Should We Care About the Little Fish in Our Lakes?

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Those of us growing up in the 1950s, ’60s, and ’70s who viewed lakes through a snorkeling mask observed a more fascinating world beneath the waves than seen today. The shallows of most lakes then teemed with schools of colorful small nongame fish (Figure 1) that kids growing up in the 21st century may never get to enjoy.

Memories can become distorted over time, but science supports at least some of our anecdotal experiences. The biodiversity loss in lakes is tangible. In Wisconsin, declines of small nongame fish species have been documented within glacial lakes since the 1970s. Darters and minnows declined in many glacial lakes as habitat became degraded. Shoreline development represented the greatest habitat change in most southeastern Wisconsin marl lakes (Marshall and Lyons 2008). Increased numbers of large piers became a prominent form of shoreline development, causing measurable habitat loss (Garrison et al. 2005; Radomski 2010). On a broader scale, the decline of freshwater fish across North America poses an unprecedented crisis in conservation (Walsh et al. 2011).

The need to survey nongame fish

Despite documented nongame fish declines, lakes assessments typically focus only on trophic state indicators (TSI) (i.e., Secchi water clarity, phosphorus, and chlorophyll), macrophyte surveys, plankton analysis, and sportfish population inventories. Focusing on water quality is understandable given the pervasive threats and impacts to lakes from agricultural and urban runoff. But important ecosystem indicators such as nearshore fish guilds are often overlooked as part of lake management strategies.

Nongame fish species are not regularly surveyed since they lack perceived economic benefit compared to popular sportfish. 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 their population declines can reveal environmental stresses that traditional lake monitoring methods overlook. Nearshore fish surveys can also be useful for gamefish management since many nongame species are important prey and juvenile stages of popular sportfish are detected in these areas as well.

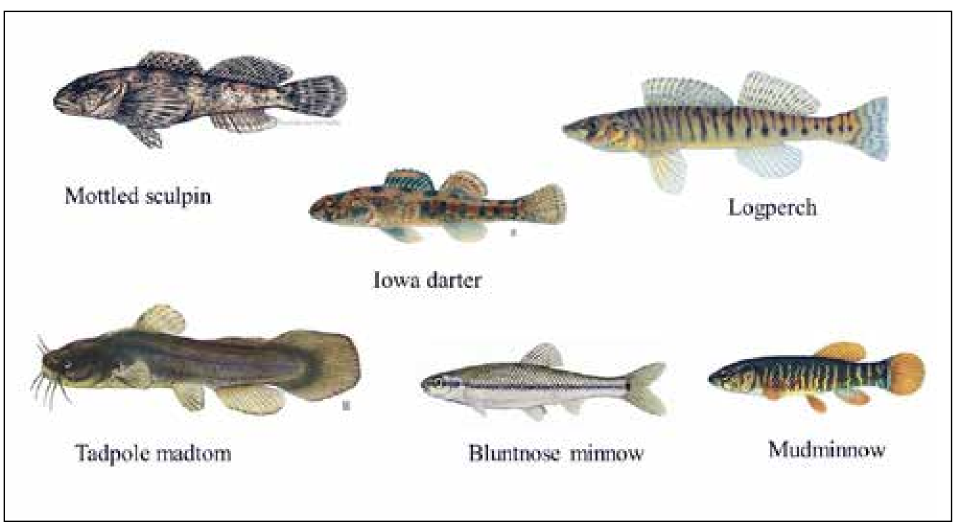

Figure 1. Photo showing a variety of colorful small nongame fish.

Yahara River Chain of Lakes surveys, Dane County, Wisconsin

Beginning in 2017, we decided to take a fresh look at the nongame fishes in the Yahara River Chain of Lakes. The Yahara Chain is in south central Wisconsin’s Dane County and includes Lake Mendota, one of the most studied lakes in the United States. The county holds Wisconsin’s second highest population (546,695 – 2019) and includes the state capital city of Madison. The status of Lake Mendota nongame fish species was assessed in detail during the early 1980s (Lyons 1989). Eight species had disappeared by that time: 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*). Their disappearance coincided with the colonization and explosive expansion of the invasive, non-native aquatic plant Eurasian watermilfoil (*Myriophyllum spicatum*) in the lake in the late 1960s and early 1970s.

