Proceedings of The National Conference
On Undergraduate Research (NCUR) 2019
Kennesaw State University
Kennesaw, Georgia
April 11-13, 2019

Fish Bioassessment of Three Different Ecosystems at the Primmer Outdoor Learning Center

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Abstract

Water quality in ponds, wetlands, and rivers in Ohio may be negatively impacted by contaminants from agriculture, industry, transportation, and other sources. Fish community data are increasingly being included in water quality assessments since they can serve as bio-indicators of ecosystem health. Sunfish species including bluegill (*Lepomis macrochirus*) are typically classified as tolerant, while other species such as darters and trout are intolerant to low water quality. The bioassessment surveys employed in this research were conducted at Capital University's Primmer Outdoor Learning Center, a 74-acre field research property in Hocking County, Ohio. The monitoring program was conducted during May-August in 2017 and 2018 and May-June in 2019 in three aquatic ecosystems: a beaver pond, a wetland, and approximately 30 m of the Hocking River. A total of 157 fish were caught and identified using live-trapping and angling methods. Preliminary results showed that longear sunfish (*L. megalotis*) and bluegill x green sunfish hybrids (*L. macrochirus x cyanellus*) were the most common species live-trapped in the wetland, suggesting good quality since longear sunfish are classified as an intolerant to moderately tolerant species. Bluegill x green sunfish hybrids were the most common species sampled in the beaver pond, which are indicative of poor quality. One hybrid and one bluegill were found in the river. Future work includes additional bioassessments and testing, particularly in the river, in order to provide conservation and management recommendations along with future research, education, and outreach opportunities focused on fish communities and their habitats at the outdoor learning center.

Keywords: Survey, Sunfish, Ohio

1. Introduction

Freshwater ecosystems serve as habitats to plants and animals, and also provide numerous services to humans including recreation, habitat, flood control, and water purification[1]. Unfortunately, freshwater ecosystems in the Midwest USA are often subject to anthropogenic influences and pollutants from sources such as agriculture, industry, and transportation[2]. Research has shown that freshwater ecosystems are being altered or destroyed at a substantial rate[3]. In St. Marys, Ohio, algae blooms have become more frequent and this raises concerns for human health and safety. The algae present can produce toxins, such as microcystin, which are potentially carcinogenic to humans[4]. If the concentration becomes too high the water is deemed unsafe to drink and unsafe for recreation. Fishing is popular but limits are enforced in multiple states, including Ohio, because many fish populations have started to decline.

Fortunately, there are still several different species of fish that are found in rivers, streams, ponds, and wetlands throughout Ohio including bass, darters, trout, and various sunfish[5]. Fish are often categorized by their tolerance and ability to thrive in different levels of water quality and degradation. For example, darters and trout are often classified as intolerant to low water quality, while some sunfish species, including bluegill (*Lepomis macrochirus*), are typically

classified as tolerant[6]. Bluegill have 5-9 dark bars on their side and when caught in muddy water they appear more silver in coloration. Green sunfish (*L. cyanellus*) are capable of thriving in muddy water, which is outside of the range of other sunfish species, such as the pumpkinseed sunfish (*L. gibbosus*)[5]. Green sunfish differ in appearance from other sunfish species with their dark olive-green colored body and iridescent blue lines on the cheek[5]. Longear sunfish (*L. megalotis*) are classified as intolerant to moderately tolerant and can be identified by the long opercle (i.e., ear flap) and the emerald blue wavy lines running from the mouth to the gill cover[6]. If particular sensitive species are missing from communities in which they would expect to be found, then conservation and management plans can be designed and implemented to improve fish biodiversity at these sites. The presence of sensitive fish species can lead to useful information about the quality of the water body and the overall health of the ecosystem.

