



RESEARCH FINAL REPORT GUIDELINES

Final reporting requirements consist of (1) a project abstract to help the reader quickly ascertain the project's purpose, including the main results and conclusions, for posting to the GLFT's public website, (2) a narrative response to the GLFT final report questions (if applicable), (3) a financial report accompanied by financial documentation verifying expenditures (form and instructions attached), and (4) attachments to include (a) a full narrative report (see guidelines below) on the research results and (b) copies of manuscripts accepted or submitted for publication (if applicable). As the GLFT continues to enhance our Web-based grant management system we may transition to an online reporting system to collect information included in progress and final reports. Please check with your grant manager for updates to our processes that may occur before your grant is completed.

PROJECT ABSTRACT

Title: Quantification of the success and potential impacts of new rock ramp fish passage in the Saginaw Bay watershed

Abstract body:

Many of the dams across the Great Lakes basin are nearing or beyond their original design life. These aging infrastructures pose a number of natural resource management challenges and opportunities. Broadly speaking, aging dams can be repaired to restore their function and maintain safety, removed to restore river connectivity and habitat, or retrofitted with a naturalized rock ramp fish passage structure to increase connectivity without losing the capacity of the upstream reservoir. The success of rock ramp structures in meeting their goals is not well documented in the Great Lakes region. The primary objectives of this research were: 1) to evaluate the success of a recently built rock ramp (Shiawassee River) for increasing upstream fish movement and reproductive success relative to a dammed (Cass River) site, and 2) evaluate the effect of the rock ramp on summer fish assemblages upstream and downstream of the rock ramp relative to dammed (Cass River) and free-flowing (Flint River) control sites. Our final assessment of the functionality of the Shiawassee River rock ramp is based on patterns observed in

upstream and downstream reaches across rivers. Essentially, are the patterns observed on the Shiawassee River (rock ramp) more similar to the patterns observed on the dammed Cass River or the free-flowing Flint River?

To accomplish the first objective, we sampled fish during spring migration periods with a boat electrofisher above and below the rock ramp (Shiawassee River) and dam (Cass River). Electrofishing data were collected in collaboration with the Michigan Department of Natural Resources and the US Fish and Wildlife Service. In addition, we fin clipped 406 fish in 2011 and dart-tagged 300 fish (individually numbered and with the lead investigators phone number to promote angler reports) in spring 2012 and 463 fish in 2013 below the rock ramp to quantify any movement above the rock ramp. We also sampled egg and larval fish density above and below the rock ramp in the Shiawassee River as well as above and below the dam on the Cass River. To evaluate the effect of the rock ramp on summer resident fish assemblages, we electrofished the summer-resident fish community using barge electrofishing at three sites above and below the rock ramp, three sites above and below the dam on the Cass River, and six sites on the Flint River. During the 2011 and 2012 field seasons, we also PIT tagged 970 Rock Bass and Smallmouth Bass in the Cass, Shiawassee, and Flint Rivers and recaptured 65 fish (all of which were recaptured in the same sites in which they were originally captured and tagged).

Catches of spring migratory fishes, particularly Walleye, Sucker, and Quillback, were two orders of magnitude higher below the rock ramp than above (similar to the dammed site), indicating that the rock ramp still presents an impediment to upstream migration. In 2011, we did not recapture any of the fish fin-clipped below the rock ramp. In 2012, we recaptured eight of 78 walleye dart tagged, and all were recaptured below the rock ramp. In 2013, we recaptured twelve fish - eight in the downstream reach where they were tagged and four fish (two Greater Redhorse, two Walleye) upstream of the rock ramp. The densities of eggs and of larval fishes were lower below the rock ramp than above.

In all three rivers, the summer fish assemblage was quite similar above and below the rock ramp, dam, or on the free-flowing river, indicating that the dam and rock ramp did not have a substantial negative impact on the upstream fish community. Although similarity of fish assemblages might provide indirect support of successful summer resident fish passage, an alternative but similarly parsimonious hypothesis is that there has been relatively little differentiation between the upstream and downstream reaches since the dam has been in place. The similarity of the assemblage above and below the rock ramp was more similar to that of a free-flowing river section than to the dammed river, indicating that the rock ramp might provide connectivity for summer-resident fish assemblages. Overall, we had relatively low recapture of PIT tagged (summer) fish. All of the recaptures (Rock Bass and Smallmouth Bass) were within the same study reach in which they were tagged, and we had no recaptures across rock ramp or dam structures. Tagging results suggest that the sampled species are largely sedentary and does not provide support for or against the effective fish passage hypothesis.