From 2017 through 2020 we assessed the current distribution and status of small-bodied, nearshore fishes in the four main Yahara River Lakes: Mendota – 2017, Monona – 2017, Waubesa – 2020, and Kegonsa – 2019 (Figure 2). Our goal was to update information on the presence and distribution of small nongame fishes and complement other ongoing sampling

Figure 2. Yahara Chain of Lakes, Dane County Wisconsin, USA.

efforts using a different methodology. For more than 25 years the University of Wisconsin-Madison Long-Term Ecological Research (LTER) Program has sampled Lakes Mendota and Monona annually for small fishes using beach seines, but few small-fish surveys have been done in Waubesa and Kegonsa since the 1940s and 50s.

In this study we sampled nearshore areas using a small tow-barge DC electroshocker while wading, a technique more effective than beach seining for collecting fish in areas with complex habitat and extensive rocks, aquatic plants, or woody debris (Figure 3). Each lake was sampled at multiple sites using the same equipment and crew and following standardized protocols, so that results could be compared within and among lakes and with previous and future surveys. At each site we measured dissolved oxygen, water temperature and specific conductance. We also described nearshore habitat conditions at each site.

Sampling locations were not selected randomly but rather included a combination of historic sampling sites and accessible shorelines where piers were not too densely packed to impede the sampling. Three general shoreline habitats were sampled: riprap, undeveloped shorelines, and cobble-gravel shoals. Deeper water was characteristic along riprap and most undeveloped shorelines compared to shoal habitats. We sampled 32 riprap shores compared with 22 cobble-gravel shoals, a ratio of 1.45:1. This ratio is far lower than what occurs around the lakes, where riprapped shorelines far exceed cobble-gravel shoals. Twenty-three undeveloped shorelines were also sampled where neither riprap nor cobble-gravel shoals were found. Cobble-gravel shoals were found along both natural shorelines and developed shorelines without submersed riprap.

Among the 77 shoreline sites we sampled, we found 12 native species in Lake Mendota, 16 in Monona, 16 in Waubesa and 18 in Kegonsa. Our recent surveys demonstrated that sunfishes (Centrarchidae) were the most abundant fish family across the Yahara Chain of Lakes (Figure 4). Nearshore nongame fishes were relatively scarce. Of the eight

Figure 3. DC tow-barge electroshocking along Lake Monona. Nearshore water depths increase rapidly around most areas in the Yahara Chain of Lakes. Electroshocking are Dave Marshall and Tim Larson. Photo: Dave Grey.

