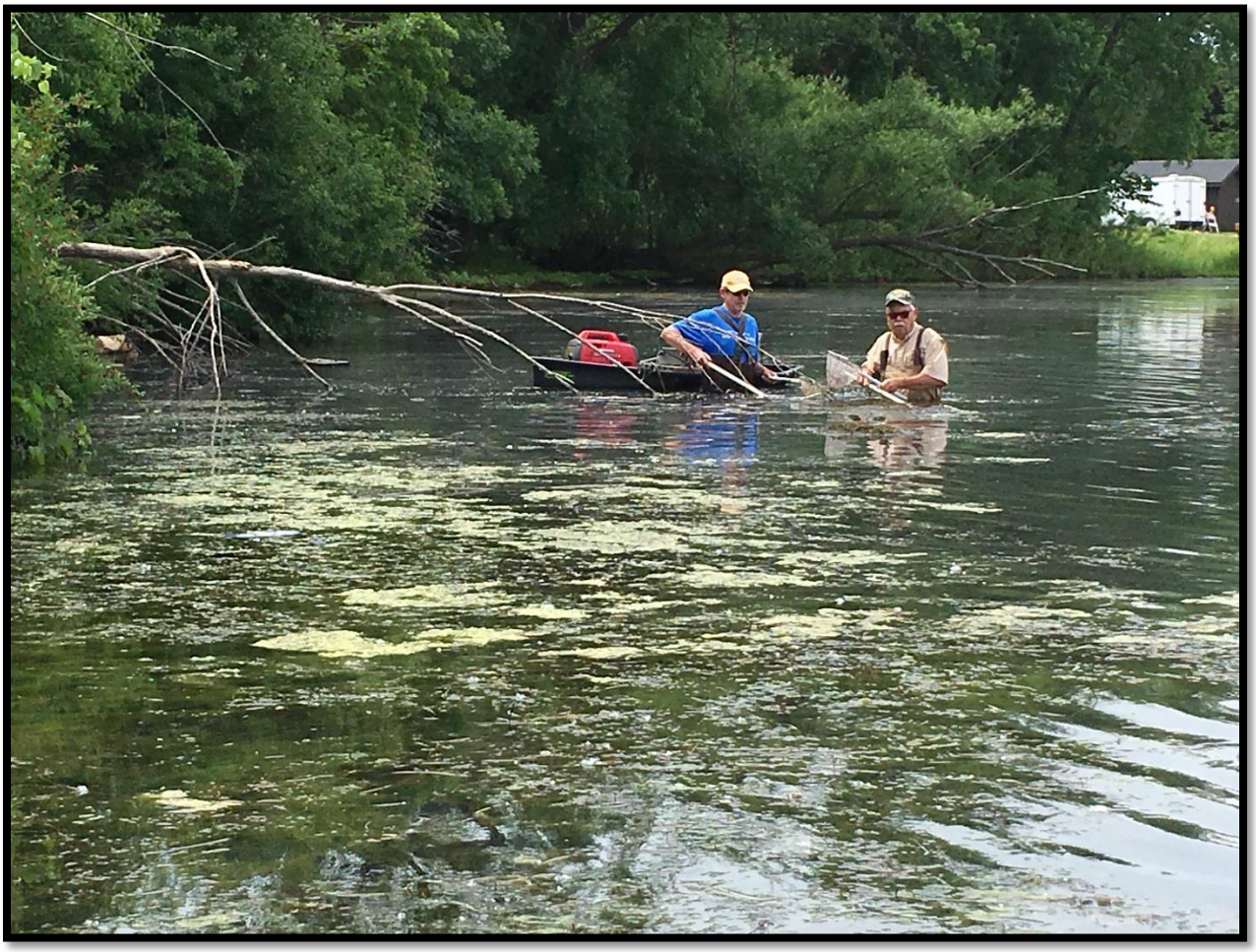
Nearshore Fish Electroshocking Surveys on Lake Mendota and Lake Monona



Dane County Department of Land and Water Resources.

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Summary

Nearshore electroshocking surveys were performed on Lake Monona in June and Lake Mendota in July, 2017. Results of the surveys demonstrated a dearth of small minnows and darters that often inhabit nearshore zones in lakes. Only two native minnow species and three darter species were found in Lake Monona and only one of each group in Lake Mendota. Among possible reasons for the low numbers include the general lack of shallow shoals, required for many small nongame fish, along shorelines in both lakes. Most shorelines are armored with riprap and relatively deep water lies at the base of the rock. Exacerbating these conditions were high water levels during the sampling period. A number of environmentally sensitive minnows and darters that had not been reported in Lake Mendota for decades and results of these surveys did not change their status.

Introduction

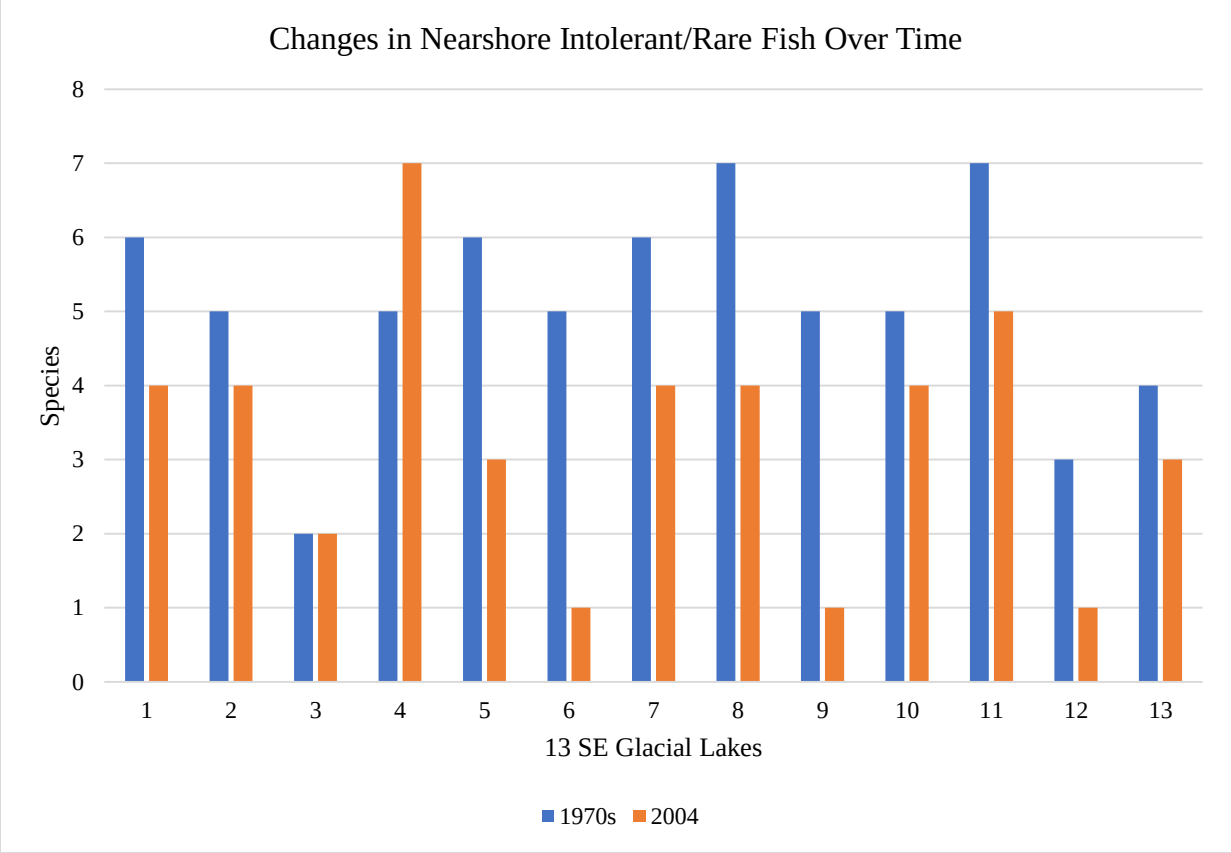
Lake assessments are typically based on trophic state indicators (i.e., TSI secchi water clarity, TSI phosphorus and TSI chlorophyll), macrophyte surveys, plankton analysis, and sportfish population inventories. Focusing on water quality is understandable given the pervasive threats and impacts to the Madison lakes from primarily agricultural phosphorus loading (Kara et al. 2014, Lathrop 2007). The most recent example was the severe Cyanobacteria bloom that occurred in Lake Mendota this past June (http://blog.limnology.wisc.edu/madison-in-bloom-blue-green-algae-hits-lake-mendota/). However, important ecosystem indicators such as nearshore fish populations can be and are often overlooked in lakes management.