Studies have shown that water quality may be indirectly assessed through biodiversity surveys of the species found there as opposed to physiochemical monitoring[7]. Macroinvertebrate monitoring has been widely used but other research shows that fish have advantages as indicator organisms[7]. The classification system is based on a series of fish community attributes including number of species, presence of intolerant species, species richness and composition of darters, suckers, and sunfish (except green sunfish), proportion of green sunfish, and proportion of hybrid individuals, along with ecological factors. A fish-based index of biotic integrity (IBI) was developed in West Virginia streams and they found that this type of assessment was an informative way to identify biologically impaired water bodies[6]. Another study was conducted in the Great Lakes coastal wetlands using data about the fish community and they concluded that IBI's provide useful information to guide future environment restoration and protection projects[8]. Therefore, fish are useful in biological assessments since life history information is generally well-known, the general public can relate to information about fish communities, and fish are typically present in all but the most polluted water sources[6,7].

The goal of this study was to conduct biological monitoring focused on the fish community in a wetland, beaver pond, and river at Capital University's Primmer Outdoor Learning Center, a 74-acre field research property in Hocking Hills, Ohio[9]. The beaver pond is relatively new on site (i.e., likely less than five years old), and the river is used by visitors to the area for canoeing and kayaking with a livery nearby. Data were collected on fish communities attributes in each habitat using live-trapping and angling methods. Then, a preliminary assessment of biotic integrity about the status of fish communities and the quality of the habitat in which they were found was made. Based on the history and current land use on site, it was hypothesized that the quality of the wetland would be highest, followed by the river, and then finally the beaver pond. This work will inform recommendations about conservation and management of these habitats. In addition, it provides preliminary results for future research, education, and outreach opportunities focused on fish communities and their habitats at an outdoor learning center for future students, faculty, and visitors of the property.

2. Methodology

2.1 Field Site

The surveys were conducted in three aquatic ecosystems during May-August of 2017 and 2018 and May-June 2019 at the Primmer Outdoor Learning Center in Logan, Ohio (Figure 1). The 74-acre property has seven ecosystems, including approximately 15 acres of a high-quality wetland and an area of groundwater seeps, which feed into three small streams. The wetland features a heron rookery with over 30 nests, and a bald eagle nest. Other ecological factors contribute to the educational value of the property, including footage along the Hocking River and a riparian forest, a secondary-growth deciduous forest, old field and pasture habitats (some of which are slowly being converted to Ohio Prairie), and a pine/spruce plantation. The three sites sampled in this study were the Willow Pond Wetland (Figure 2a), a Beaver Pond (Figure 2b), and the Hocking River (Figure 2c).

Figure 1. Map of the 74-acre Primmer Outdoor Learning Center in Logan, Ohio. The three aquatic ecosystems surveyed in this project are labeled: Willow Pond Wetland, Beaver Pond, and Hocking River.