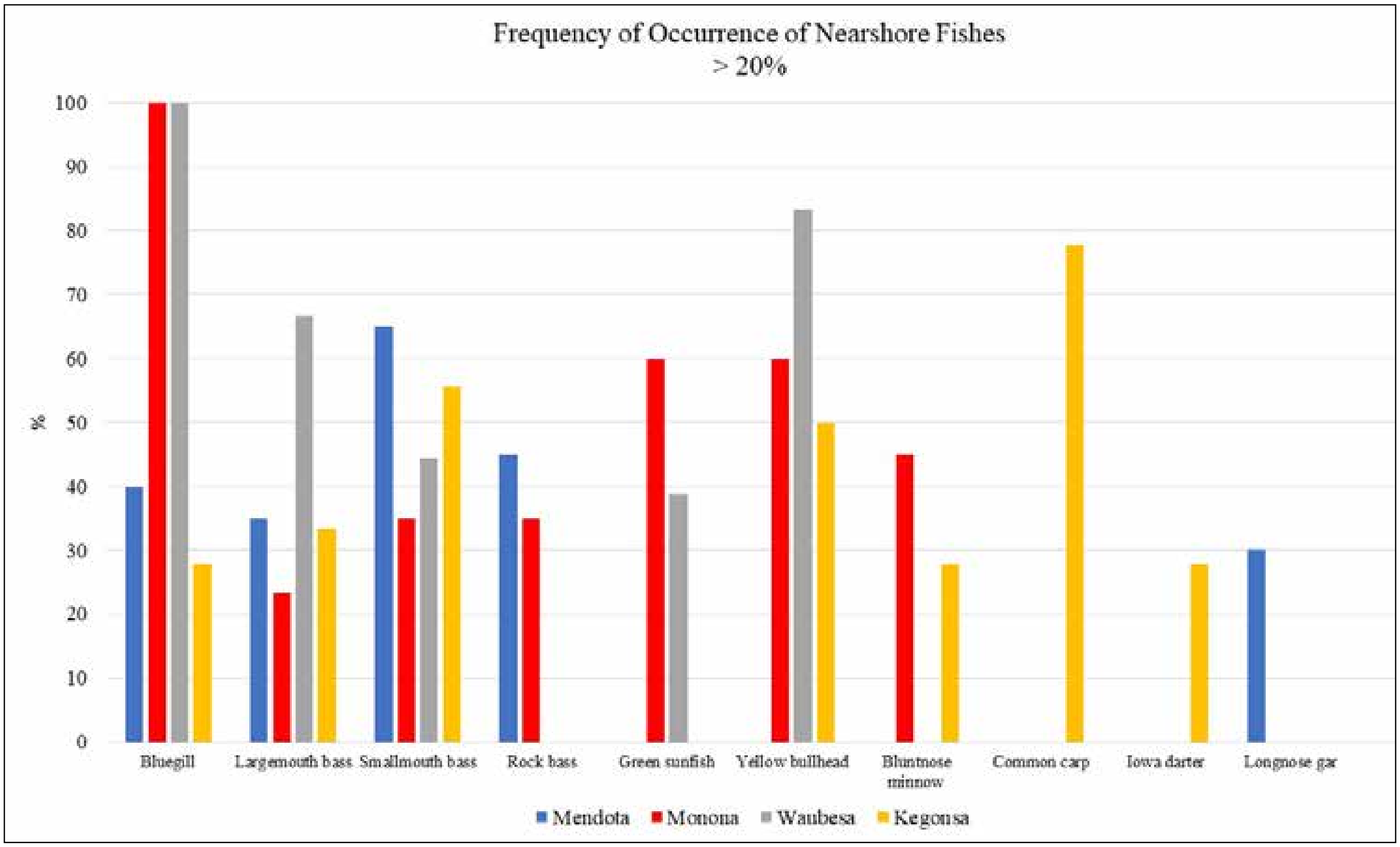

Figure 4. Dominant Yahara Chain of Lakes fish based on frequency of occurrence in each lake.

fish species that disappeared from Lake Mendota (Lyons 1989), we found just one of them but not in Lake Mendota. We collected three tadpole madtoms along two Lake Kegonsa cobble-gravel shoals. Overall, we found far fewer species of nongame fish than historically lived in the Yahara lakes.

Table 1. Yahara Chain of Lake Water Quality Condition Summaries (WDNR 2021).

Lake	*Acres*	*General Condition*	*USEPA 303d Listing*	*Impairment Type*
Mendota	9,842	Poor	Impaired	Cyanobacteria, phosphorus
Monona	3,274	Poor	Impaired	Cyanobacteria, phosphorus, contaminants
Waubesa	2,080	Poor	Impaired	Cyanobacteria, phosphorus, contaminants
Kegonsa	3,210	Poor	Impaired	Cyanobacteria, phosphorus

Likely causes for low numbers of nongame fish in the Yahara Chain

Long-term habitat changes and water quality declines have occurred in the Yahara Chain. The Wisconsin Department of Natural Resources (WDNR) currently lists the Yahara lakes as phosphorus- and algae-impaired (Table 1). Eurasian watermilfoil declined in the lakes over a decade ago and is no longer considered as serious an ecological threat. Of these three issues, our data indicate that habitat change is currently the most significant factor limiting nongame fish in these lakes.

In Lake Mendota, cyanobacteria blooms and other cultural eutrophication problems are less severe compared with the other three lakes. But that is where we found the lowest number of nearshore fish species. On the opposite end of the four-lake spectrum, we found the most nongame fish species in Lake Kegonsa, which has been described as the most eutrophic lake in the chain (Lathrop 2007).

Five environmentally intolerant species currently inhabit the Yahara lakes, and they are more sensitive to pollution than some of the locally extirpated and declining nongame species. A few of the environmentally sensitive species remain more abundant than less sensitive nongame fish found in the lakes. The mere survival and abundance of environmentally intolerant species suggests that other factors besides water quality can affect fish species distribution.