Nongame fish species are rarely surveyed since they offer no perceived economic benefit compared to more familiar gamefish populations. Some nearshore fish species are very sensitive to environmental degradation and have been described as “canaries in the coal mine” (Gaumnitz 2005). Small nongame fish are important food web links and population declines can reveal environmental stresses that traditional lake monitoring methods overlook. Nearshore fish surveys are also useful since juvenile stages of more popular sportfish also inhabit these areas.

The status of Lake Mendota nongame fish species was first assessed 28 years ago (Lyons 1989). Lyons documented the decline and disappearance of eight species; the pugnose shiner (*Notropis anogenus*), common shiner (*Luxilus cornutus*), blackchin shiner (*Notropis heterodon*), blacknose shiner (*Notropis heterolepis*), tadpole madtom (*Noturus gyrinus*), banded killifish (*Fundulus diaphanus*), blackstripe topminnow (*Fundulus notatus*), and fantail darter (*Etheostoma flabellare*). This decline was associated with the expansion of Eurasian watermilfoil in the lake.

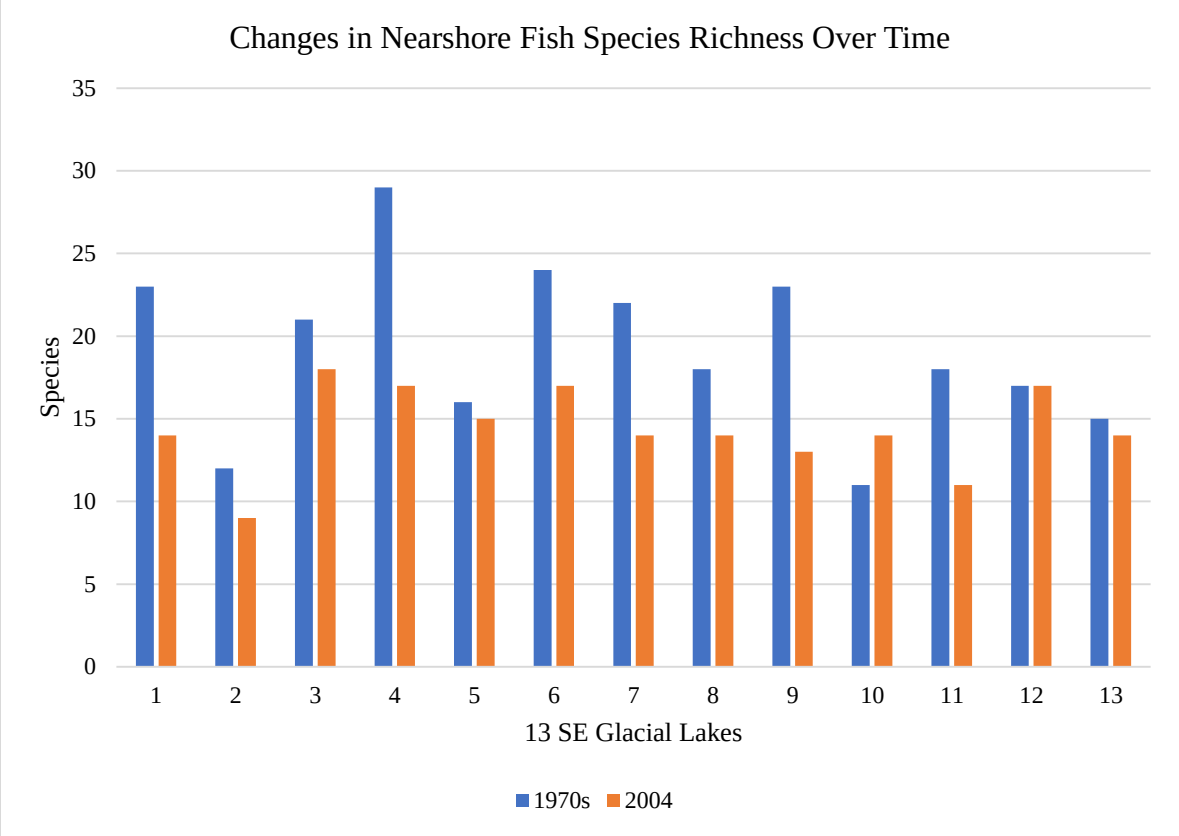
Other habitat factors can also affect environmentally sensitive nongame fish. For example, large piers can destroy fish habitat by fragmenting and shading aquatic plants (Garrison et al. 2005, Radomski 2010). A 2004 survey of 13 southeast Wisconsin glacial lakes that exhibited mesotrophic conditions revealed significant declines in a number of small nongame species that inhabit nearshore shoals (Marshall and Lyons 2008). The survey repeated nearshore seining surveys completed as part of the Fish Distribution Study during the 1970s. Significant declines had occurred in most of the 13 lakes between the 1970s and 2004 (Figures 1 and 2). Water quality in these lakes did not change significantly over time but rather significant changes occurred in the amount of shoreline development. Species declines included State Special Concern banded killifish, State Threatened pugnose shiner, blackchin shiner, blacknose shiner, State Special Concern least darter (*Etheostoma microperca*) and State Special Concern lake chubsucker (*Erimyzon sucetta*). Other aspects of the study demonstrated that native species declines coincided with increased pier densities (Figure 3); structures with direct impacts on fish habitat but are also indicators of other shoreline developments.

Figure 1: Declines of Environmentally Sensitive/Rare Nongame Fish Inhabiting Nearshore Shoals