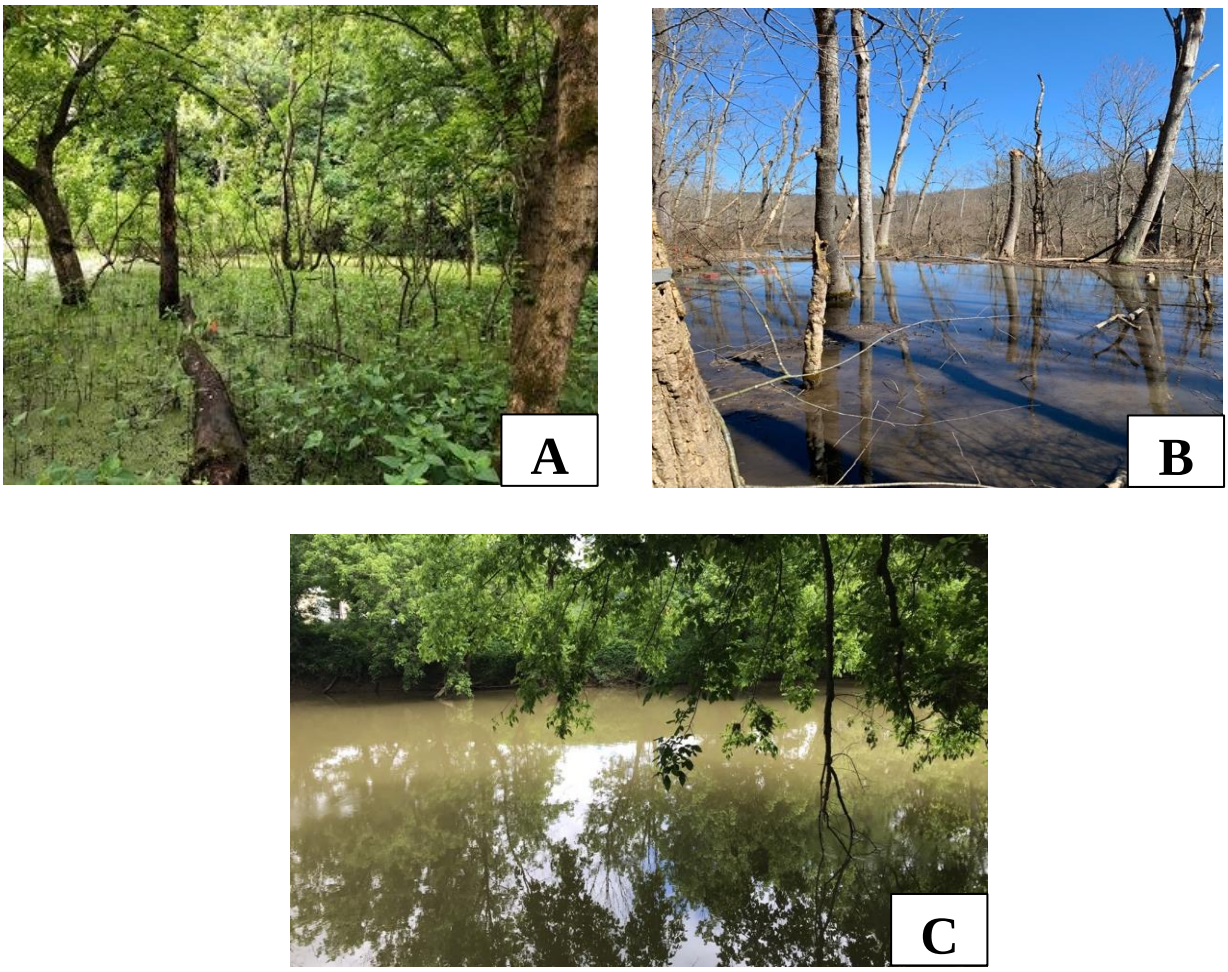

Figure 2. The (a) Willow Pond Wetland, (b) Beaver Pond, and (c) Hocking River at Capital University's Primmer Outdoor Learning Center.

2.2 Field Methods

The wetland and beaver pond were surveyed using small (45 x 25 cm) and large (90 x 30 cm) Promar minnow live-traps (Figure 3). In 2017, a total of 20 live-traps were set in wetland and a total of 30 live-traps were set in the beaver pond on multiple trapping dates. In 2018, 59 traps were set in the wetland and 10 traps were set the beaver pond. Lastly, in 2019, 15 traps were set in the wetland and 10 traps set in the beaver pond. Different numbers of live-traps were set in the different habitats since they were also be used to survey for amphibians in another project, and to provide more overall sampling in the wetland in this project since it was substantially larger than the beaver pond.

Figure 3. A large Promar minnow live-trap checked in the wetland containing approximately 45 individual sunfish.

Due to depth of > 1 meter, and a relatively rapid current, angling was the only method employed in the Hocking river. The Hocking River was fished in 2018 four times for a total of 150 minutes. Canadian night crawlers were used as live bait[5].

2.3 Data Collection

Photographs were taken of all fish at release from the live-traps. The Stream Fishes of Ohio and Sport Fish of Ohio wildlife publications from the ODNR Division of Wildlife were used to make identifications. Difficult or questionable identifications were confirmed by the Associate Curator of the Fish Division of the Museum of Biological Diversity at the Ohio State University.

