2023 Shoreline Fish Survey Results and Implications for Geneva Lake Management

Survey conducted June 26 – 28, 2023

Prepared By

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Summary

In June 2023, three Department of Natural Resources (DNR) retirees - Tim Larson, Richard Wedepohl, Dave Marshall - and Jacob Schmidt (Director Geneva Lake Environmental Agency – GLEA) completed a shoreline fish electroshocking survey around Geneva Lake. This was the fourth Geneva Lake nearshore fish survey since they began in 1978. We found 20 fish species, more than were found during both the two previous surveys in 2018 and 2004, but nine fewer species (species richness) than were originally reported in 1978. We found low overall numbers of fish in 2023 that can be partly explained by the type of sampling gear (DC towed electroshocking and not small mesh seining) we used, but environmental stressors such as piers, motorboat wave turbulence and dense growths of filamentous algae may have contributed to lower fish numbers. We had anticipated greater numbers of fish from most the 18 sites and habitats we sampled.

Introduction

Why survey little one-inch-long fish that few people know exist? This is a common question. Besides the fact that native nongame fish are part of our natural heritage, they are also important links in lake food chains (Marshall et al. 2022). Popular sport fish are dependent on nongame fish for growth and survival. Small bottom dwelling darters and shiny minnow species, are also sensitive to environmental changes and have been described as "canaries in a coal mine" (Gaumnitz 2005).

The first Geneva Lake nearshore fish survey was conducted in June 1978 as part of the DNR Wisconsin Fish Distribution Study (Fago 1992). The study ended by the early 1980s since the study was deemed "lower priority" compared to routine surveys of popular gamefish and panfish. The Comprehensive Fish Survey Report for Geneva Lake (Roffler et al. 2015) is an example of fish management surveys that DNR routinely conducts across Wisconsin, using boomshocking and fyke netting designed to sample larger fish.

In 2004, DNR resampled a subset of the 1978 Fish Distribution Study sites in high quality calcareous glacial lakes (including Geneva Lake). DNR lake biologists initiated in 2004 over concerns regarding the pace and impacts of shoreline development. High quality (mesotrophic) lakes were selected to eliminate water quality as a potential environmental variable and therefore restricted potential impacts to other factors, particularly nearshore habitat changes and possibly invasive species. Long term water chemistry data indicated minimal water quality changes in the study lakes over time, while aerial photography demonstrated significant shoreline changes. Findings from the 2004 study demonstrated that native species richness declined by 85% and rare/environmentally sensitive fish declined by 31% compared to the 1978 survey (Marshall and Lyons 2008).

More broadly, Bryan and Scarnecchia (1992) found reduced aquatic plant habitat and lower fish species richness along developed shorelines compared to undeveloped shorelines in an Iowa glacial lake. Christensen et al. (1996) measured reduced woody debris, important for fish and macroinvertebrate production, along developed shorelines among 16 north temperate lakes. Elias and Meyer (2003) reported reduced floral complexity and woody debris where development occurred in northern Wisconsin lakes. Radomski et al. (2006) found reduced floating-leaf and emergent vegetation in most Minnesota lakes where shorelines were developed. Fish species richness and environmentally sensitive fish decline near developed shores (Kaufmann et al. 2014c, Whittier et al. 1997a). Assessing potential cumulative impacts of development on habitat loss (Jennings et al. 1999, Jennings et al. 2003) became standard for understanding impacts of incremental shoreline development increases.

As development and invasive species continue to threaten inland lake ecosystems, tracking nearshore fish populations can enable GLEA to detect subtle ecosystem changes before major environmental problems can occur in Geneva Lake.