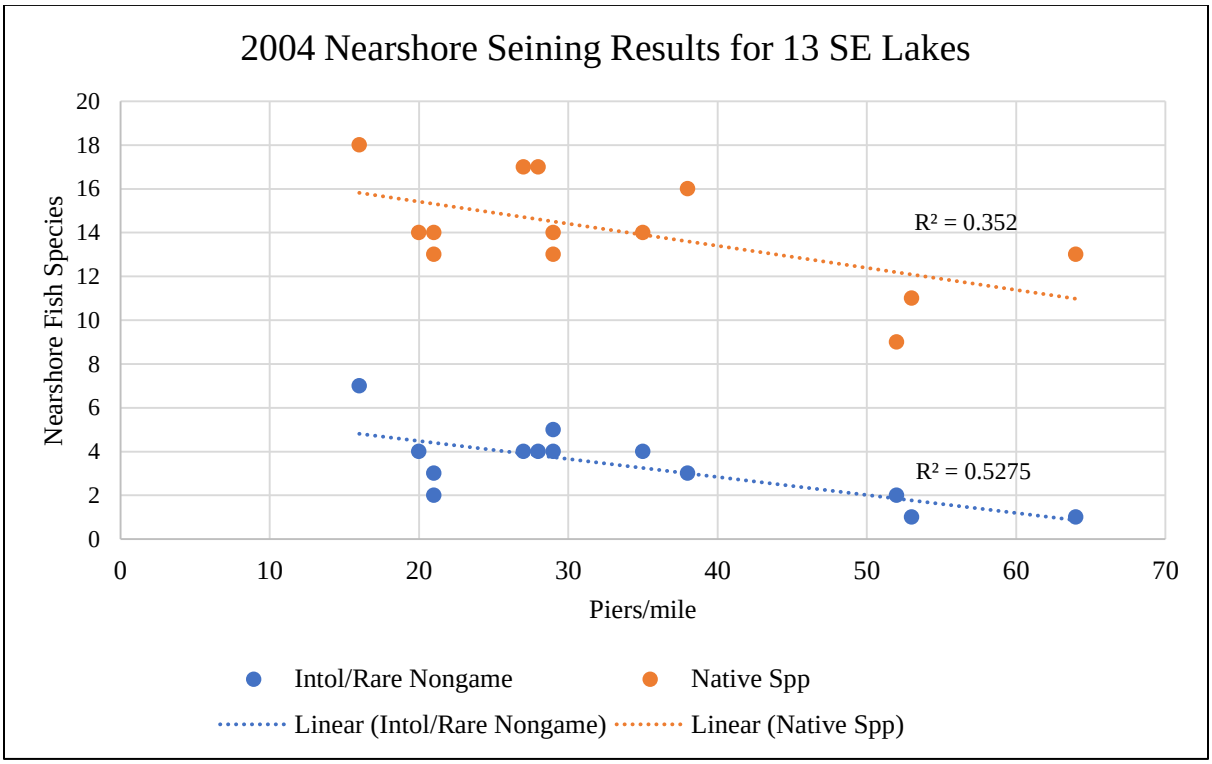
Significant declines occurred from the 1970s to 2004 (P = 0.002)

Figure 2: Declines of Native Fish Inhabiting Nearshore Shoals in 13 SE Glacial Lakes



Significant declines occurred from the 1970s to 2004 (P = 0.002)

Figure 3: Numbers of Native Fish and Intolerant Rare Species in Relation to Pier Densities



Based on species accounts, declines of numerous Lake Mendota nongame fish appeared to occur prior to the declines observed in some of the 13 southeast lakes. A few species in Lake Mendota had disappeared near the turn of the 20th century. Our recent surveys of Lake Mendota and Lake Monona were designed to provide an update on the types of species that inhabit the nearshore zones. Towed DC electroshocking equipment that we used in the 2017 surveys is an alternative to the more commonly used small mesh seines, mini-fyke netting and DC boom shocking surveys. The towed electroshocking gear can effectively sample small fish that inhabit woody debris, dense aquatic vegetation and rocky substrates close to shore. Since 2012, we used this gear to sample nearshore fish populations in Rock Lake Jefferson County, Lake Ripley Jefferson County, Fish Lake Dane County, Crystal Lake Dane County, Swan Lake Columbia County, Big Green Lake Green Lake County and Lake Wisconsin. In Rock Lake, we revealed a rare small catfish, the State Endangered slender madtom (Noturus exilis), that had never been previously found in lake environments (Lyons, personal communication). In Lake Wisconsin, we collected State Special Concern banded killifish that had not been reported in the Wisconsin River system since 1928 (Lyons, personal communication). Nearshore towed electroshocking is particularly effective for sampling darters and small catfishes. Thirty-five native fish species had been reported from Lake Monona and 44 from Lake Mendota (WDNR Fish Mapping Application 2017 - https://cida.usgs.gov/wdnr_fishmap/map/). The nearshore electroshocking surveys were not designed and

will not effectively sample all species, including species that inhabit offshore areas in lakes. The complete inventories of Lake Monona and Lake Mendota species, including locally extirpated species, appear in Tables 1 and 2.

Methods

Twenty sampling sites were selected on both Lake Mendota and Lake Monona. The site selection was not random but rather was focused on historic sampling locations. Figure 4 is a map of Lake Monona and Figure 5 is a map of Lake Mendota sampling sites. An ETS DC electroshocker barge with two electrodes was used to sample various shorelines totaling about 1.1 miles per lake. The shocker was operated at 4 amps and 160 volts. A Garmin GPS Map76 was used to identify start and end points. The trip odometer function was used to determine typical 300 feet sampling lengths. Some of the sites had to be relocated since high pier densities posed sampling obstructions. At some sites, we managed to shock underneath piers when there was enough height between the water and piers. A YSI ODO meter was used to measure dissolved oxygen and temperature. An Extech ExStik II was used to measure specific conductance. We attempted to assess habitat at each station qualitatively but the high water recorded this summer undermined this effort. In Lake Mendota, nearshore depths were also taken and were compared with the long term USGS lake level data (https://waterdata.usgs.gov/wi/nwis/uv?05428000).

Lake Monona Findings

Lake Monona was sampled on June 21 and 27. Water levels exceeded the long-term median levels by about 0.7' during the surveys (Figure 6). Dissolved oxygen levels ranged from 7.7 to 16.1 mg/l, the latter supersaturation measurement occurred during a Cyanobacteria bloom. Specific conductance levels ranged from 495 to 596 uS/cm. Shorelines at most sites were armored with riprap and in one instance a seawall. No fish were found along the seawall section at the sampling station. Otherwise, nearshore shoals were scarce around the lake, particularly at the base of armored shorelines. Small nongame fish species collected, including mottled sculpin (Cottus bairdi), Iowa darter, spotfin shiner (*Cyprinella spiloptera*), bluntnose minnow (*Pimephales notatus*), Johnny darter (*Etheostoma nigrum*) and logperch (*Percina caprodes*). These species were generally found in shallow nearshore areas and predominantly along the south shoreline. Woody debris was scarce except along undeveloped public shorelines. A total of sixteen species were collected from Lake Monona nearshores during the two survey dates. Four of the species are designated environmentally sensitive; rock bass, smallmouth bass, mottled sculpin and Iowa darter (Table 1). The top five species sampled in Lake Monona were bluegills (100% frequency), largemouth bass (70%), green sunfish (60%), yellow bullhead (60%) and bluntnose minnow (45%). A

fish kill that included common carp, drum, white bass, largemouth bass and panfish occurred near the Yahara River inlet on June 21. The fish kill was caused by a major Cyanobacteria bloom.