Our findings indicate that riprap is unfavorable for most small nongame fishes and selects for juvenile largemouth bass, juvenile smallmouth bass, rock bass, green sunfish, bluegills, hybrid sunfish, bullheads (*Ameiurus* sp.), and young of year common carp. These species were also common in other habitat types as well (Figure 4). However, unlike sunfishes and bullheads, nongame fishes were rarely

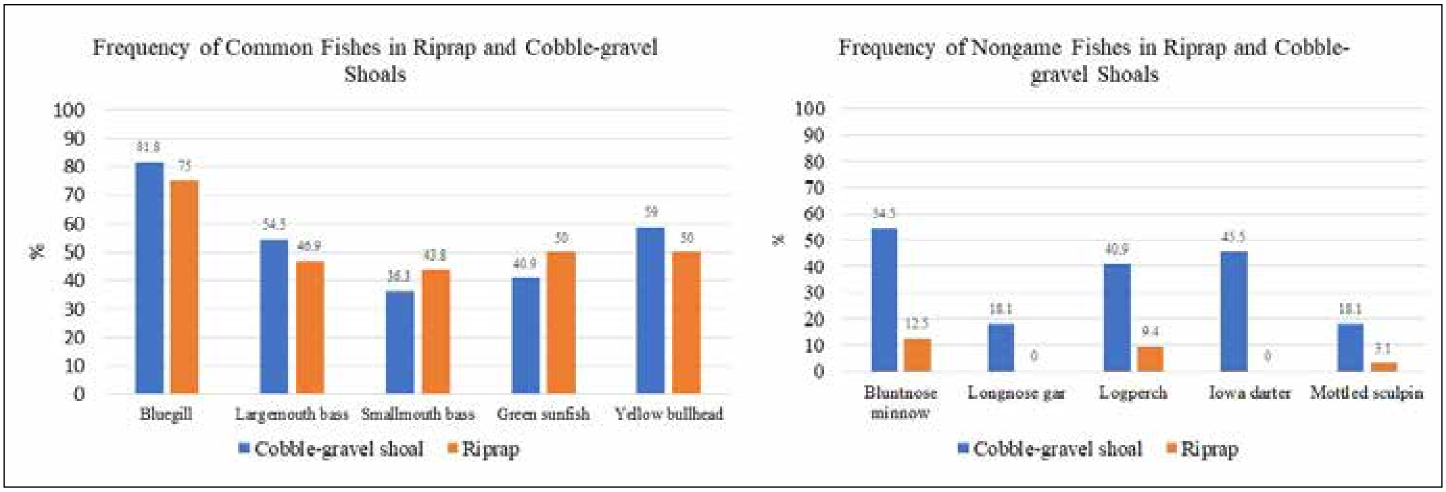

Figure 5. Frequency of occurrence for 10 Yahara lakes fish species in riprap and cobble-gravel shoals. Common species versus declining nongame species. Shoals N = 22, Riprap N = 32.

found near riprap (Figure 5). Most nongame fishes were found within cobble-gravel shoals and to a lesser extent undeveloped shoreline without riprap (Figure 6). The relative dearth of nongame fish that we found in Lake Mendota compared with the greater numbers in more eutrophic Lake Kegonsa suggests that habitat change now controls the distribution of many small fishes. Native fish species richness was also significantly greater (<.05) in cobble-gravel shoals than in riprap (Figure 7). Riprapped sites are usually deeper with the greatest habitat change that occurs when lake levels are higher. In contrast, cobble-gravel shoals have a gentle slope and very shallow water that appears to be more favorable for most nongame fishes.

Discussion

Dams are used to regulate water levels in all four lakes. WDNR and partners established higher water levels in 1979 to expand watercraft navigation and potentially improve northern pike spawning opportunities. Riprap construction gradually followed along most shorelines susceptible to erosion. Later, increasing precipitation from climate change contributed to even higher water levels within the Yahara Chain's urbanized floodplain, which limits discharge from the lakes. United States Geological Survey (USGS) data revealed that seasonal water levels in the lakes