3. Results

A total of 157 different individual sunfish and hybrids were identified in this preliminary fish community monitoring program at Capital University's Primmer Outdoor Learning Center in the Hocking Hills region of southeast Ohio (Figure 4). Longear (*L. megalotis*) sunfish (n=56), bluegill x green sunfish (*L. macrochirus x cyanellus)* hybrids (n=47), and bluegill (*L. macrochirus*; n=2), were found in the Willow Pond Wetland, longear sunfish (n=2) and bluegill x green sunfish hybrids (n=48) were live-trapped in the Beaver Pond, and a bluegill (n=1) and a green sunfish x longear (*L. cyanellus x megalotis*) hybrid (n=1) were caught in the Hocking River (Figure 5).

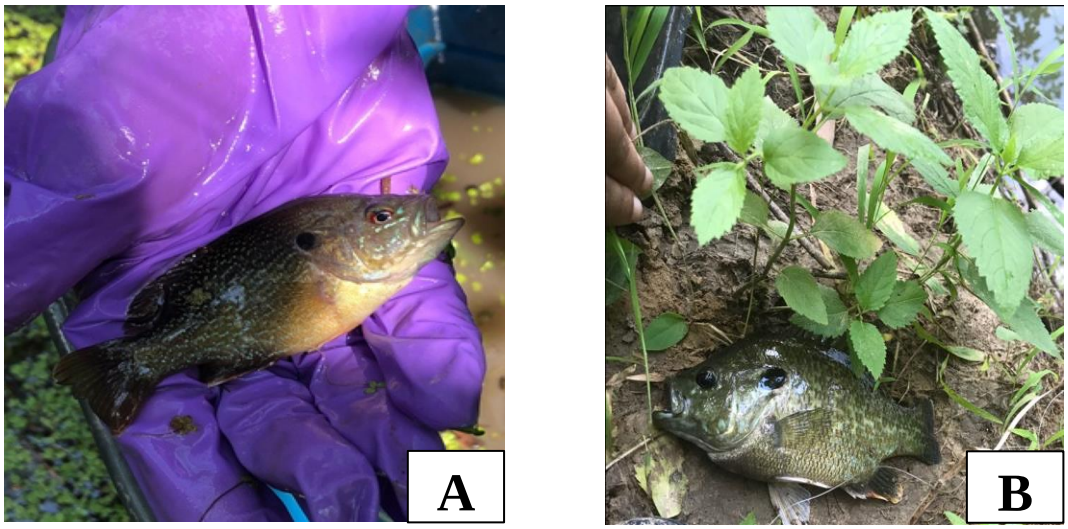

Figure 4. One of the most common species detected at the field site included (a) Longear sunfish (*Lepomis megalotis*). One of the two species caught in the Hocking river was a (b) hybrid green x longear sunfish (*L. cyanellus x megalotis*).

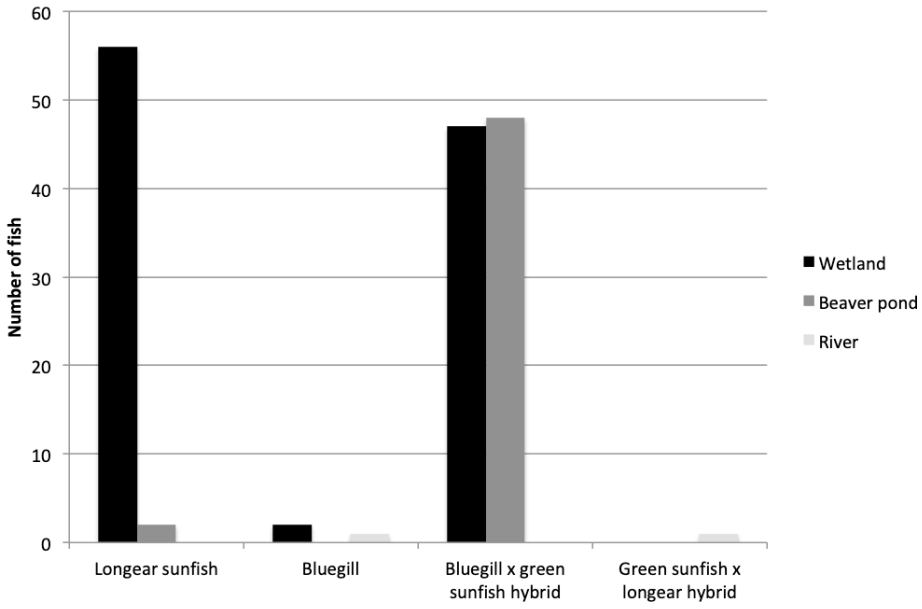

Figure 5. The number of each fish species found in three habitats at the Primmer Outdoor Learning Center during this study.