Figure 4: Lake Monona Sampling Sites

Figure 5: Lake Mendota Sampling Sites

Figure 6: Lake Monona Water Levels with stars indicating survey days

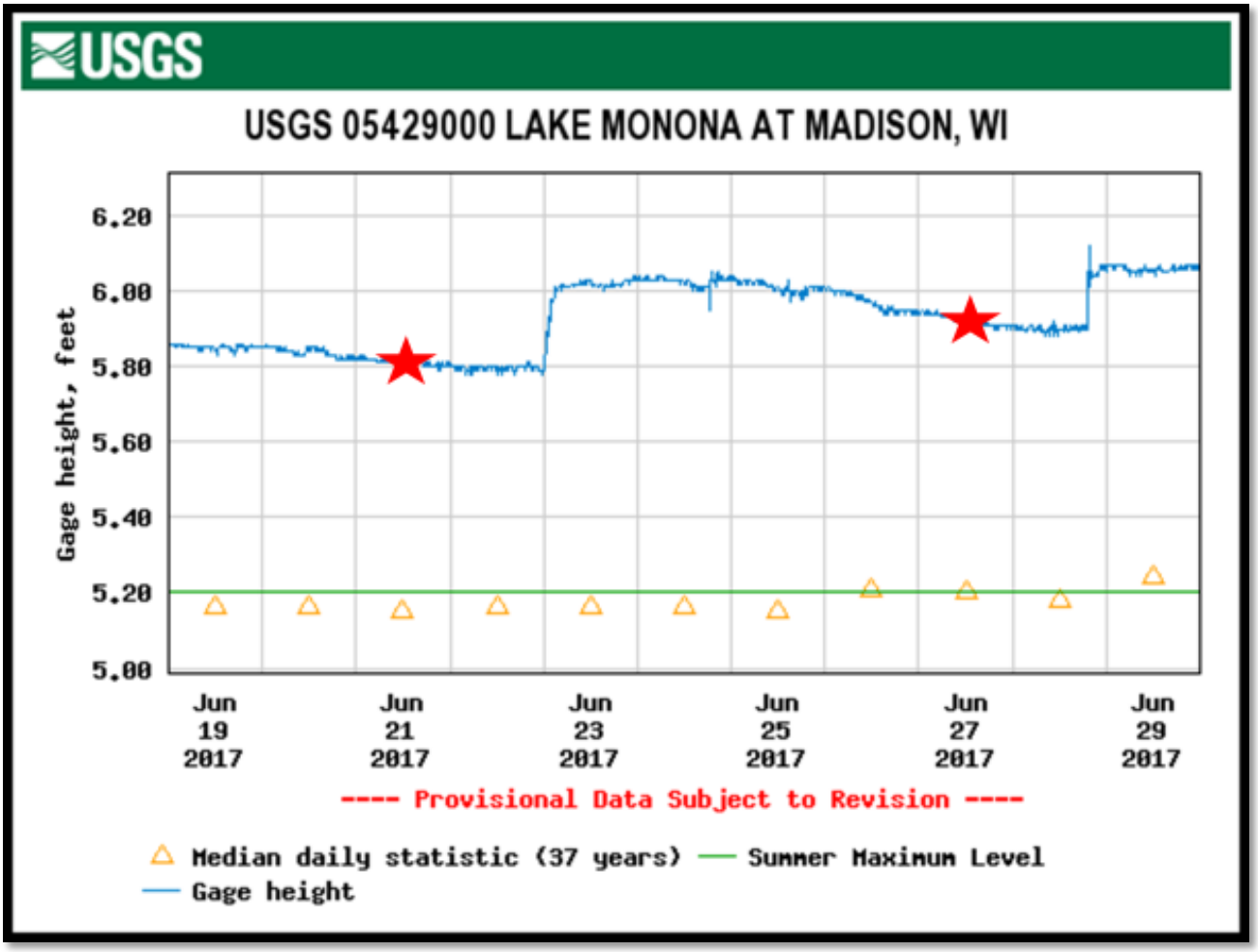


Table 1: Fishes of Lake Monona and recent nearshore survey results

Species	Scientific Name	Historic Occurrence	Tolerance	2017 total	2017 Sites
Lake Sturgeon	*Acipenser fulvescens*	Rare	NA		
Bowfin	*Amia calva*	Uncommon	Medium		
Longnose gar	*Lepisosteus osseus*	Uncommon	Medium		
Northern pike	*Esox lucius*	Common	Medium		
Muskellunge	*Esox masquinongy*	Common	Medium	1	
Common carp	*Cyprinus carpio*	Common	Tolerant	6	2
Fathead minnow	*Pimephales promelas*	Common	Tolerant		
Bluntnose minnow	*Pimephales notatus*	Uncommon	Tolerant	44	9
Golden shiner	*Notemigonus crysoleucas*	Common	Tolerant		
Emerald shiner	*Notropis atherinoides*	Common	NA		
Spottail shiner	*Notropis hudsonius*	Uncommon	NA		
Spotfin shiner	*Cyprinella spiloptera*	Uncommon	Medium	6	2
Bigmouth buffalo	*Ictiobus cyprinellus*	Uncommon	Medium		
White sucker	*Catostomus commersoni*	Common	Tolerant		
Burbot	*Lota lota*	Rare	Medium		
Brook silverside	*Labidesthes sicculus*	Uncommon	NA		
Channel catfish	*Ictalurus punctatus*	Common	Medium		
Black bullhead	*Ameiurus melas*	Common	Tolerant	6	4
Yellow bullhead	*Ameirurus natalis*	Common	Tolerant	29	12
Drum	*Aplodinotus grunniens*	Common	Medium		
White bass	*Morone chrysops*	Abundant	NA		
Yellow bass	*Morone mississippiensis*	Uncommon	NA		
Bluegill	*Lepomis macrochirus*	Abundant	Medium	320	20
Pumpkinseed	*Lepomis gibbosus*	Common	Medium	11	4
Green sunfish	*Lepomis cyanellus*	Common	Tolerant	12	98
Black crappie	*Pomoxis nigromaculatus*	Common	Medium		
White crappie	*Pomoxis annularis*	Uncommon	Medium		
Rock bass	*Ambloplites rupestris*	Common	Intolerant	7	9
Smallmouth bass	*Micropterus dolomieu*	Abundant	Intolerant	2	1
Largemouth bass	*Micropterus salmoides*	Abundant	Medium	64	14
Yellow perch	*Perca flavescens*	Abundant	Medium	14	7
Walleye	*Stizostedian vitreum*	Common	Medium		
Logperch	*Percina caprodes*	Uncommon	Medium	14	5
Iowa darter	*Etheostoma exilis*	Uncommon	Intolerant	4	2

Johnny darter	*Etheostoma nigrum*	Uncommon	Medium	1	1
Mottled sculpin	*Cottus bairdi*	Uncommon	Intolerant	7	4

Environmental tolerance ratings from Lyons (2012).

Lake Mendota Findings

Lake Mendota was sampled on July 11, July 25 and July 30. Water levels exceeded the long-term median from approximately 0.5' to 1.1' during the survey (Figure 7). Dissolved oxygen ranged from 6.7 to 16.3 mg/l, the latter supersaturation level occurred within a wind driven Cyanobacteria bloom. Specific conductance levels ranged from 459 to 495 uS/cm. Similar to Lake Monona, most shorelines are armored with riprap. Nearshore depths were relatively deep and were higher than the long-term median levels during the survey. Figure 8 displays actual water sampling depths per site (bars) along with long-term median water levels (markers) at distances three and six feet from water edge. Woody debris was scarce except along publicly owned undeveloped shorelines. A total of 13 native species were collected with only three representing the typical nearshore nongame assemblage; mottled sculpin, logperch and bluntnose minnow. The top five species sampled were smallmouth bass (65% frequency), rock bass (45%), bluegill (40%), largemouth bass (35%) and longnose gar (30%). Environmentally sensitive species collected from Lake Mendota were rock bass, smallmouth bass and mottled sculpin (Table 2). Two fish collections of interest included juvenile and yoy longnose gar that were found at six sites. Abundant yoy common carp were found at sites on the north end of the lake, indicating recruitment. The former species is an important desirable predator species while the latter is a well-established invasive species that continues to pose significant lake management challenges.

