Shallow Lake Renovation Based on Alternative Stable Trophic States

Study 7027 (Approach 4) Completion Report
Federal Aid to Sport Fish Restoration
Iowa Fisheries Research

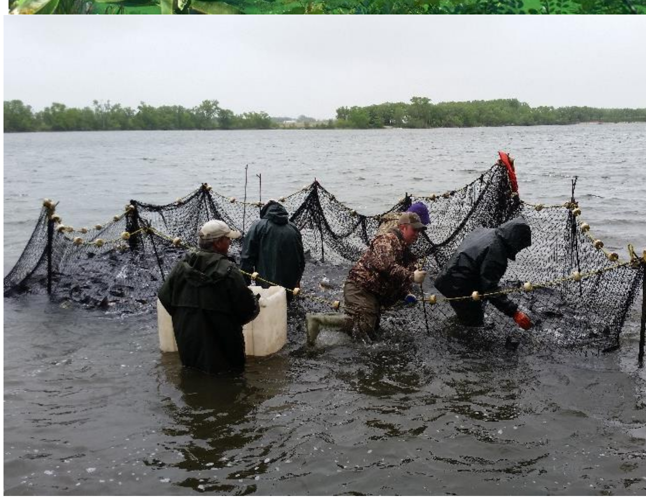

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Table of Contents

Over 21 years, Research Study 7027 yielded a substantial amount of data and spawned several side projects. Data collected for Research Study 7027 was used in the manuscripts and reports listed below and will not be reprinted here:

- Larscheid, JG and JR Meerbeek. 2019. Shallow Lake Renovation Based on Alternative Stable Trophic States. Iowa Department of Natural Resources. Federal Aid in Sport Fish Restoration, Completion Report, Des Moines
- Meerbeek, JR and MJ Hawkins. 2021. The Lost Island Lake renovation project – design, implementation, and adaptive management. Iowa Department of Natural Resources. Special Publication 21-02, Des Moines
- Simonson, M, A Annear, and MJ Weber. 2022. Evaluation of commercial harvest of Common Carp and Bigmouth Buffalo in shallow natural lakes. Final report to the Iowa Department of Natural Resources 17CRDLWMBALM-0006, Department of Natural Resource Ecology and Management, Iowa State University, Ames.

This executive summary compiles major findings from Research Study 7027 and presents them with citations to these other works. In most cases, those reports and manuscripts should be cited directly; however, material included only in this completion report can be cited as:

Meerbeek, JR. 2023. Shallow Lakes Renovation Based on Alternative Stable Trophic States – Approach 4. Iowa Department of Natural Resources. Federal Aid in Sport Fish Restoration, Completion Report, Des Moines.

Executive Summary

Natural lakes across the Midwest have been plagued with highly altered landscapes and noxious populations of plankti-benthivorous fishes for over a century. Many techniques to improve water quality and sport fish populations have been attempted in Iowa and elsewhere, yet few have resulted in long-term ecosystem benefits (Rose 1949; Rose and Moen 1953; Jennings 1967; McWilliams 1987; Meronek et al. 1996). For example, water level manipulations and simple fish community stockings post-treatment in shallow lakes during the initial approaches of this project either had no effect on aquatic macrophytes and plankti-benthivorous fish biomass or were short-lived due to inadequate control of plankti-benthivorous fish populations (Larscheid and Meerbeek 2019). Researchers have found that biomanipulation projects considered successful required reductions in plankti-benthivorous fish biomass by >75% (Meijer et al. 1999; Søndergaard et al. 2000). Therefore, previous biomanipulation attempts in Iowa have all resulted in systems that eventually revert back to a turbid, algae dominated system due to the lack of long-term plankti-benthivorous fish recruitment control.

Research completed during this study showed that a systematic and multi-faceted approach to managing non-native Common Carp *Cyprinus carpio* and other plankti-benthivorous fish species was critical for long-term (> 10 years) water quality and sport fishery improvements in Iowa's shallow lakes (Meerbeek and Hawkins 2021). For example, strategic placement of fish barriers, intense commercial plankti-benthivorous fish harvest, targeted rotenone applications, watershed improvements, and enhanced piscivore stockings were used in tandem and were highly successful in achieving long-term fishery improvements at Lost Island Lake (1,100-acre natural lake). In this study, four consecutive years of Common Carp commercial harvest ranging between 90-208 lb/ac resulted in significant fishery and water quality improvements that lasted more than 10 years. These long-term benefits would likely not have been achieved without construction of fish barriers and the ability to manipulate water levels within connected wetlands. Adaptive management was a key component to the success of the Lost Island Lake restoration and should be considered a necessary component to any lake restoration project. In addition, lake restoration projects must include a continued monitoring program post-renovation that includes water quality and/or fisheries benchmarks that are periodically reevaluated.