Methods

We sampled 18 sites around Geneva Lake from June 26 – 28, 2023 (Figure 1). Most of the sites were established during the Fish Distribution Study but some sites had gradually been replaced as newer piers and related structures filled the sampling areas. This year we replaced Site 10 (with 10a) since pier expansions eliminated the sampling area. We located sampling sites with GPS and site photographs that were taken during the 2018 survey. Small mesh seines had been used for both the 1978 and 2004 surveys. We later learned that using a towed DC electroshocker (Figure 2) was more effective for sampling nearshores with greater habitat complexity (boulders and tree falls). We used both methods in 2018 but only the DC electroshocker in 2023 since we did not have enough people required for labor intensive seining. Seining can often yield greater fish numbers but often misses species that specialize in complex habitats. Towed electroshocking will typically capture greater numbers of species than seining alone. If only one sampling method is used, we discovered towed electroshocking is the most efficient method. In addition to electroshocking we recorded notes and frequently measured dissolved oxygen concentrations, water temperature and specific conductivity.

Figure 1: Aerial photo of the Geneva Lake nearshore sampling sites

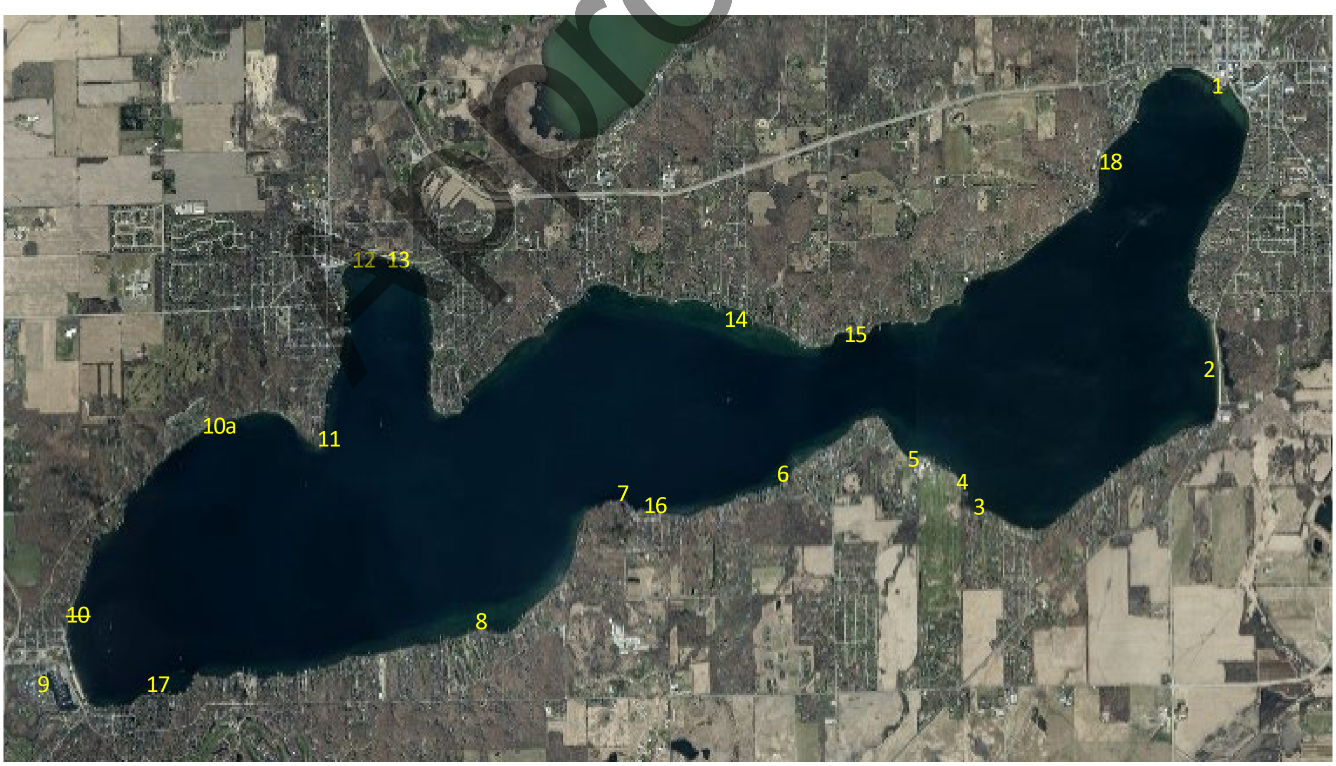

Photo 1: Towed DC electroshocker. Operated at 4 amp and 145 volts. Photo by Jake Schmidt.