Figure 7: Lake Mendota water levels with stars indicating survey days

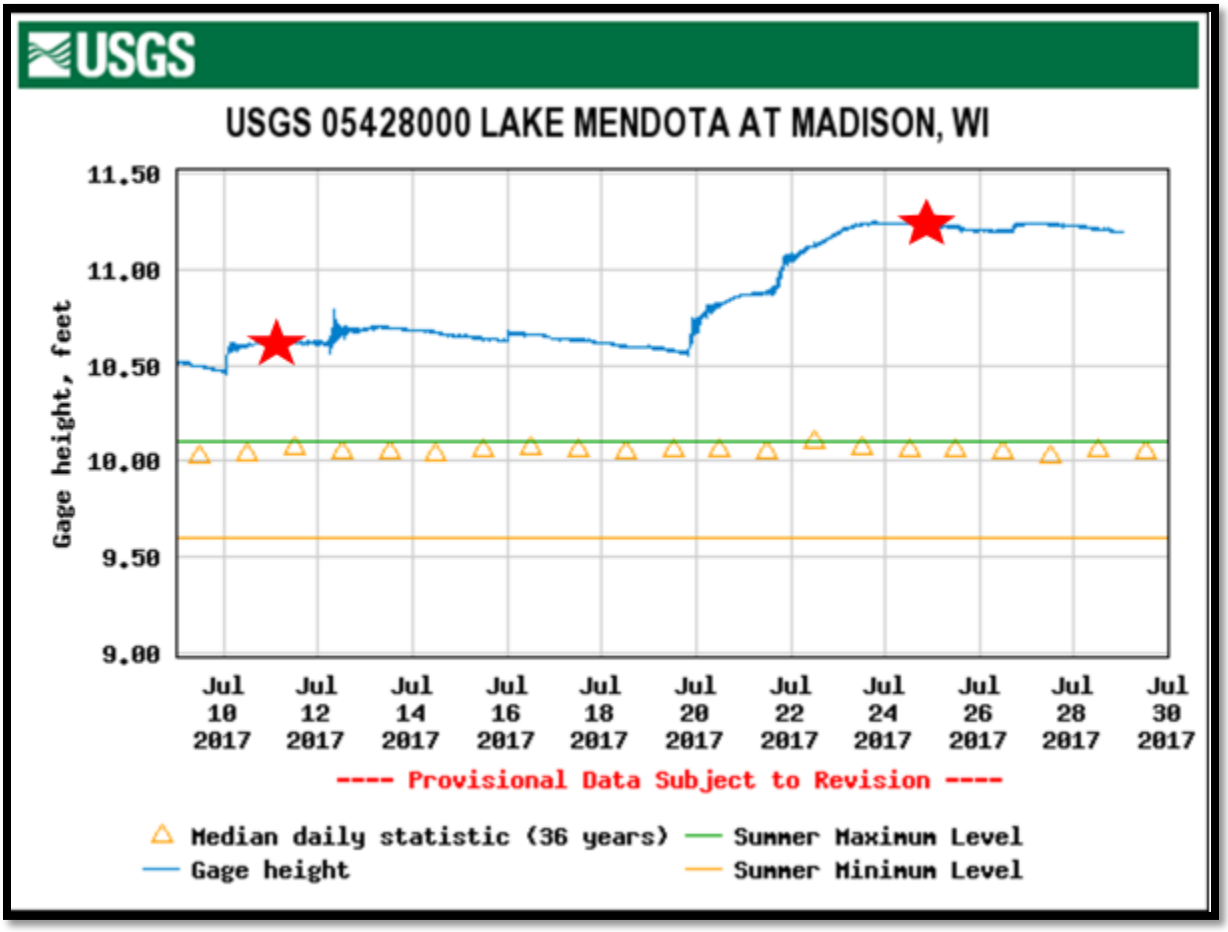


Table 2: Fishes of Lake Mendota and recent nearshore survey results

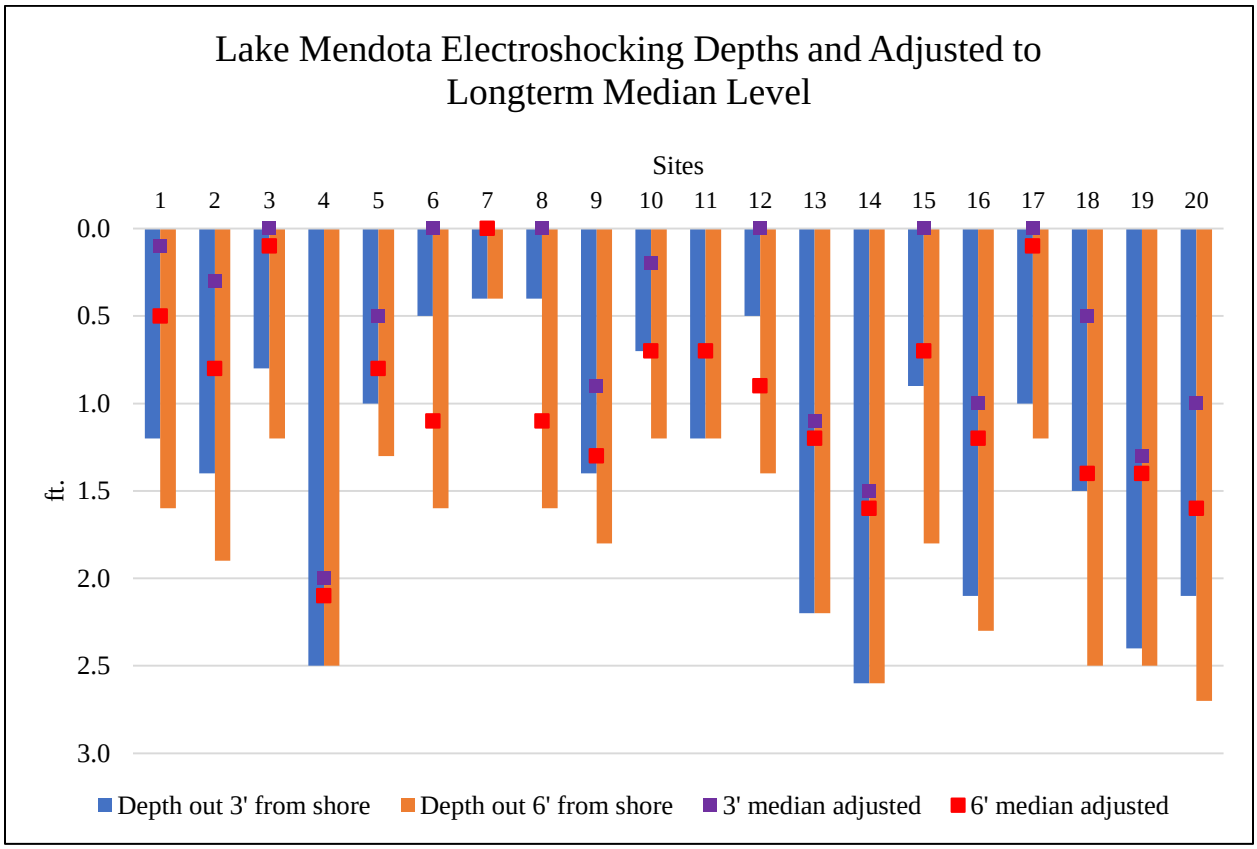
Species	Scientific Name	Historic Occurrence	Tolerance	2017 total	2017 Sites
Lake Sturgeon	*Acipenser fulvescens*	Rare	NA		
Bowfin	*Amia calva*	Uncommon	Medium		
Longnose gar	*Lepisosteus osseus*	Uncommon	Medium	9	6
Cisco	*Coregonus artedi*	Uncommon	NA		
Northern pike	*Esox lucius*	Common	Medium		
Muskellunge	*Esox masquinongy*	Common	Medium		
Common carp	*Cyprinus carpio*	Common	Tolerant	>300 yoy	2
Fathead minnow	*Pimephales promelas*	Common	Tolerant		
Bluntnose minnow	*Pimephales notatus*	Uncommon	Tolerant	10	2
Golden shiner	*Notemigonus crysoleucas*	Common	Tolerant		

