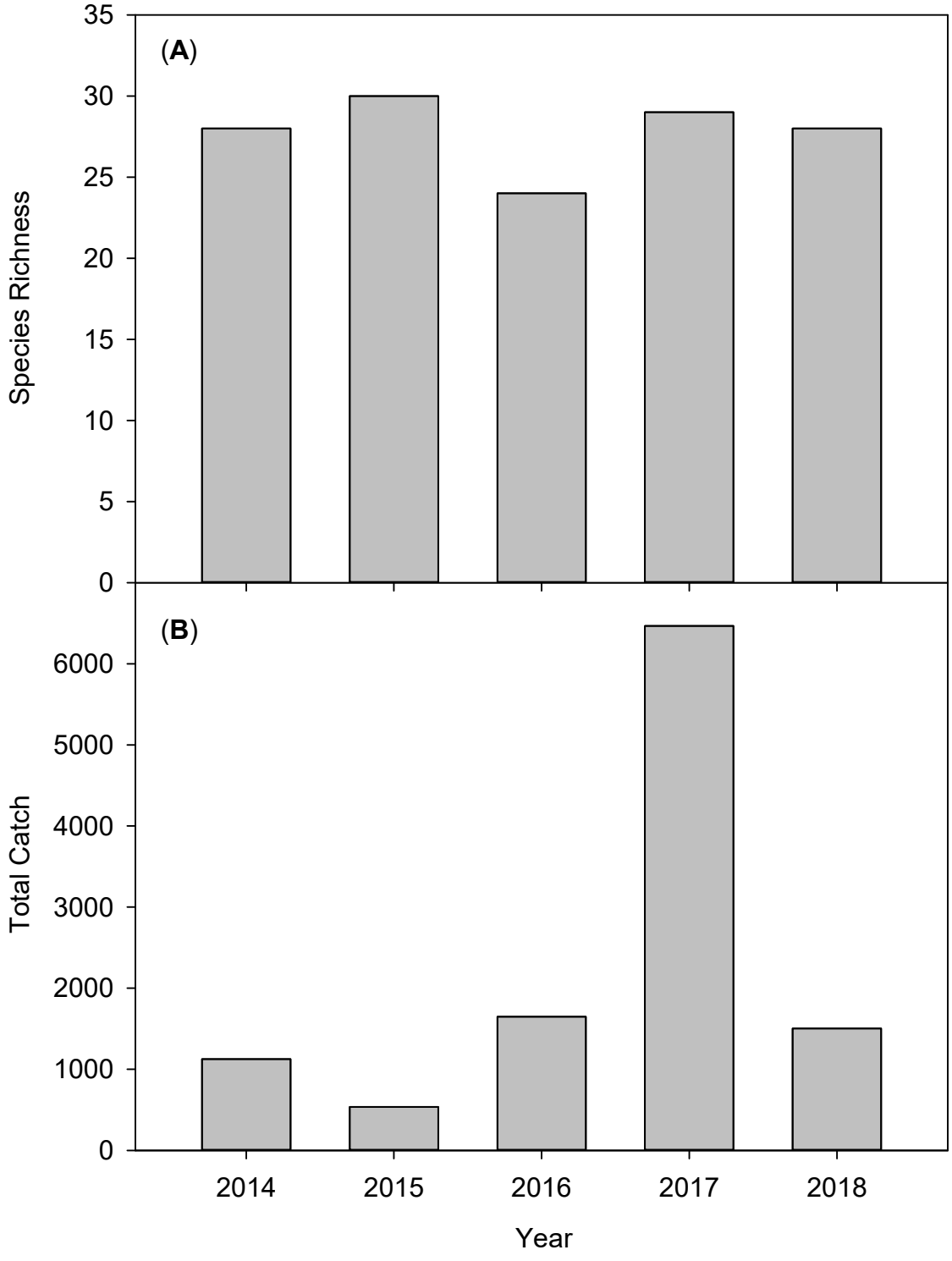

Figure 4. (**A**) Number of fish species captured and (**B**) total number of fish captured using both fyke netting and boat electrofishing each year in Lake Macatawa. *Note*: the high catch in 2017 was due to 5,288 brook silversides captured from a single fyke net at site #4.