Successful biomanipulation of Common Carp observed by Meerbeek and Hawkins (2021) was highly dependent on robust estimates of Common Carp population biomass so realistic incentivized harvest goals could be established and Common Carp growth/recruitment could be monitored. However, obtaining population estimates of Common Carp or other plankti-benthivorous fish species is incredibly time consuming, labor intensive, and costly, thus limiting the ability for fisheries managers to work on multiple renovation projects concurrently. Bajer and Sorenson (2012) recently documented that electrofishing catch-per-effort could be used as reliable metric of Common Carp abundance in small (< 380 acre), shallow natural lakes. Little is known regarding the effects of lake size and other biotic and abiotic variables on ability to index Common Carp or other plankti-benthivorous fish abundance via electrofishing or various other standardized sampling gears. At Lost Island Lake, both summer bottom trawling and spring electrofishing catch-per-uniteffort (CPUE) were positively correlated to Common Carp density (Meerbeek and Hawkins 2021). Similarly, significant correlations between Common Carp biomass estimated via mark-recapture techniques and bottom trawl biomass was found at Clear Lake, a 3,600-acre natural lake located in north-central Iowa (Meerbeek 2013). Since electrofishing CPUE is a gear that is commonly used by management teams to assess fish populations in Iowa and has been found to have significant correlations between CPUE and density in both Minnesota and Iowa, electrofishing was a gear that was of particular interest to fisheries managers to index Common Carp and other plankti-benthivorous fishes (i.e., Bigmouth Buffalo *Ictiobus cyprinellus*). But it is relatively unknown if an electrofishing CPUE density index for these species could be applied across a gradient of lake size, depth, shoreline complexity and habitat. Therefore, the objectives of Approach 4 were to: (1) determine the ability of electrofishing CPUE to asses changes in Common Carp and Bigmouth Buffalo abundance in multiple shallow natural lakes; and (2) monitor fish, habitat, and water quality changes in lakes exposed to various levels of commercial harvest.

To accomplish these objectives, a partnership between the Iowa Department of Natural Resources (Iowa DNR), Iowa State University, and Iowa DNR Lake Restoration Program was established and mark-recapture population estimates were conducted for Common Carp and Bigmouth Buffalo from seven lakes across Northwest Iowa between 2017 and 2021 (Simonson et al. 2022). Common Carp abundance estimates ranged from 600-84,000 fish, whereas Bigmouth Buffalo abundance ranged from 200-39,000 fish among lakes. Electrofishing CPUE of both species varied among months, but highest catch rates were observed in either May (Bigmouth Buffalo) or June (Common Carp) and declined throughout the summer. However, use of electrofishing CPUE to index abundance for either species at any lake was found to be largely unsuccessful. For example, > 10 hr of electrofishing effort was necessary to detect an appreciable change in Common Carp abundance and more than 35 hr of electrofishing effort was required to detect a change for Bigmouth Buffalo. Electrofishing effort of this quantity to index Common Carp or Bigmouth Buffalo is not feasible for many Iowa DNR management teams working on multiple renovation projects, often simultaneously. Simonson et al. (2022) suggested that it may be necessary to explore alternative sampling gears to monitor these populations. Commercial fishers are often more effective at capturing large numbers these fish species via seines, but this gear is not used by Iowa DNR and requires special commercial fisher contracts to be successful (Meerbeek and Hawkins 2021).