Common shiner	*Luxilus cornutus*	1964-65	Medium		
Emerald shiner	*Notropis atherinoides*	Common	NA		
Spottail shiner	*Notropis hudsonius*	Uncommon	NA		
Spotfin shiner	*Cyprinella spiloptera*	Uncommon	Medium		
Pugnose minnow*	*Opsopoeodus emiliae*	1964, 1975	Sp. Concern		
Pugnose shiner*	*Notropis anogenus*	1900	Threatened		
Blackchin shiner*	*Notropis heterodon*	1905-1915	Intolerant		
Blacknose shiner*	*Notropis heterolepis*	1905-1975	Intolerant		
White sucker	*Catostomus commersoni*	Common	Tolerant		
Bigmouth buffalo	*Ictiobus cyprinellus*	Uncommon	Medium		
Burbot	*Lota lota*	Rare	Medium		
Brook silverside	*Labidesthes sicculus*	Uncommon	NA		
Banded killifish*	*Fundulus diaphanus*	1905-1975	Sp. Concern		
Blackstripe topminnow*	*Fundulus notatus*	1900	Medium		
Black bullhead	*Ameiurus melas*	Common	Tolerant		
Brown bullhead	*Ameiurus nebulosus*	Uncommon	Medium		
Yellow bullhead	*Ameirurus natalis*	Common	Tolerant	1	1
Tadpole madtom	*Noturus gyrinus*	1914, '64, 2016	Medium		
Channel catfish	*Ictalurus punctatus*	Common	Medium	1	1
Drum	*Aplodinotus grunniens*	Common	Medium		
White bass	*Morone chrysops*	Abundant	NA		
Yellow bass	*Morone mississippiensis*	Uncommon	NA		
Bluegill	*Lepomis macrochirus*	Abundant	Medium	9	8
Pumpkinseed	*Lepomis gibbosus*	Common	Medium		
Green sunfish	*Lepomis cyanellus*	Common	Tolerant	5	3
Black crappie	*Pomoxis nigromaculatus*	Common	Medium	3	2
White crappie	*Pomoxis annularis*	Uncommon	Medium		
Rock bass	*Ambloplites rupestris*	Common	Intolerant	62	9
Smallmouth bass	*Micropterus dolomieu*	Abundant	Intolerant	30	13
Largemouth bass	*Micropterus salmoides*	Abundant	Medium	28	7
Yellow perch	*Perca flavescens*	Abundant	Medium		
Walleye	*Stizostedian vitreum*	Common	Medium		
Logperch	*Percina caprodes*	Uncommon	Medium	1	1
Iowa darter	*Etheostoma exilis*	Uncommon	Intolerant		
Johnny darter	*Etheostoma nigrum*	Uncommon	Medium		

Fantail darter*	*Etheostoma flabellare*	Dates?	Medium		
Mottled sculpin	*Cottus bairdi*	Uncommon	Intolerant	32	3

Environmental tolerance ratings from Lyons (2012). * Indicates locally extirpated species.

Figure 8: Lake Mendota nearshore sampling depths compared with long-term median levels



Discussion

Only two native minnow species (Cyprinidae) and three darters (Percidae) were found in Lake Monona and only one of each group in Lake Mendota. While the fish kill in Lake Monona demonstrated that no fish species is spared from severe water pollution and Cyanobacteria blooms, the survival of some environmentally sensitive species in the lakes suggest that other environmental factors may be important in addition to water quality.

At the WDNR Website (http://dnr.wi.gov/lakes/criticalhabitat/), the following quote describes the importance of nearshore zones for fish and biodiversity: "*Eighty percent of the plants and animals on the state's endangered and threatened species list spend all or part of their life cycle within the near shore zone. As many as ninety percent of the living things in lakes and rivers are found along the shallow margins and shores*". Yet, it is the nearshore zones that are physically altered the most around lakes due

a number of activities including construction of large piers, seawalls, riprap, dredging and effects of motorboat prop wash (Asplund and Cook 1997). Herbicides applications can also be toxic to fish and disrupt nearshore habitat.

The dearth of shallow shoals along Lake Monona and Lake Mendota may be an additional factor for the decline of small nongame fish. At most locations, deep water next to shore appeared to favor adult panfish and bass given the observed water depths. Adjusting depths to the long-term median levels, even "normal" depths may not provide enough favorable shallow habitat required for small nongame fish and various juvenile stages of some other species. The south end of Lake Monona displayed the most favorable habitat for small fishes despite the higher than normal water levels. Depth changes in that area were more gradual with a variety of rock sizes. It is the area where we found the most darter and minnow species. In Lake Wisconsin and elsewhere, we generally did not find many darters in heavily armored shorelines with large boulders but rather in shallow areas with rock of variable sizes.

The surveys demonstrated that the nongame fish losses previously documented (Lyons 1989) may be permanent with the exception of tadpole madtom. In 2016 a single tadpole madtom was collected in Cherokee Marsh using mini-fyke nets (Jopke and Marshall 2016). Figures 9 and 10 below compares Lake Mendota and Lake Monona species richness with other lakes sampled using tow electroshocking gear near shore.

Figure 9: Comparative Number of Species Caught in Different Lake Nearshore Fish Surveys