4. Discussion

To date, 157 individual fish representing 2 species and 2 hybrids were found in three freshwater habitats at the Primmer Outdoor Learning Center. Specifically, longear sunfish (*L. megalotis*), bluegill (*L. macrochirus)*, bluegill x green sunfish (*L. macrochirus x cyanellus)*, and green x longear sunfish (*L. cyanellus x megalotis)* were identified with live-trapping and angling field methods in 2017-2019. Overall, the most common species found at Primmer were bluegill x green sunfish hybrids (n=95) in this study.

Bluegill are common in Ohio and are present in nearly every body of water in the state[5]. They are an important sport fish in the United States and larger fish are usually caught while spawning in large groups in late spring or early summer[5]. Green sunfish (*L. cyanellus*) are native to Ohio and found throughout the state[5]. They are often the only sunfish found in very muddy waters[5]. They do have a strong preference to hide around structures such as rocks, logs, or brush piles. Bluegill and green sunfish readily hybridize with each other as well as other species of sunfish. Both bluegill and green sunfish are classified as some of the most tolerant fish species found in degraded habitats in the Midwest[6,7].

Longear sunfish are native to Ohio and two subspecies are found in the state. They are typically found in clear streams with slow to moderate flow and spend most of their time in pools near beds of aquatic vegetation where they feed on terrestrial and aquatic insects and other small invertebrates[5]. They spawn multiple times between mid-May and mid-August and males aggressively guard the nest built on gravel substrate[5]. It is classified as moderately tolerant in one source[6] focused on classifying fish communities in West Virginia and intolerant in another study[7] conducted in Illinois.

Preliminary assessment results in the current study showed that longear sunfish were the most common species live-trapped in the wetland, followed by bluegill x green sunfish hybrids and bluegill. This suggests good habitat quality since longear sunfish are classified as an intolerant to moderately tolerant species[6,7]. Longear sunfish are typically found near aquatic vegetation[5], and the wetland at Primmer contains buttonbush (*Cephalanthus occidentalis*) and other grasses, forbs, and sedges that can become quite dense during the summer months. The wetland is also not used currently for recreation of any kind on site. Karr's assessment system defines 'good' biotic community quality based on species richness being somewhat below expectation, especially due to loss of most intolerant forms; some species with less than optimal abundances or size distribution; and if the trophic structure shows some signs of stress[7]. It is therefore recommended that the wetland be regularly monitored in the future to see if hybrids start to become more common. If so, then removal of hybrids or stocking of other species may be needed.

Bluegill x green sunfish hybrids were the most common species sampled in the beaver pond which are indicative of poor water quality. The Karr's assessment system defines poor quality as being dominated by omnivores, pollution-tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present[7]. Sunfish hybrids are relatively common when closely related species overlap in distribution and habitat and feeding preferences[7]. The presence of hybrid species often suggests that they are better suited for survival in an environment than the parent species[1]. Most of the sunfish species identified in this assessment were hybrids of species that are typically considered tolerant species and can thrive under a variety of ecological conditions and habitats[5,6]. Their presence suggests that water quality is low in the beaver pond at Primmer. This was expected since the beaver pond is less than five years old, and the water is often muddy. The water flows into the beaver pond from the groundwater streams to the west, and the water mixes with the wetland (likely the source of the fish in the pond) only when the water levels in the wetland are high. While hybridization occurs frequently, the similarities among hybrids and parent species may hamper precise identification of species[7]. Visual identifications of fish are frequently used in biological monitoring studies and other research on fishes, but DNA barcoding could be used in future work to confirm identifications of species and their hybrids at Primmer. In DNA barcoding, one or two mitochondrial genes are sequenced from extracted tissue samples and then compared to databases of published sequences from other researchers. This is commonly done in studies based on amphibians to determine species of tadpoles[10].