Although the study design lacks statistical replication (i.e., evaluating multiple rock ramps was not possible), the consistency of measures of impact on spring migratory

fishes and their reproductive success indicates that the rock ramp is not providing the intended level of ecosystem connectivity between Lake Huron fish and tributary spawning habitats in the Shiawassee River. However, indirect evidence suggests that the rock ramp may be partially successful in allowing summer-resident fish passage.

FINAL NARRATIVE REPORT GUIDELINES

- **Project Title:** Quantification of the success and potential impacts of new rock ramp fish passage in the Saginaw Bay watershed
- **Grantee Organization:** Central Michigan University (CMU) and Michigan State University (MSU)
- **Project Team:** Tracy Galarowicz (Department of Biology, CMU), Brent Murry (Department of Biology, CMU), Daniel Hayes (Department of Fisheries and Wildlife, MSU), Daelyn Woolnough (Department of Biology, CMU), Donald Uzarski (Department of Biology, CMU), Clarence Fullard (MS student, CMU), Gabriel Madel (MS student, CMU), and Jacob Stoller (MS student, MSU)
- **Contact Person:** Tracy Galarowicz, Department of Biology, Central Michigan University, galar1tl@cmich.edu
- **Grant Amount:** \$257,430 (\$258,675 match); \$516,105 total project budget
- **Start and End Dates:** January 2011-December 2013
- **Key Search Words:** Rock ramp, Walleye, spawning, fish eggs, larval fish, fish assemblages, fish passage

Background/Overview

1. Briefly summarize the project description as outlined in the original proposal.

Dam removals and construction of fish passages are rapidly becoming the dominant initiatives associated with Great Lakes' fishery and ecosystem restoration. Rigorous scientific assessment of whether or not fish passages are meeting their intended conservation goals and evaluation of potential negative effects are, however, lacking in the Great Lakes region. We evaluated: 1) the success of a recently built (Shiawassee River) and a pending (Cass River) rock ramp fish passage at meeting their intended restoration goals (i.e., increased upstream fish movement and reproductive success), and 2) changes to existing fish assemblages upstream and downstream of the dam and rock ramp.
2. Briefly summarize any significant changes to the work performed in comparison to the plan of work originally proposed and funded. If changes were made, describe how they affected your ability to achieve the intended outcomes for the work.

We successfully completed the bulk of the project as originally outlined in the plan of work with a few notable modifications. We used a different tagging method in collaboration with the Michigan Department of Natural Resources, which allowed us to tag more fish over a greater time frame than originally expected. In addition, the ARCGIS model to describe fish movement was not developed due to the low number of recaptures of tagged fish and limited fish movement (i.e., most were recaptured at same site they were tagged at and none crossed the rock ramp or dam).

We originally proposed a before/after/control/impact (BACI) study design, which also included sites on the dammed Tittabawassee River; however, this study design proved impossible due to factors beyond our control. When this project was initiated, the dam on the Cass River was scheduled for replacement with a naturalized rock ramp fish passage in August/September 2011. Under this anticipated barrier modification we should have had before (2011) and after (2012) on the Cass River. The design also had two different types of control sites: free-flowing controls on the Flint River and dammed controls on the Tittabawassee River. To date (February 2014), the dam on the Cass River remains, and the rock ramp is scheduled to be built at the end of summer in 2014. Further, while we collected all proposed summer fish assemblage data on the Tittabawassee River, we had to use different sampling methods because of the river's larger size. Therefore, we do not feel confident using the Tittabawassee River data for direct comparisons to the other rivers (all of which are similar in size). Per the original proposal, there were three transects sampled upstream and downstream of the dam on the Tittabawassee River 2-3 times between June and August in 2011 and 2012, and these data are valuable as baseline data in the event that the dam on the river is breached in the future. Ultimately, our study design focused on comparisons between the Shiawassee River with the rock ramp and the Cass River, dammed during the duration of this study, and the Flint River, which is free-flowing throughout our study section (downstream of an existing dam).

Complementary funding was obtained to support additional projects that provided added value to this core study including: evaluations of food web trophic relationships of the summer fish assemblages (on all three summer study rivers) using stable isotope and stomach content analyses that complemented a companion US Fish and Wildlife Service fish tissue contaminants study on the Cass River, a walleye otolith microchemistry study within Saginaw Bay tributaries, and preliminary unionid mussel surveys in the Cass and Shiawassee Rivers. See Related Efforts for funding details.