Results

We found 20 species of fish along with a few hybrid sunfish during the 2023 shoreline survey. Our species collection included one longnose gar, one creek chub and one johnny darter at Site 3. These species had not been found since the 1978 survey. Site 3 is somewhat sheltered and contained abundant aquatic plants and woody debris, conditions not found in most other areas of the lake we sampled. Consistent the first towed electroshocking survey (Lyons et al. 2018), we found yellow bullheads and fantail darters not previously collected during seining surveys. Compared with the 2004 and 1978 surveys, far fewer numbers of fish were found in 2018 even though sampling included both seine and electroshocking. Total numbers of fish dropped by about two-thirds in 2023 although we did not seine. Higher fish numbers were expected nonetheless. Table 1 contains the 2023 electroshocking results and Table 2 compares four years of survey data.

Dissolved oxygen (DO) concentrations around the lake did not vary significantly, ranging from 5.6 to 10.4 mg/l. All DO measurements exceeded minimum water quality criterion (5 mg/l). The lowest DO level (5.6) was measured at Site 3 where we also found the greatest species richness. Specific conductivity measurements ranged from 530 to 565 and water temperatures ranged from 21.7 C (71.1 F) to 23 C (73.4 F). Site 9 was the only location where we found state special concern least darters. Habitat changed significantly since the 2018 survey when the aquatic plants Chara and northern watermilfoil provided good habitat. However, most of the northern watermilfoil was absent or decomposing at Site 9. We collected no fish at Sites 2, 5, 8 and 13. Sites 2 and 13 are habitat limited beach sites. We had no explanation for why fish were absent from Sites 5 and 8 where habitat was more favorable. At Site 6, we observed large schools of mimic shiners and bluntnose minnows beyond the electroshocking survey area but in water shallow enough for small mesh seining. More generally, we found fewer fish where boat waves pounded the shorelines or where dense growths of filamentous algae covered the bottom just off shore (Photos 2 and 3).

Photo 2: 40x enlargement of filamentous green algae with attached diatoms and other periphyton.

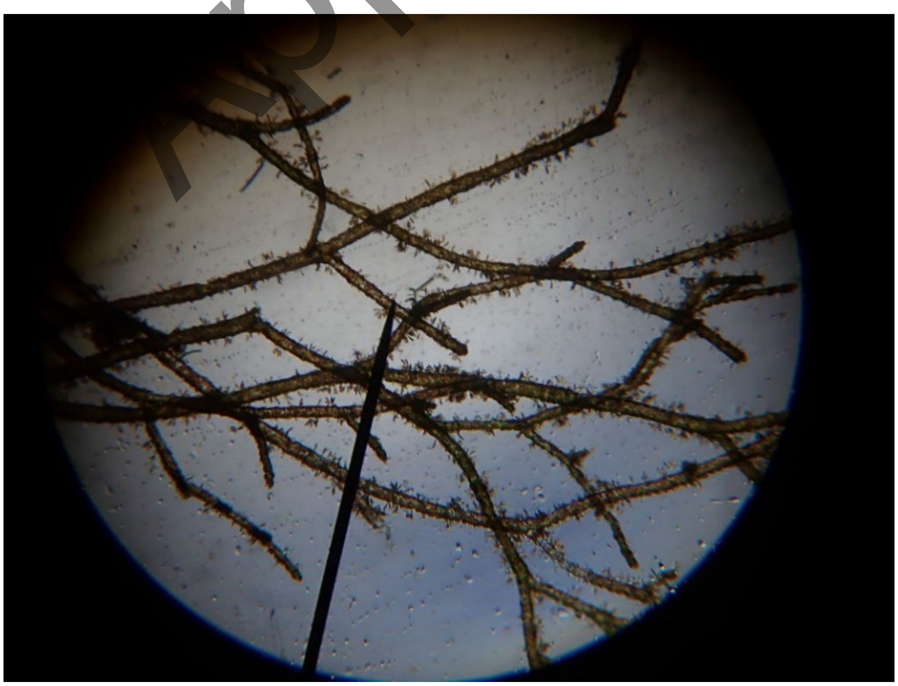

Photo 3: Filamentous algal growths that covered much of the lake bottom in shallow water areas.