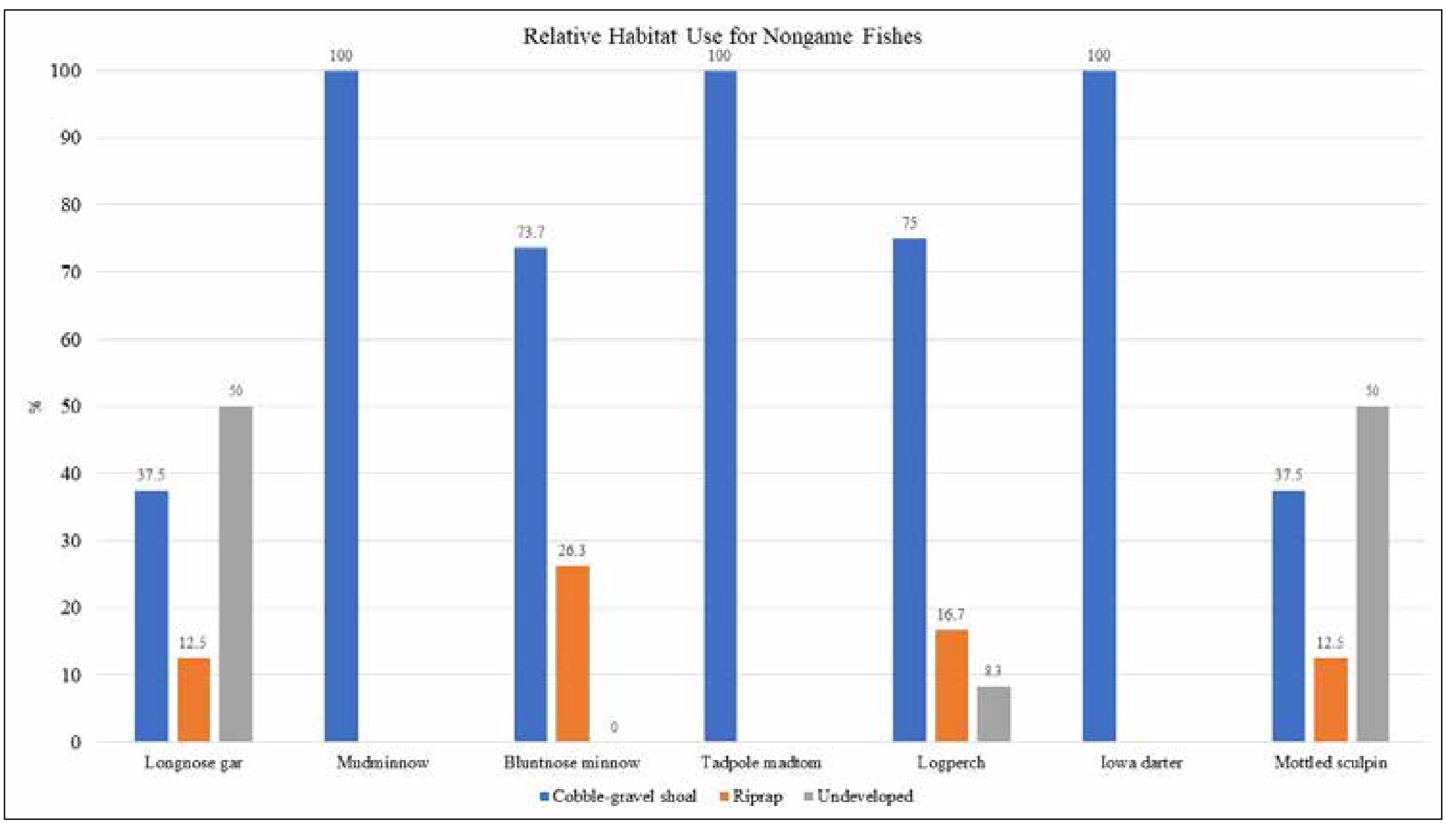

Figure 6. Comparison of habitats where Yahara lakes nongame fish collected as part of this study.