Outcomes

Please characterize key outcomes of the project related to *knowledge*, *training*, *relationships*, and *practice*. Not all projects will have outcomes of all types.

3. To what extent and how (if at all) did this research project advance scientific knowledge of the issue?

To our knowledge, this project is the first to clearly evaluate the effectiveness of a rock ramp structure in achieving population and fish assemblage objectives in the Great Lakes region, advancing our knowledge of this management tool. Furthermore, the dam on the Cass River is scheduled to be replaced by a rock ramp in 2014. Our extensive data set provides indices of pre-rock ramp conditions – data that are often missing in fish passage studies. Our electrofishing and freshwater mussel sampling also provide evidence of a fish passage structure serving as habitat for a wide variety of aquatic species. Analysis of our sampling effectiveness also provides guidance on sample sizes and sampling frequency needed to adequately characterized fish assemblages found in these rivers.

The stable isotope food web analyses provided clear insight into the seasonal importance of the invasive Round Goby and perhaps even more interesting the seasonal importance of summer migratory fish (e.g., Gizzard Shad) to the food web energy dynamics in the river tributaries (e.g., downstream reaches of the Cass and Shiawassee Rivers).

As a complementary project to our spring migratory spawning fish studies here, we also received funds to examine the otolith microchemistry of walleye in the Flint, Cass, Shiawassee, Tittabawassee, and Kawkawlin Rivers. Samples from our critical second season of sampling are presently being processed, but samples collected during the first season of sampling (only a subset of rivers) have identified clear microchemistry signals differentiating the Tittabawassee and Kawkawlin Rivers. This represents a significant new set of knowledge and tools that will support future Walleye stock assessments with continued tributary habitat restoration and changing lake conditions.

4. To what extent and how (if at all) did this project contribute to the education and advancement of graduate or undergraduate students focused on Great Lakes fishery issues?

Three students (G. Fullard, CMU; G. Madel, CMU; J. Stoller, MSU) completed their Master of Science degrees with the support of this project. In addition, six students were employed as technicians on the project and are now in or seeking graduate projects. Finally, twenty-six undergraduate or graduate students volunteered in the field or the laboratory to gain invaluable experience.

5. To what extent and how (if at all) did this work help you or others on your team build new relationships with others in the research or management communities?

Through this research, the principal investigators at CMU and MSU, who had not previously worked together, developed a collaborative working relationship that we anticipate will continue in the future. We also worked extensively with the Michigan Department of Natural Resources (Jim Baker and Joe Leonardi) and the U.S. Fish and Wildlife Service (Andrea Ania and Justin Chiotti). The sampling accomplished through this project and the agencies have allowed us to reach collective goals that would not have otherwise been possible and will form the basis for future sampling efforts on these rivers. We have also participated in much broader discussions regarding research and management efforts in the Saginaw Bay watershed through various meetings and workshops (e.g., USDA Saginaw R&D, discussions with researchers from Ohio State University, Wayne State University, University of Windsor, etc.).

6. To what extent and how (if at all) do the findings have action implications for fishery managers? If the research has direct management implications, do you have any knowledge of use of the findings by managers? If the research does *not* have direct management implications at this stage, to what extent did the research advance the process of identifying management responses to critical issues?

Our research has direct application to future dam removals and installation of rock ramps in Great Lakes tributaries. For example, there are several dams under

consideration for removal within the Saginaw River basin – this work will inform anticipated effects on fish movement and assemblage structure.

7. Considering the above or other factors not listed, what do you consider to be the most important benefits or outcomes of the project?

The most important benefit of the project is the documentation of important migratory species such as Walleye and Redhorse above the rock ramp structure on the Shiawasee River. However, we did not document spawning of these species above the rock ramp. Although the rock ramp structure may allow passage of fish, we do not have evidence to date that there is a positive effect on migratory fish. Our early research suggested that water conditions during the spring in the rock ramp may limit movement. The rock ramp was modified in 2012, and additional research will be able to further address this issue. Additional research also documented the extent and impact of the Round Goby invasion in Great Lakes tributaries. Analyses of sampling efficiency also have important implications for the design of future studies in similar rivers.

Related Efforts

8. Was this project a stand-alone effort, or was there a broader effort beyond the part funded by the GLFT? Have other funders been involved, either during the time of your GLFT grant or subsequently?