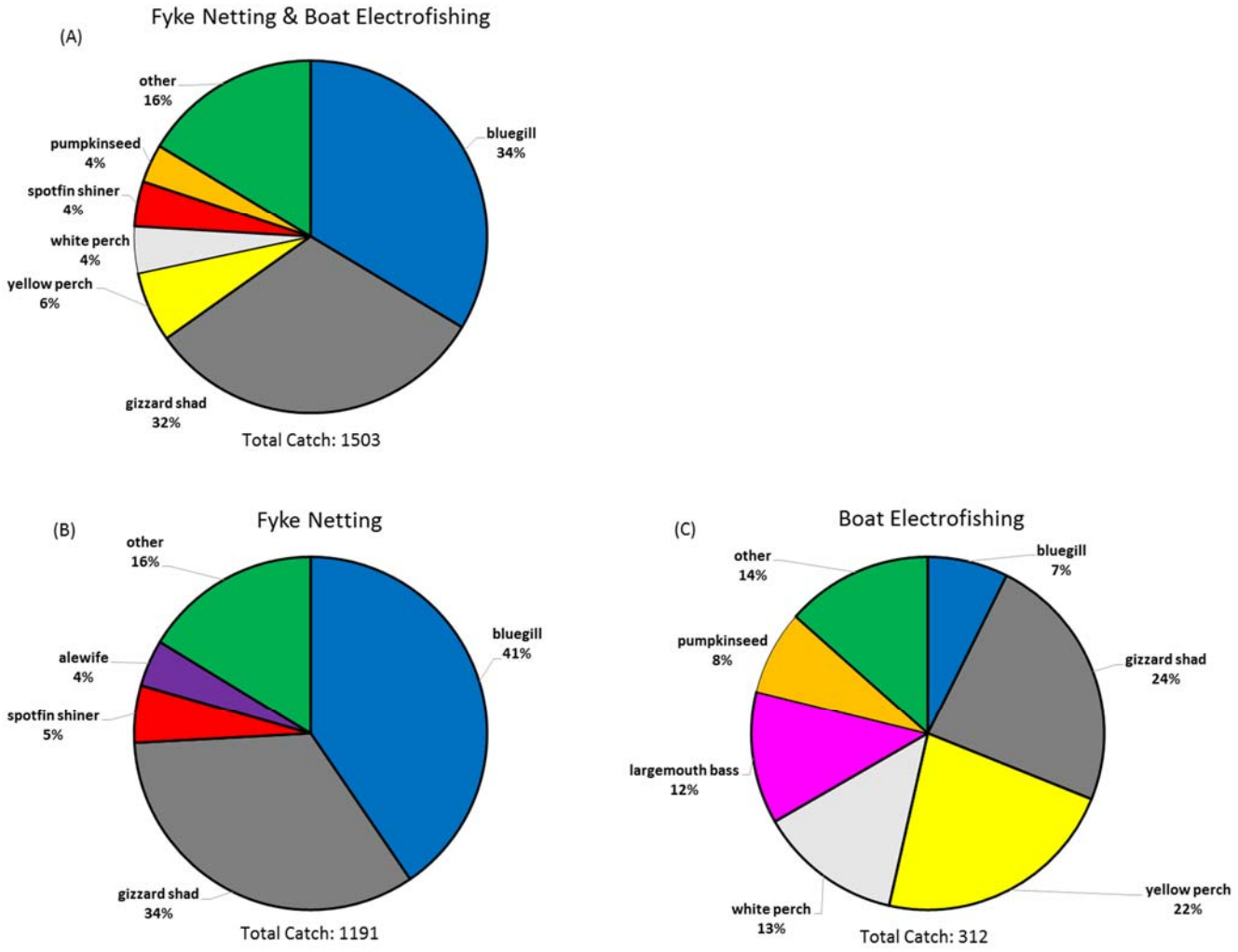

Figure 5. Fish species captured in littoral habitats of Lake Macatawa by (**A**) fyke netting and boat electrofishing (i.e., combined catch), (**B**) fyke netting (n = 12 nets), and (**C**) boat electrofishing (n = 4 transects) during September 2018. Catch data, including the species pooled in the "other" category, are reported in Table 4.