Table 1: Geneva Lake nearshore fish species caught per site. Shaded areas indicate no fish collected.

Species / Site ->	1	2	3	4	5	6	7	8	9	10a	11	12	13	14	15	16	17	18
Longnose gar			1															
northern pike									2									
Mimic shiner															5			1
Bluntnose minnow				1								1						5
Fathead minnow												2						
Creek chub			1															
Yellow bullhead	2		1															1
Banded killifish			1	1								1						
Rock bass	2					1	5			1	1						2	
Green sunfish	1		1			4	3		6								2	
Pumpkinseed	1		1						1									
Bluegill			21			2	15		13									
Sunfish hybrids	2																	
Smallmouth bass						1	7			4	4						7	4
Largemouth bass			1						1							10		
Iowa darter														2				4
Fantail darter	5			6		1				16	11			1				
Least darter									13									
Johnny darter	1																	
Yellow perch			10			5	2		4		1	3			2	1		3

Table 2: Total numbers and species caught for the 2023, 2018, 2004, and 1978 fish surveys of 18 shorelines sites around the Lake Geneva shoreline, Walworth County.

Species/Survey dates	June 26-28, 2023	Aug 7-8, 2018	June 17, 2004	June 20-26, 1978
Longnose gar yoy*	1	0	0	1
Bowfin	0	0	0	1
Central stoneroller	0	0	0	4
Spotfin shiner	0	0	0	1
Common shiner	0	0	0	1
Golden shiner	0	0	1	149
Emerald shiner	0	0	0	20
Spottail shiner	0	0	0	1
Mimic shiner	6	2	5525	436
Bluntnose minnow	7	54	158	226
Fathead minnow	2	1	3	193
Creek chub	1	0	1	3
White sucker	0	0	1	83
Black bullhead	0	2	1	87
Yellow bullhead	4	7	0	0
Brown bullhead	0	0	0	18
Northern pike	2	0	3	0
Cisco	0	0	0	2
Banded killifish	3	6	34	98
Brook stickleback	0	0	0	81
Rock bass	12	20	4	43
Green sunfish	20	32	0	101
Pumpkinseed	5	30	89	146
Bluegill	51	288	290	146
Sunfish hybrids	2	4	1	5
Smallmouth bass	27	67	25	93
Largemouth bass	12	134	19	16
Rainbow darter	0	0	0	8
Iowa darter	6	0	4	5
Fantail darter	40	1	0	0
Least darter	13	52	66	3
Johnny darter	1	0	0	2
Yellow perch	30	241	509	1023
Total species	20	15	17	29
Total catch	265	956	6751	3025
Gear	Electro	Electro&Seine	Seine	Seine

*yoy = young of year

Discussion

Korth and Klessig (1990) considered inland lakes across Wisconsin an example of "The Tragedy of the Commons" (Harden 1968). Lake were threatened by seemingly limitless forms of private exploitation, mostly recreation, development and real estate income. This problem is compounded by human population growth and each succeeding generation establishes a new experiential baseline for what is normal. As a result, environmental impacts often become extreme before economic losses occur. Simply look at lakes where frequent toxic Cyanobacteria blooms had little impact on property values. Many lakes across Wisconsin have reached or exceeded their carrying capacities, and shoreline development is an important reason why. Development impacts can be exacerbated by invasives species that often thrive where habitat disturbances occur.

Shoreline development affects the most productive area in a lake for both gamefish and nongame fish as an essential link in the food web. A reduction of small benthic fish, primarily darters (Perch Family) and some minnow species (Minnow Family) can alter energy flow from shallow littoral zones to pelagic areas and affect lake ecosystems (Vander Zanden and Vadeboncoeur 2020).

Piers can destroy lake habitat directly (Garrison et al. 2005) and are the loci for other forms of nearshore human disturbances (Radomski et al. 2010). In 2004, DNR compared pier densities (numbers of piers per mile) with numbers of environmentally sensitive and rare fish species in southeast Wisconsin lakes. A strong negative relationship was found between pier numbers and numbers of small environmentally sensitive fish species (Figure 2). The southeast Wisconsin intolerant-rare nongame fish species are listed in Table 3.