Correlations among Common Carp and Bigmouth Buffalo commercial harvest and biotic and abiotic fishery characteristics were generally not observed in the seven lakes evaluated during this study. Both Center Lake and North Twin Lake were exposed to intense Bigmouth Buffalo commercial harvest during a < 1-year period and neither lake had desirable fishery, water quality, or habitat results (Simonson et al. 2022). Accordingly, other lakes that were exposed to lower harvest levels of Common Carp and Bigmouth Buffalo also had no appreciable change in system characteristics. Additionally, there was no relationship among Common Carp and Bigmouth Buffalo population dynamics (growth, mortality, and condition) across lakes exposed to short or long-term harvest. Common Carp and Bigmouth Buffalo harvest events were inconsistent and generally low at most lakes over the course of this study. As observed at Lost Island Lake, higher levels of commercial harvest spanning multiple years may be necessary to reduce Common Carp and/or Bigmouth Buffalo populations to levels sufficient to improve water quality for most Iowa lakes. Furthermore, the results from Simonson et al. (2022) highlight the need for lake restoration projects to include a multi-faceted approach in order to achieve long-term improvements.

The strategies used at Lost Island Lake may not be appropriate for all lakes nor may they have the same outcome if applied elsewhere. Lost Island Lake was initially selected as a suitable candidate for restoration due to its favorable watershed size, amount of public land within the watershed, location of catchment basins, and high rates of internal loading. Lakes that have large watersheds and high rates of external nutrient loading may not respond similarly and may require a more comprehensive in-lake and watershed approach. The process for renovation for Lost Island Lake, however, is promising for natural lakes that are relatively small and have small watersheds. In Iowa, only a few natural lakes exist that have physical characteristics similar to that of Lost Island Lake. The process for a successful renovation as outlined in this study (see Meerbeek and Hawkins 2021) provide a framework that may be used for renovation projects in similar lakes, from design and feasibility, to construction, and to public outreach. One fundamental reason for success at Lost Island Lake was the inclusion of the lake within the Lake Restoration Program and strong education and support from the local community and various partners. Without proper funding sources and local support, many of the fish barriers and water level manipulation structures would not have been constructed and Common Carp removal would have likely resulted in short-term improvements in water quality and fisheries. Identifying potential partners and funding sources will likely be a large component of future lake restorations in Iowa and across the Midwest. We feel that the benefit of the lake restoration effort at Lost Island Lake far outweighs the financial and time investment. Managers interested in lake restoration techniques using a combination of removal, barriers, water control structures, and piscivore stockings need to carefully consider biotic and abiotic interactions as well as the physical characteristics of lakes and watersheds so that realistic and obtainable objectives can be established prior to lake renovation efforts.

Recommended best management practices from this research were as follows:

- Biomanipulation experiments in Iowa that are limited to water level manipulations and fish eradications have relatively short-term ecosystem benefits. Approaches of this type require continuous monitoring of the fish population and repeated treatments to sustain ecosystem health.
- Plankti-benthivorous fish recruitment control and more diversity in fish stocking post-renovation may be necessary to improve likelihood of sustained long-term benefits for shallow, natural lakes in Iowa.
- Our multi-faceted approach at Lost Island Lake was successful in providing long-term ecosystem benefits. Managers need to take into consideration lake connectivity, habitat, bathymetry, internal/external nutrient loading, and fish population characteristics on a lake-specific basis prior to conducting lake renovation experiments. Also, managers need to use adaptive management techniques to enhance project success.
- The use of electrofishing CPUE to index Common Carp or Bigmouth Buffalo across a gradient of lakes in Iowa was largely unsuccessful and other techniques to estimate abundance of these populations should be explored. The use of commercial fishing gear (i.e., seines) via commercial contract incentives may be a more cost-effective approach to achieve population estimates.
- Common Carp and Bigmouth Buffalo populations were difficult to estimate as well as to control via commercial harvest.
- Developing sustainable incentives for commercial fishers that entice high harvest over multiple years would have higher probabilities of meeting water quality and fish population goals in Iowa lakes.

Acknowledgements

This study was funded through the Federal Aid in Sport Fish Restoration Program. Many full-time and seasonal staff from the Iowa DNR Conservation and Recreation Division provided substantial technical and field assistance throughout the study and their involvement was crucial to the success of the project. In particular, many of these projects required Wildlife and Fisheries bureau staff to work cooperatively to achieve water quality improvements. Multiple other partners, including, but not limited to the Palo Alto and Clay County Conservation Boards, Lost Island Protective Association (LIPA), Ducks Unlimited, the Palo Alto County Soil and Water Conservation District, Iowa DNR Lake Restoration Program, Iowa DNR 319 Program, and Iowa State University were all instrumental in the project. This manuscript was improved with comments from George Scholten.

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