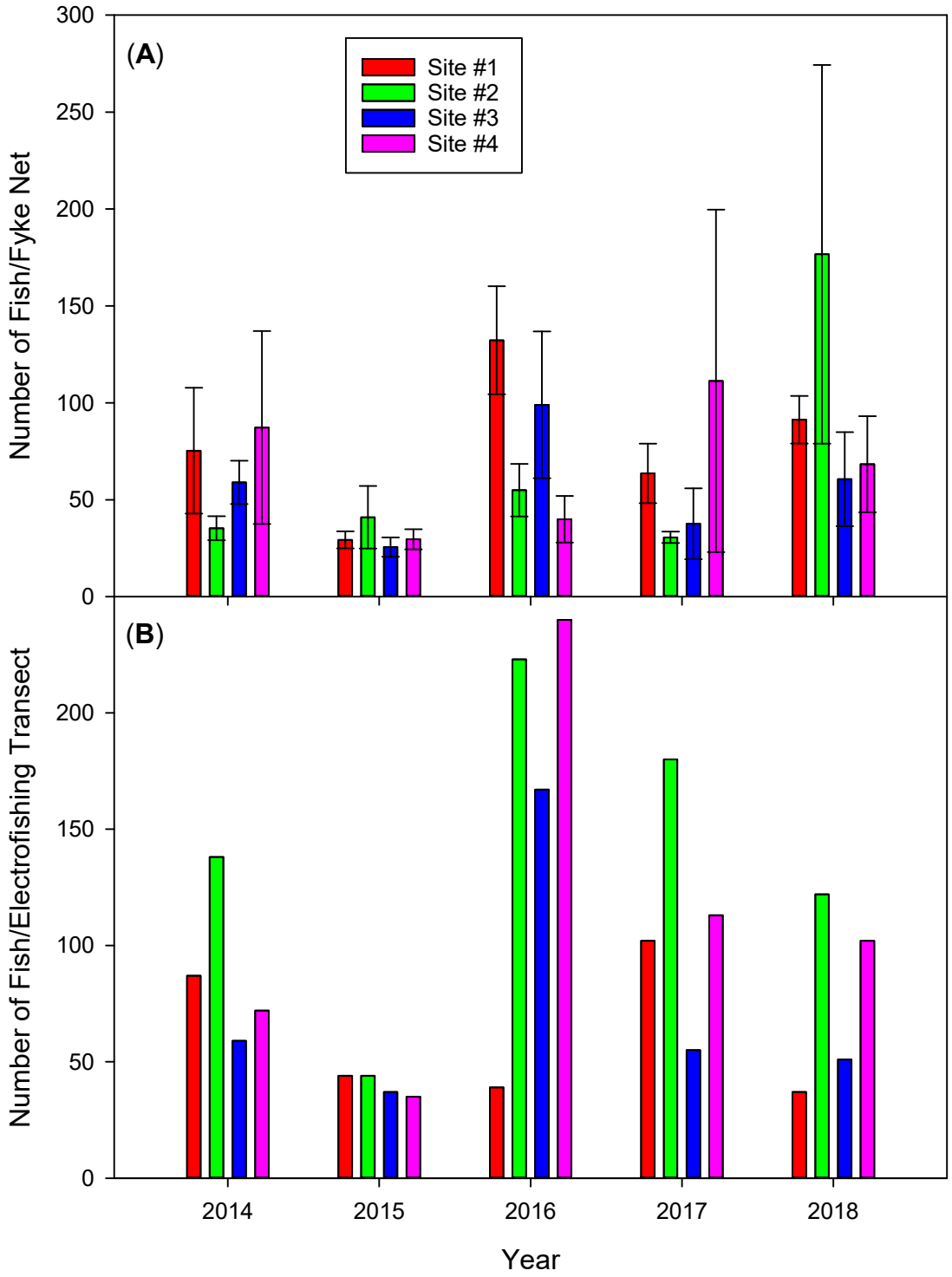

Figure 6. (**A**) Mean number (±1 standard error) of fish captured in fyke nets (n = 3 nets per site) and (**B**) number of fish captured during a boat electrofishing transect (n = 1 transect per site) in Lake Macatawa. *Note*: 5,288 brook silversides captured in a single fyke net at site #4 in 2017 were excluded when calculating means for fyke netting.