Figure 2: Native Intolerant-Rare Nongame Fish versus Pier Density

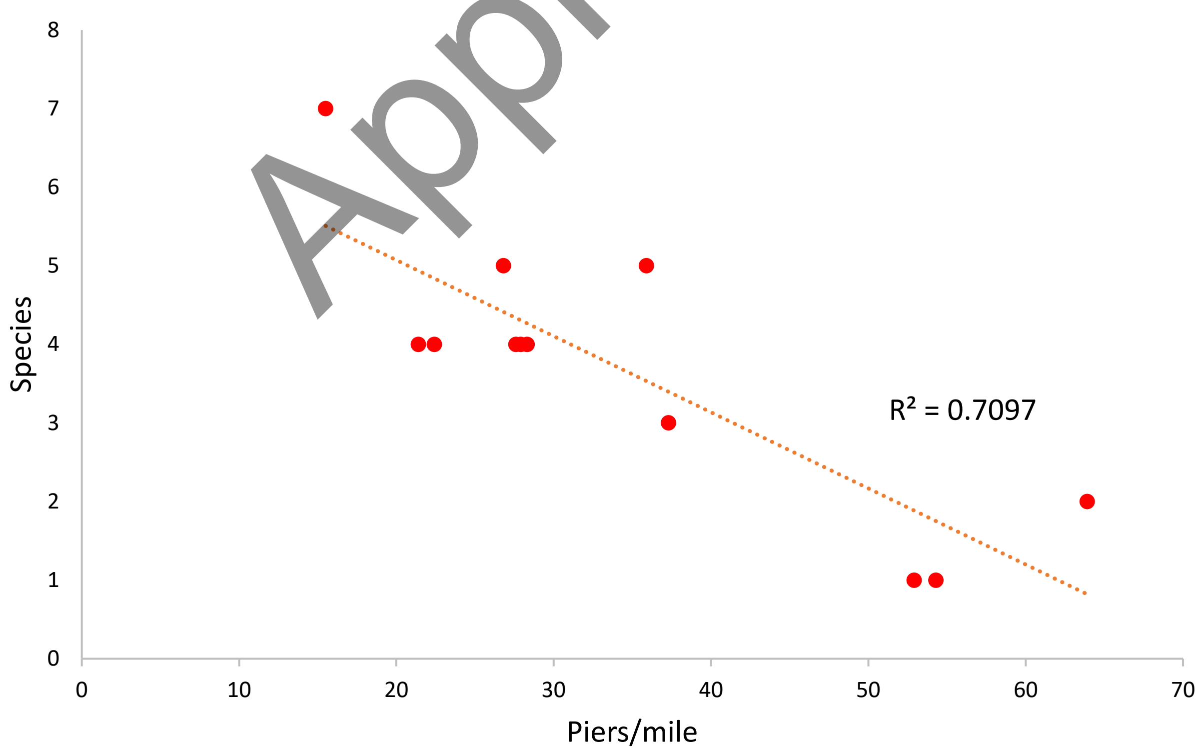

Table 3: List of southeast Wisconsin intolerant-rare nongame fish species used in Figure 2

Common name	Scientific Name	Classification
pugnose shiner	*Notropis anogenus*	State Threatened
pugnose minnow	*Opsopoeodus emiliae*	Rare
blackchin shiner	*Notropis heterodon*	Intolerant
blacknose shiner	*Notropis heterolepis*	Intolerant
lake chubsucker	*Erimyzon sucetta*	State Special Concern
banded killifish	*Fundulus diaphanus menona*	Rare
starhead topminnow	*Fundulus dispar*	State Endangered
least darter	*Etheostoma microperca*	State Special Concern
Iowa darter	*Etheostoma exile*	Intolerant
rainbow darter	*Etheostoma caeruleum*	Intolerant

DNR counted piers around Geneva Lake in 2004 at a density of 37 piers/mile (Figure 2). Least darters, Iowa darters and banded killifish are three Geneva Lake native intolerant-rare nongame fish found in all four surveys. Intolerant rainbow darters have not been seen in the lake since 1978.