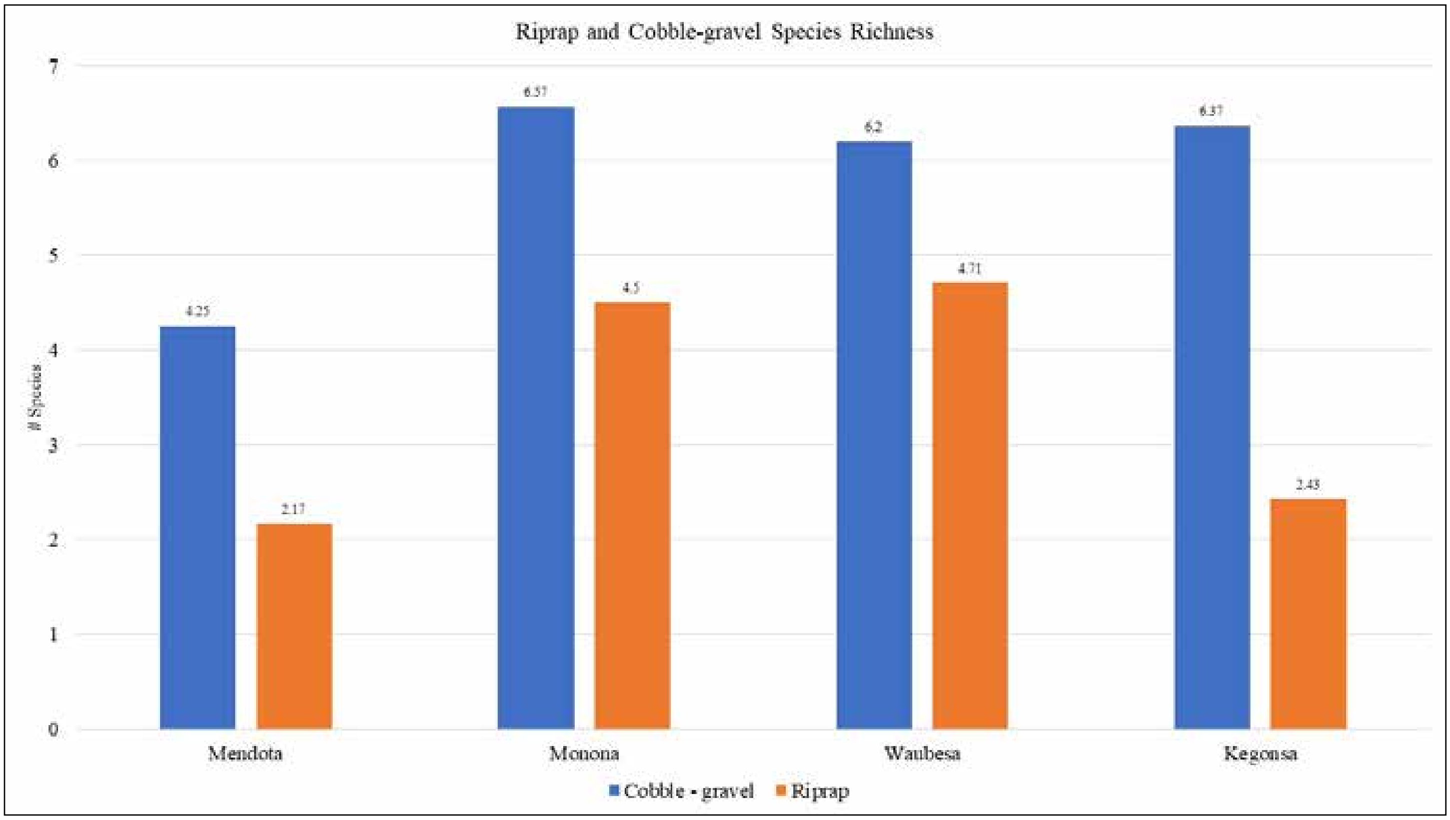

Figure 7. Nearshore fish species richness at shallow cobbler-gravel shoals and riprap, P <.05 significant for Mendota, Monona, and Kegonsa.

often exceed long-term median levels as well as the target summer maximum levels (Figure 8). In effect, the Yahara Chain of Lakes has become bathtubs with few shoals remaining for small fishes to inhabit. Figure 9 illustrates how riprap habitat differs from cobble-gravel shoals.

In 2018, Dane County communities along the Yahara River Chain of Lakes experienced unprecedented flooding. Dane County government established a task force to study flood prevention alternatives that included possibly changing established lake levels. We found one site on Lake Waubesa of particular interest since it may indicate nearshore habitat under lower water conditions. It was the only site where we found riprap and a cobble-gravel shoal co-existing along the same stretch of shoreline. The site was atypical since the riprap base was not submersed. When we sampled the site, the riprap sat above the water line which exceeded the target summer maximum level. We found Iowa darters in the cobble-gravel shoal (Figure 10) located below the dry riprap. By most standard measures, habitat at this heavily developed site is considered poor but a cobble-gravel shoal persisted. Shorelines