One hybrid and one bluegill were found in the river. Unfortunately, angling was not particularly successful as a sampling method there. Additional research is needed in order to put together a comprehensive management plan with recommendations, particularly for the Hocking River. The wetland was also sampled more intensively in this study, followed by the beaver pond, and then the river. More live-traps were utilized in the wetland since it was substantially larger than the beaver pond, but this introduces other variables into the study. Angling in kayaks or canoes along with electroshock fishing should be employed for a more comprehensive monitoring survey. In addition, water samples from the three sites have not been recently tested for nitrate, ammonia, temperature, or pH. In 2018, the three streams that feed into the beaver pond (and then the nearby wetland when water levels are high) were tested as part of a different research project and all results were within normal limits[11]. Another potential research project can compare assessments based on the fish community with the macroinvertebrate community at all three sites.

Future work can also utilize polymerase chain reaction (PCR) testing of water samples for the presence of specific species that have not yet been detected to date using angling and live-trapping methods. Environmental DNA (eDNA) methods involve collecting and filtering water samples, extracting DNA, and using species-specific primers in PCR to detect presence or absence of particular species[12,13]. Kits have already been developed to test for the presence of species of shiner, dace, pike, carp, and trout, and you can also develop your own test with published species-specific primers.

Biological surveys are helpful and frequently used by researchers because they provide an array of information. For example, a study by Kovalenko and other researchers also utilized fish as environmental indicators for their study in the Great Lakes region[14]. In their study, the researchers identified key physical habitat factors that would potentially impact coastal fish biodiversity and distribution. The goal of their study was to increase understanding of areas that could be biological hotspots for fish and prioritize these areas for protection programs. Other research has been conducted in the open waters of the five Great Lakes[15]. This project was related to coastal wetlands and the results suggested that most of the wetlands were degraded or altered as they contained species of fish that are tolerant to silt and turbidity[15]. In other work, a fish-based Index of Biotic Integrity was developed to inform state and federal regulatory agencies of the impairment status of warm wadeable streams and rivers in West Virginia[6]. Their work on fish communities as indicators of ecological health in West Virginia rivers showed that using a fish and macroinvertebrate measure together will enhance current biomonitoring and will provide an avenue for evaluating current and future land use practices[6]. Future research is needed at the Primmer Outdoor Learning Center in order to fully evaluate the three aquatics habitats on site.

In conclusion, 157 individual fish were included in this preliminary assessment of three freshwater habitats at the Primmer Outdoor Learning Center in Logan, OH. Based on the intolerant, moderately tolerant, and tolerant species found there, it was concluded that the wetland was good in quality while the beaver pond was poor. But, additional sampling is needed, particularly in river. In addition, eDNA and DNA barcoding methods can be used to detect and confirm species identifications made in the field. Macroinvertebrate sampling and water quality testing can also be used to confirm conclusions based on fish community assessments. This research lays the groundwork in designing new activities about fishes and freshwater ecosystems in order to host new groups of college students and children on site for environmental education. Hands-on ecology and environmental science laboratories focused on fish diversity and aquatic habitats can also be conducted on site. Additional research, education, and outreach are key ways to inform conservation of freshwater habitats and work towards correcting human-caused environmental degradation at a university field research site[1,6].

5. Acknowledgements

I would like to thank Dr. Christine Anderson for her mentorship and support throughout this project. I would like to thank Capital University's Primmer Fund and the Boyd Fund for Undergraduate Scholarship for financial support to complete this project. I would like to thank other student field researchers at the Primmer Outdoor Learning Center who helped to check traps and record data. I also would like to thank Marc Kibbey at the Ohio State University Museum of Biological Diversity who provided invaluable assistance with fish identification of the hybrid species. Finally, I would like to thank an anonymous reviewer for feedback on a previous draft of this paper.