In the latter part of the 20th century, the DNR Pier Planner became an important lake management decision tool used to balance private access rights and protect public waters under the Public Trust Doctrine. Private piers were always allowed within the scope of science and reasonable use. At times DNR denied over-size piers when scientific data predicted significant ecological harm and cumulative impacts to a lake. Overall this regulatory tool had minimal effect given the proliferation of private structures placed over public waters and productive littoral zone habitats, including Geneva Lake.

The 2023 Geneva Lake nearshore fish survey is only the fourth on record. This sampling frequency is probably insufficient to detect subtle changes in the lake ecosystem. In spite of this low sampling frequency, most lakes in Wisconsin are sampled less or not at all (Marshall et al. 2022). Since 2004 the State Legislature determined that sampling fish populations other than popular sportfish is an unauthorized DNR use of segregated fishing license funds. This seems like an odd interpretation (and contrary to the opinions of DNR scientists) of what constitutes fish management since sustaining gamefish requires a thorough understanding of their environment and food webs.

Korth and Klessig (1990) argued that "overcoming the tragedy of the commons" requires local lake management investment and leadership. GLEA remains among just a handful of local lake management authorities in Wisconsin (along with Green Lake Sanitary District, Lake Ripley Management District, Jefferson County Land Conservation Department and Dane County Department of Land and Water Resources) that independently pursued nongame fish surveys as a source of ecological data.

The public doesn't need to look at TSI data to appreciate that Geneva Lake is a clear high-quality lake (thanks in part to geology and Chara abundance where significant coprecipitation of calcite and P occurs). However comprehensive lake studies in addition to nutrient data can educate the public about important natural heritage features and why Geneva Lake cannot sustain limitless development.

Options for Future Investigations

We discovered two potentially significant issues in 2023 that should probably be investigated. Our survey revealed few fish were found where boat wakes pounded shorelines. Waves produced by watercraft are more irregular and turbulent than wind generated waves, and more stressful to most fish and invertebrates (Whitfield and Becker 2014). Watercraft turbulence poses an additional stressor to shoreline habitat loss and invasive species. Placement of large boulders along selected shorelines is one option to function as barrier reef-like wave suppressor. Placing boulder reefs just beyond shore and well inside the navigation zones may reduce stressful turbulence. This form of habitat management could be a potential research and demonstration project.

Another 2023 observation was expansive growths of benthic algae along most shorelines, primarily beyond the shoreline wave turbulence. We found few fish within the dense growths of (unidentified at this point) filamentous green algae (Photos 2 and 3). In the Laurentian Great Lakes, massive growths of green filamentous algae (mostly Cladophora) thrive where invasive zebra mussels pump biologically available phosphorus back into the water column (Page et al. 2022). Did zebra mussels in Geneva Lake contribute to the filamentous algae growths and internal P loading? Filamentous algae growths can alter energy flow in a lake and pose a host of ecological problems (Page et al. 2022).

Four separate nearshore fish surveys on Geneva Lake demonstrated that towed electroshocking can detect more species while small mesh seining will typically yield more fish. The highest total number of fish collected during the 2004 survey was likely reflected summer fish population recruitment and seasonal distribution of mimic shiners. The other three surveys were conducted earlier in the growing season before population recruitment peaked.

Future nearshore fish surveys could include both fish sampling methods but small mesh seining requires more effort than towed DC electroshocking. Nearshore fish surveys could be paired with quantitative habitat surveys to identify critical habitat features influencing nongame fish distribution and abundance. USEPA and DNR (2020) recently adopted shoreline habitat survey methodologies. The USEPA methodology (PHAB) (Kaufmann et al. 2014b) is based on collecting data from equidistant stations around a lake. Shoreline fish surveys could be paired with the habitat sites along with continued natural shoreline sampling. Site 10 was moved to the Yerkes Observatory shoreline, one of the few remaining natural areas around the lake. Natural shorelines like this one are worthy of protection.

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