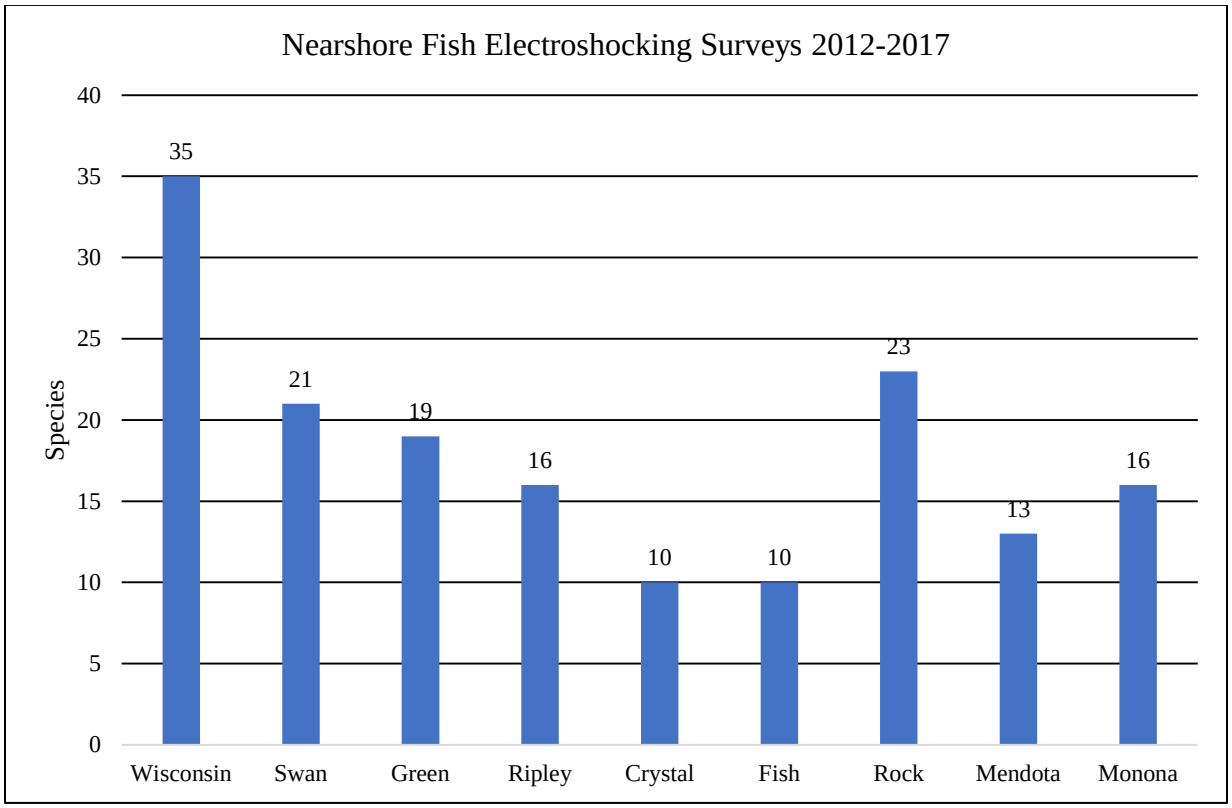
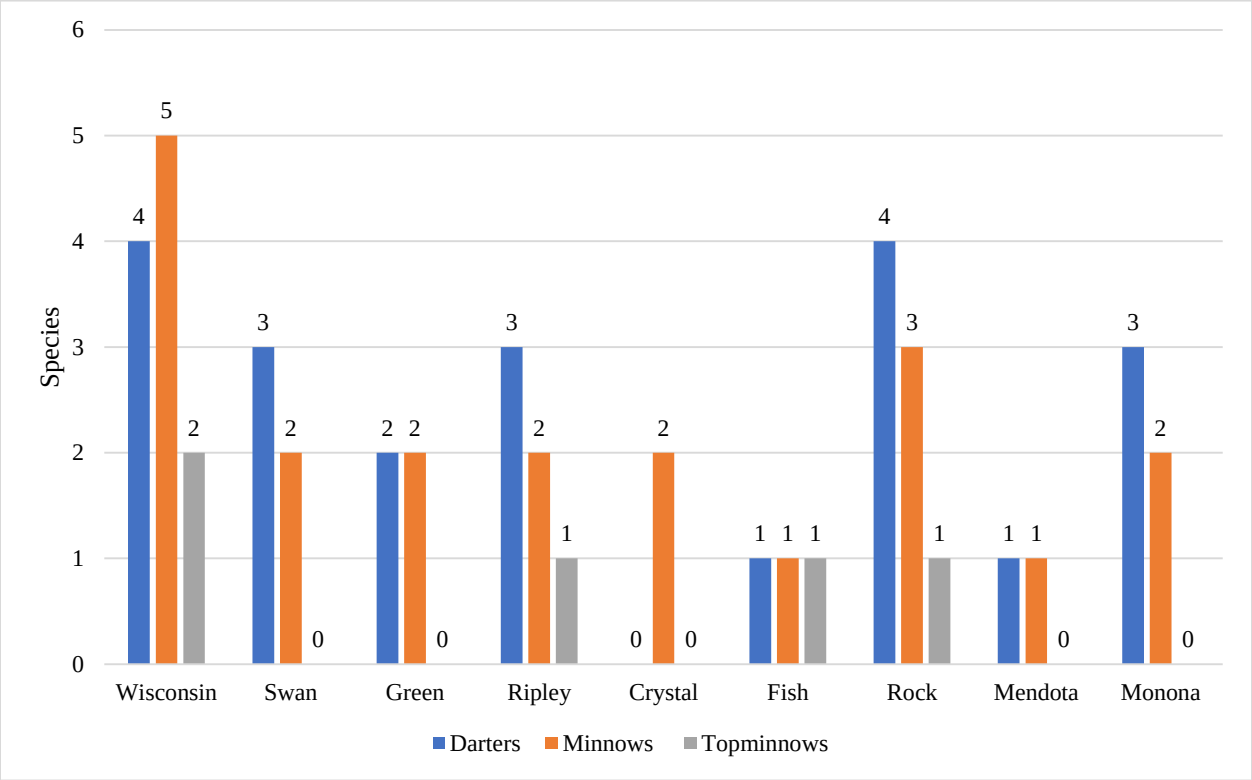


Figure 10: Comparative Number of Darters (Percidae), Minnows (Cyprinidae) and Topminnows (Fundulidae) Species Caught in Different Lake Nearshore Fish Surveys 2012-2017



Recommendation

Nearshore fish electroshocking and seining surveys should be performed routinely. Lake Mendota and Lake Monona should be resampled, when the long-term median levels are not greatly exceeded, since the high-water levels may have reduced sampling effectiveness.

Deep water next to shore at most locations supported larger gamefish including the largemouth bass.

Immature longnose gar

Green sunfish

Mottled sculpin.

YOY common carp along north end of Lake Mendota

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Lake Monona Sites	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Musky										1										
Common carp									1	5										
Bluntnose minnow		1		3			3		3		8	2			8	14	2			
Spotfin shiner												2	4							
Yellow bullhead	1	5	1			2	2		4	1	1			1		1			4	6
Black bullhead									2					1			1		2	
Bluegill	2	20	5	9	12	33	11	5	2	31	6	1	36	35	26	56	1	11	9	8
Pumpkinseed													6	2	1				2	
Green sunfish	8	9	2		1	1		2	11	1						5		14	19	25
Hybrid sunfish												2		2						
Rock bass	1	1	2					1	1						1	2				
Largemouth bass		2				1	2	10	2		2	11	9	5	10	2		6	1	3
Smallmouth bass											2									
Yellow perch		2	1	1		2	1			6		1								
Logperch							1				3	3	6		1					
Iowa darter											3				1					
Johnny darter															1					
Mottled sculpin									2		2	2			1					

Lake Mendota Sites	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Longnose gar					1	1	2	2				2				1				
Bluntnose minnow						2	8													
Common carp						1		>300												
Yellow bullhead								1												
Channel catfish								1												
Bluegill		2		1	1		1	1			1		1		1					
Green sunfish	1				2	2														
Hybrid sunfish		2																		
Black crappie														2	1					
Rock bass	1			3							1	2	8			1		13	23	10
Largemouth bass	2					5	12	3			1			4	1					
Smallmouth bass		5	1	2	5	3				2	1	2	1			1	2		4	1
Logperch											1									
Mottled sculpin												1						13	18	

Site Data

Lake Monona	**1**	**2**	**3**	**4**	**5**	**6**
Date	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017
Start Lat	43.07471	43.07753	43.08562	43.08977	43.09038	43.08866
Start Long	89.37605	89.3681	89.35352	89.34317	89.3373	89.33226
End Lat	43.07522	43.07084	43.08624	43.08974	43.09019	43.08813
End Long	89.3751	89.36685	89.35255	89.34178	89.33607	89.3316
Temp C	24	23.9	23.9	24	24	23.8
D.O. mg/l	13.3	11.8	10.2	15.1	9.6	12.2
Sp Cond uS/cm	560	560	558	540	585	568
Substrate						
Bedrock						
Boulder	100	60	90	80	80	100
Cobble						
Gravel						
Sand		40	10	20	20	
Silt						
Veg						
Submersed	Low	Low	Medium	Low	Low	Low
Floating	Absent	Absent	Absent	Absent	Absent	Absent
Emergent	Absent	Absent	Absent	Absent	Absent	Absent
Algae	Low	Low	Medium	High	High	Medium
Comments	riprap deep	riprap deep	riprap deep fish kill	riprap deep	riprap deep	riprap deep