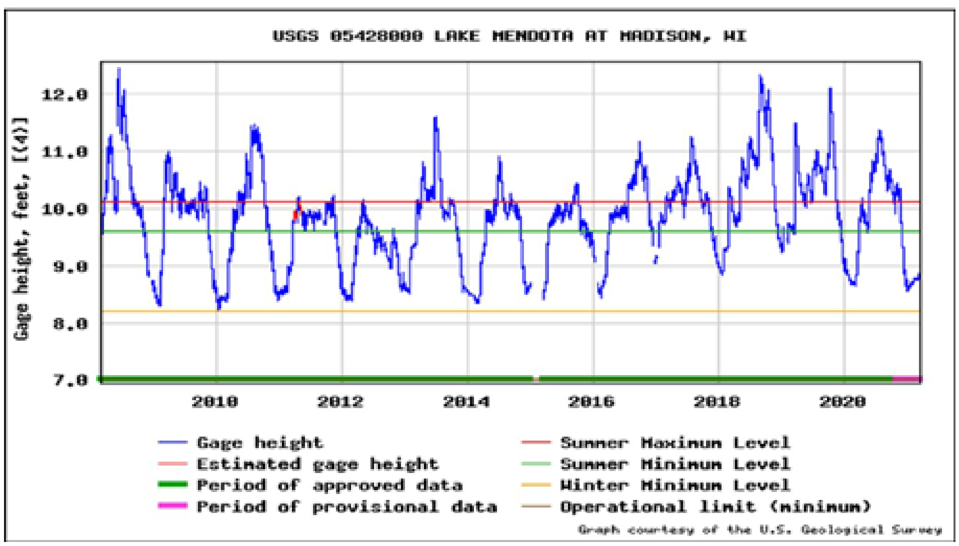

Figure 8. USGS Lake Mendota graph demonstrating frequency of water levels exceeding summer maximum target.

such as this one could potentially expand if water levels were lowered.

Chen et al. (2019) reported that flooding could be reduced if target lower minimum lake levels were established for Lake Mendota. Higher lake levels became established as part of the 1979 order, in part to improve northern pike spawning. This goal should be re-evaluated since higher lake levels may not sufficiently compensate for general loss of wetlands and floodplain connectivity. Floodplain elevation often increases in agricultural watersheds due to gradual sediment deposition (Knox 2006).

Riprap has generally been considered a relatively benign form of shoreline armoring, compared with seawalls that lack habitat complexity. As a result, riprap has been widely permitted across the four

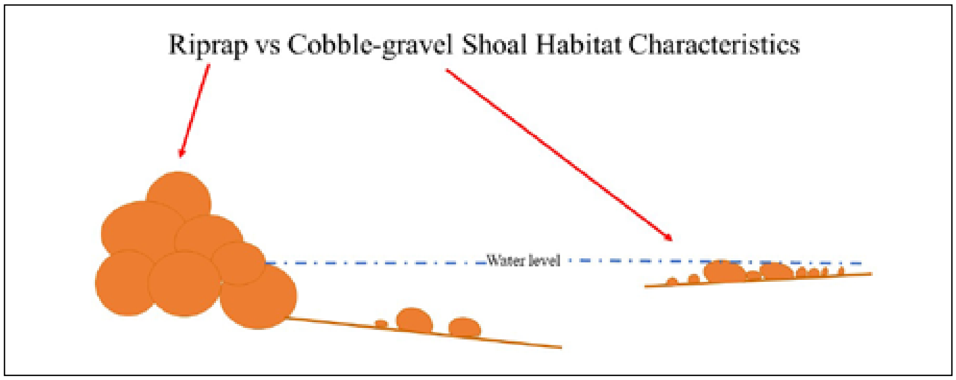

Figure 9. Illustration of characteristic riprap and cobbler-gravel shoal habitats. Riprap creates shoreline dams that have abrupt slopes and keep nearshore water deeper than ideal for many small non-game fishes whereas cobble-gavel shorelines have gentle slopes and provide a range of depths available, including the shallow waters favored by many small non-game fishes.

Figure 10. Heavily developed site where a shallow cobble-gravel shoal existed because the riprap was constructed above the high-water level.

lakes (Figure 11). Our data suggest that riprap is not as benign as regulatory agencies previously thought, at least from the perspective of nongame fish habitat. Riprap appears to create adverse conditions for many of these small fish. We don't know for certain why nongame fishes become scarce near riprap. It may be related to increased predation near riprap where water is often a foot or so deeper next to shore. We found a similar pattern in other lakes we sampled where nongame fish were primarily found in cobble-gravel shoals instead of riprap. In another lake in an adjacent county, we found a rare small catfish known as the slender madtom (*Noturus exilis*) using our tow-barge electroshocking gear (Lyons et al. 2020). It was previously found only in streams and is listed state endangered. Without the use of our DC tow-barge electroshocking gear, we would never have stumbled across this unlikely rare species. Consistent with most other nongame fishes we find, the slender madtom inhabits cobble-gravel shoals.