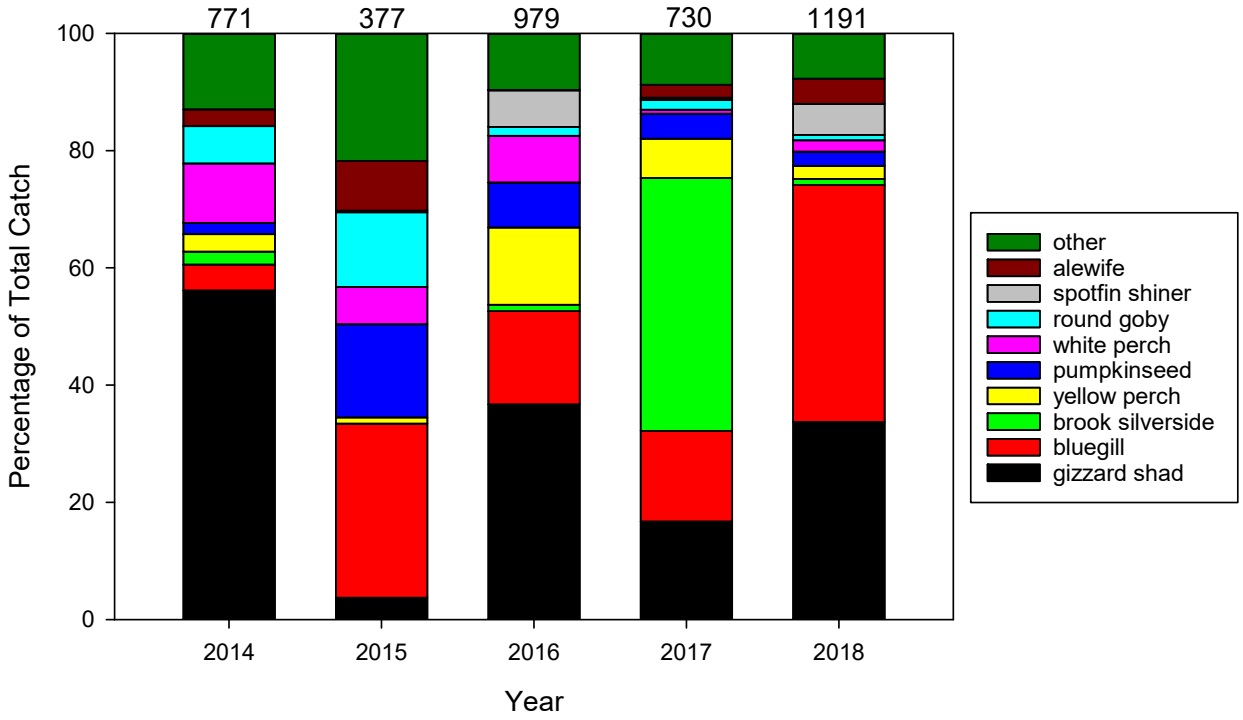

Figure 7. Fish species composition (pooled across sites) in fyke netting surveys for each sampling year. The number of fish captured differed among years, which is reported at the top of each bar. *Note*: 5,288 brook silversides captured in a single fyke net at site #4 in 2017 were excluded from the percentage of total catch.

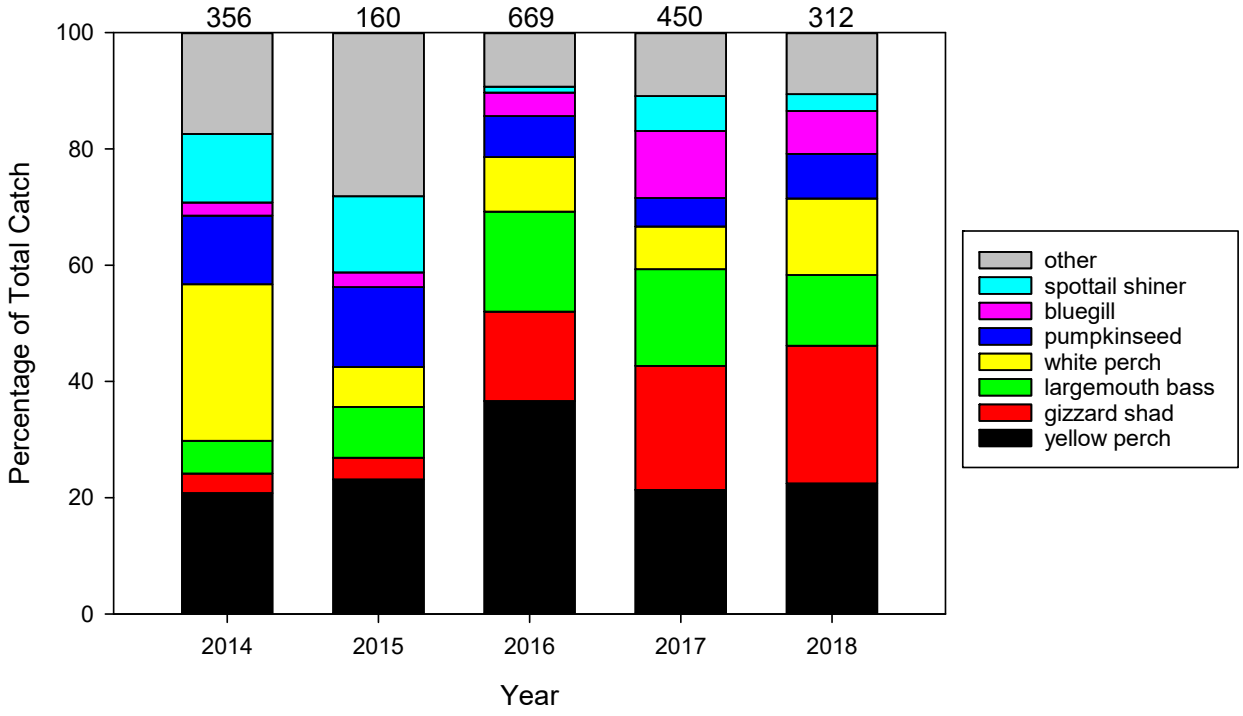

Figure 8. Fish species composition (pooled across sites) in nighttime boat electrofishing surveys for each sampling year. The number of fish captured differed among years, which is reported at the top of each bar.