6. References

1. Primack, R. (2012). *A Primer of Conservation Biology*. Sunderland, MA: Sinauer Associates Inc. Publishers
2. Richard T. Wright, (2005). Pollution and Prevention. In *Environmental Science: Toward a Sustainable Future.* 9th ed. Upper Saddle River, NJ: Pearson/Prentice Hall
3. Baron, J. S., Poff, L. N., Angermeier, P. L., Dahm, C. N., Gleick, P. H., Hairston, N. G., Jr., Jackson, R. B., Johnston, C. A, Richter, B. D., Steinman, A. D. (2003). Sustaining Healthy Freshwater Ecosystems. *Issues in Ecology, 10.* Retrieved from https://www.esa.org/wp-content/uploads/2013/03/issue10.pdf
4. Steffen, Morgan M., Zhi Zhu, Robert Michael L. Mckay, Steven W. Wilhelm, and George S. Bullerjahn. (2014) Taxonomic Assessment of a Toxic Cyanobacteria Shift in Hypereutrophic Grand Lake St. Marys (Ohio, USA). *Harmful Algae* 33, 12-18. https://doi.org/10.1016/j.hal.2013.12.008
5. Ohio Division of Wildlife, Stream Fishes of Ohio Field Guide. Retrieved from wildlife.ohiodnr.gov/species-and-habitats/species-guide-index/fish.
6. Anderson, A. M. (2015). *Fish communities as indicators of ecosystem health in West Virginia rivers.* Ph.D. Dissertation, West Virginia University, Morgantown, WV.
7. Karr, James R. (1981). Assessment of Biotic Integrity Using Fish Communities. *Fisheries*, 6(6), 21-27. Retrieved from DOI: 10.1577/1548-8446(1981)006<0021:AOBIUF>2.0.CO;2

8. Uzarski, Donald G., Thomas M. Burton, Matthew J. Cooper, Joel W. Ingram, and Steven T.a. Timmermans. (2005). Fish Habitat Use Within and Across Wetland Classes in Coastal Wetlands of the Five Great Lakes: Development of a Fish-based Index of Biotic Integrity. *Journal of Great Lakes Research, 31*, 171-87. Retrieved from https://doi.org/10.1016/S0380-1330(05)70297-5
9. Primmer Outdoor Learning Center. (n.d.). Retrieved from https://www.capital.edu/primmer/
10. Vences, M., Thomas, M., Bonett, R. M., & Vieites, D. R. (2005). Deciphering amphibian diversity through DNA barcoding: chances and challenges. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, *360*(1462), 1859–1868. Retrieved from doi:10.1098/rstb.2005.1717
11. (Z. Drake & Anderson, C.S., unpub. data).
12. McKee, Anna & Calhoun, Daniel & Barichivich, William & Spear, Stephen & Goldberg, Caren & Glenn, Travis. (2015). Assessment of environmental DNA for detecting presence of imperiled aquatic amphibian species in isolated wetlands. Journal of Fish and Wildlife Management. 6. Retrieved from doi: 10.3996/042014-JFWM-034.
13. Thomsen, P. F., Kielgast, J., Iversen, L. L., Wiuf, C., Rasmussen, M., Gilbert, M. T. P., … Willerslev, E. (2011). Monitoring endangered freshwater biodiversity using environmental DNA. *Molecular Ecology*, 21(11), 2565–2573. Retrieved from doi: 10.1111/j.1365-294X.2011.05418.x
14. Kovalenko, Katya E., Lucinda B. Johnson, Catherine M. Riseng, Matthew J. Cooper, Kristofer Johnson, Lacey A. Mason, James E. Mckenna, Beth L. Sparks-Jackson, and Donald G. Uzarski. "Great Lakes Coastal Fish Habitat Classification and Assessment." *Journal of Great Lakes Research* 44, no. 5 (2018): 1100-109. Retrieved from https://doi.org/10.1016/j.jglr.2018.07.007
15. Jude, David J., and Janice Pappas. (1992): "Fish Utilization of Great Lakes Coastal Wetlands." *Journal of Great Lakes Research* 18, (4). 651-72. Retrieved from https://doi.org/10.1016/S0380-1330(92)71328-8