Conclusion

The original goal of the surveys was to assess species richness and distribution of nearshore fishes in the Yahara lakes, with particular interest in rare and declining small nongame species. Beyond the local nongame fish extinctions that had occurred in Lake Mendota during the 1980s, declines of other nongame species continue as a result of shoreline habitat change. As an unexpected finding of our study, we demonstrated that extensive shoreline riprap, along with higher water levels, are contributing to nongame fish declines and lower species richness. Lake Kegonsa, the most eutrophic lake in the Chain, has more cobble-gravel shoals and supported the most nongame fish. Our study demonstrated that nearshore tow-barge electroshocking surveys provided valuable insights into lake ecology and development impacts that would have been overlooked using more traditional lake assessment tools.

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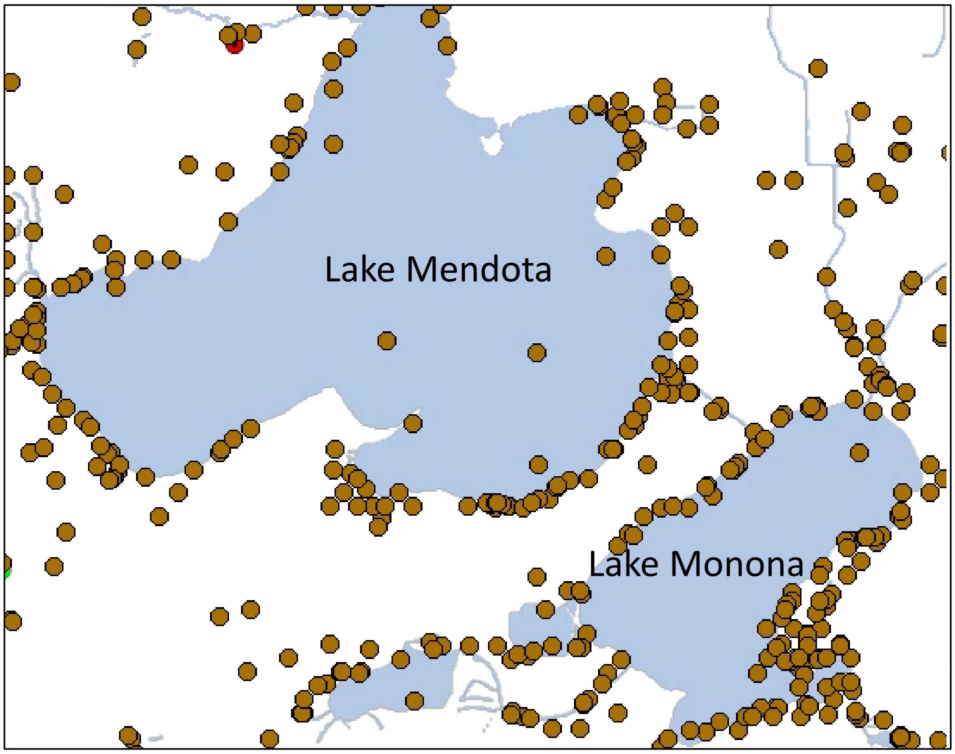

Figure 11. Regulated shoreline modifications around Lake Mendota and Lake Monona. Dots indicate shoreline changes that occurred from 2004-2019. Most permits were for riprap construction and to a lesser degree seawall, shoreline armoring repair, and dredging (WDNR Surface Water Data Viewer 2021).

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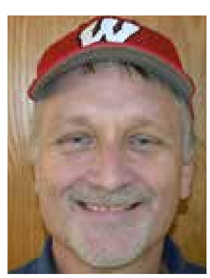

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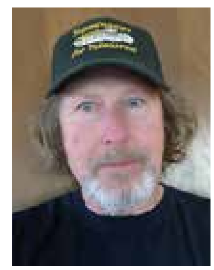

Dave Marshall (covid hair edition) worked for Wisconsin DNR lakes and fish habitat protection programs from 1976 to 2006. Following early retirement in 2006, he established Underwater Habitat Investigations LLC focusing on lakes management, oxbow lake research, and nearshore fish distribution surveys. He received his B.A. degree in biological aspects of conservation from the University of Wisconsin Milwaukee (1975).