Lake Monona	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Date	6/21/2017	6/21/2017	6/27/2017	6/27/2017	6/27/2017	6/27/2017	6/27/2017
Start Lat	43.07773	43.0719	43.05483	43.05621	43.05032	43.0477	43.04518
Start Long	89.32767	89.33771	89.34753	89.33826	89.35036	89.35777	89.36743
End Lat	43.07814	43.07207	43.05418	43.05526	43.05013	43.04747	43.04537
End Long	89.32677	89.33904	89.34667	89.33796	89.35168	89.35886	89.36854
Temp C	23.8	24.1	20.5	20.3	20.3	22.2	22.2
D.O. mg/l	14.1	7.7	10.4	7.5	8	12.9	12.9
Sp Cond uS/cm	590	596	579	584	585	508	508
Substrate							
Bedrock							
Boulder	30	100	75	20	50		
Cobble	10				25	25	25
Gravel	30		15	10	25	25	25
Sand	30		10	50		50	50
Silt				20			
Veg							
Submersed	Low	Low	Low	Low	Low	Low	High
Floating	Absent	Absent	Absent	Low	Absent	Absent	Low
Emergent	Low	Absent	Absent	Low	Absent	Absent	Low
Algae	High	Medium	High	High	Medium	Medium	High
Comments	nongame habitat	riprap deep	riprap deep	Wood	shallow shoal	shallow shoal	filament.
			seawall no fish		nongame habitat	nongame habitat	

Lake Monona	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Date	6/27/2017	6/27/2017	6/27/2017	6/21/2017	6/21/2017	6/21/2017	6/21/2017
Start Lat	43.04802	43.05231	43.0534	43.05861	43.05725	43.05809	43.06355
Start Long	89.37065	89.36817	89.37296	89.38396	89.38909	89.39828	89.39299
End Lat	43.04884	43.05253	43.05403	43.05822	43.05812	43.05753	43.03843
End Long	89.37032	89.3691	89.37375	89.3829	89.38847	89.39784	89.2364
Temp C	22	22.5	22.5	23.2	23.3	23.2	22.8
D.O. mg/l	12.2	13.5	13.5	16.1	11	8.1	10.3
Sp Cond uS/cm	495	538	538	550	516	560	552
Substrate							
Bedrock							
Boulder		50	80	50	100	100	100
Cobble		20					
Gravel		20	10	20			
Sand	100	10	10	30			
Silt							
Veg							
Submersed	High	Low	Low	Medium	High	Medium	High
Floating	Medium	Absent	Absent	Absent	Absent	Absent	Absent
Emergent	Low	Absent	Low	Absent	Absent	Absent	Absent
Algae	High	Medium	Low	Medium	Low	Low	Low
Comments	filament.	shallow shoal nongame habitat	Wood	riprap deep	riprap deep	riprap deep	riprap deep

Lake Mendota	**1**	**2**	**3**	**4**	**5**	**6**
Date	7/25/2017	7/25/2017	7/25/2017	7/11/2017	7/11/2017	7/11/2017
Start Lat	43.09067	43.10811	43.10974	43.12352	43.14009	43.13302
Start Long	89.47957	89.47302	89.45734	89.43843	89.42523	89.40919
End Lat	43.09129	43.10837	43.10956	43.12254	43.14064	43.13378
End Long	89.48017	89.42703	89.45616	89.43931	89.42498	89.40842
Temp C	24.3	24.3	24.3	25.8	28.5	27.5
D.O. mg/l	8.9	8.9	8.9	9.5	16.3	11.9
Sp Cond uS/cm	476	476	476	493	459	428
Substrate						
Bedrock						
Boulder	100	100		60	40	
Cobble				20	10	
Gravel			100	10	20	
Sand				10	20	80
Silt					10	20
Veg						
Submersed	Low	Low	Low	Low	Medium	Medium
Floating	Absent	Absent	Absent	Absent	Low	Absent
Emergent	Absent	Absent	Absent	Absent	Medium	High
Algae	Low	Low	Low	Medium	Low	Low
Comments	riprap deep	riprap deep		riprap deep	Six Mile	relatively deep
	Depth ft	Depth ft	Depth ft	Depth ft	Depth ft	Depth ft
Depth out 3'	1.2	1.4	0.8	2.5	1.0	0.5
Depth out 6'	1.6	1.9	1.2	2.5	1.3	1.6
3' median adjusted	0.1	0.3	0	2	0.5	0
6' median adjusted	0.5	0.8	0.1	2	0.8	1.1

Lake Mendota	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Date	7/11/201 7	7/11/201 7	7/11/201 7	7/11/201 7	7/11/201 7	7/11/201 7	7/25/201 7
Start Lat	43.12583	43.12649	43.12889	43.11149	43.0939	43.08685	43.0786
Start Long	89.40093	89.39818	89.38086	89.37188	89.37219	89.37765	89.41414
End Lat	43.12665	43.12706	43.12841	43.11077	43.0943	43.08736	43.07853
End Long	89.40073	89.39848	89.38011	89.37112	89.37105	89.37678	89.41489
Temp C	28.4	28.6	29	29.6	27.5	27.4	25.6
D.O. mg/l	6.7	11.1	11.9	11.2	14.8	11.9	9.6
Sp Cond uS/cm	478	464	463	463	460	478	460
Substrate							
Bedrock							
Boulder		20	30	100		70	100
Cobble							
Gravel		10	10				
Sand	70	60	60			30	
Silt	30	10					
Veg							
Submersed	High	High	Low	Low	Low	Medium	Low
Floating	Low	Low	Absent	Absent	Absent	Absent	Absent
Emergent	High	Low	Absent	Absent	Absent	Absent	Absent
Algae	High	Low	High	High	High	Medium	Low
Comments	floating Val. mats	yoy carp	riprap deep	riprap deep			riprap deep wood
	Depth ft	Depth ft	Depth ft	Depth ft	Depth ft	Depth ft	Depth ft
Depth out 3'	0.4	0.4	1.4	0.7	1.2	0.5	2.2
Depth out 6'	0.4	1.6	1.8	1.2	1.2	1.4	2.2
3' median adjusted	0	0	0.9	0.2	0.7	0	1.1
6' median adjusted	0	1.1	1.3	0.7	0.7	0.9	1.1

Lake Mendota	**14**	**15**	**16**	**17**	**18**	**19**	**20**
	7/25/201	7/25/201	7/25/201	7/25/201	7/25/201	7/25/201	7/25/201
Date	7	7	7	7	7	7	7
Start Lat	43.08039	43.08554	43.0873	43.08973	43.09268	43.09093	43.0888
Start Long	89.42507	89.42471	89.41996	89.42442	89.43087	89.43642	89.44125
End Lat	43.08056	43.08537	43.08765	43.08723	43.09217	43.09135	43.08897
End Long	89.42527	89.42345	89.41874	89.4231	89.43024	89.43522	89.44057
Temp C	25.6	25.6	25.6	25.6	24.9	24.9	24.5
D.O. mg/l	9.5	9.6	9.3	9.3	8.7	8.8	9.1
Sp Cond uS/cm	460	460	460	460	478	477	495
Substrate							
Bedrock			40		10	30	50
Boulder	60		10		90	70	50
Cobble			10	30			
Gravel	10	50	20	70			
Sand	30		20				
Silt		50					
Veg							
Submersed	Medium	Medium	Low	Low	Low	Low	Low
Floating	Medium	Medium	Absent	Absent	Absent	Absent	Absent
Emergent	Medium	Low	Low	Absent	Absent	Low	Low
Algae	Low	Low	Low	Low	Low	Low	Low
Comments	deep wood	deep wood	wood deep	wood	deep wood	wood deep	wood deep

	Depth ft	Depth ft	Depth ft	Depth ft	Depth ft	Depth ft	Depth ft
Depth out 3'	2.6	0.9	2.1	1	1.5	2.4	2.1
Depth out 6'	2.6	1.8	2.3	1.2	2.5	2.5	2.7
3' median adjusted	1.5	0	1	0	0.5	1.3	1
6' median adjusted	1.5	0.7	1.2	0.1	1.4	1.4	1.6