Initial funding for the project was provided by the Saginaw Bay Watershed Initiative Network (WIN) to PIs Murry and Galarowicz (CMU). Additional funding has been secured from the US Fish and Wildlife Service to PIs Murry and Galarowicz.

- Quantification of the effectiveness of the Frankenmuth fish passage (Cass River, MI): assessment of walleye reproductive success. Saginaw Bay Watershed Initiative Network (WIN). February 2010 – December 2013.
- Continued monitoring of rock ramp fish passages in the Saginaw Bay Basin. US Fish and Wildlife Service. August 2013 – December 2016.

9. Has there been any spin-off work or follow-up work related to this project? Did this work inspire subsequent, related research involving you or others?

The US Fish and Wildlife Service funding (above) provides continued monitoring during the 2014 field season. PI Murry secured additional funding through the US Fish and Wildlife Service for stable isotope analyses of the river food webs.

- Restoring river connectivity: evaluating fish as vectors of contaminants in the Saginaw River/Bay Area of Concern. US Fish and Wildlife Service. 2012 – 2013.
- NFPP-Prioritizing dam removals within the Saginaw Bay watershed based on spawning river contributions to the walleye population of Saginaw Bay. US Fish and Wildlife Service. 2011 – 2013.
- Continued monitoring of rock ramp fish passages in the Saginaw Bay Basin. US Fish and Wildlife Service. August 2013 – December 2016.

Communication/Publication of Findings

10. List publications, presentations, websites, and other forms of formal dissemination of the project deliverables, tools, or results, including those that are *planned* or *in process*.

Completed:

Theses

- Fullard, C. D. J. 2014. Diet and energy pathway perturbations of rock bass and smallmouth bass in three round goby invaded Great Lakes tributaries. M.S. thesis, Central Michigan University, Mt. Pleasant, MI.
- Madel, G. M. 2014. Examining the food web structure and dynamics of temperate river fish communities using stable isotopes and size spectra analyses. M.S. thesis, Central Michigan University, Mt. Pleasant, MI.
- Stoller, J. B. 2013. Effects of a rock ramp structure on summer fish assemblage in the Shiawassee River. M.S. thesis, Michigan State University, East Lansing, MI.

Presentations

- Briggs, A.S., A. Ania, J.C. Boase, J.A. Chiotti, T.L. Galarowicz, and B.A. Murry. 2014. Survey of fish communities upstream and downstream of a dam prior to rock-ramp installation. Midwest Fish and Wildlife Conference, Kansas City, MO, January 2014.
- Fullard, C. D. J., B. A. Murry, T. Galarowicz, G. Madel, J. Stoller, M. Haas, D. Hayes, and J. Chiotti. 2013. Characterizing changes in energy pathways leading to centrarchid top predators resulting from the round goby invasion of Saginaw Bay tributaries. American Fisheries Society 143rd Annual Meeting. Little Rock, AK, September 2013.
- Madel, G., B.A. Murry, T. Galarowicz, D.B. Hayes, C. Fullard, J. Stoller, and M. Haas. 2013. The influence of trophic guild composition on the body size distributions and trophic structure of mid-order river fish communities. 143rd Annual Meeting of the American Fisheries Society, Little Rock, AK, September 2013.
- Fullard, C. D. J., B. A. Murry, T. Galarowicz, G. Madel, M. Haas, D. Hayes, J. Stoller, and J. Chiotti. 2013. Preliminary findings of round goby predation by smallmouth bass above and below an impoundment on the Cass River, Michigan. Michigan Chapter of the American Fisheries Society, Gaylord, MI, February 2013.
- Stoller, J., D. Hayes, B. Murry, T. Galarowicz, M. Haas, G. Madel, and C. Fullard. 2013. Effects of a rock ramp fishway on summer fish assemblage in the Shiawassee River. Michigan Chapter of the American Fisheries Society Annual Meeting, Gaylord, MI, February 2013.
- Stoller, J., D. Hayes, B. Murry, T. Galarowicz, C. Fullard, and G. Madel. 2012. Effectiveness of a rock ramp structure on the Shiawassee River. Michigan DNR Fisheries Division Research-Management Meeting, Traverse City, MI, December 2012.

- Murry, B. A., T. Galarowicz, C. Fullard, G. Madel, J. Stoller, J. Chiotti, A. Ania, J. Boase, J. Leonardi, and D. B. Hayes. 2012. Effects of restored fish passage on food web properties: an evaluation of new rock ramp structures within the Saginaw River, MI, drainage. International Association of Great Lakes Researchers annual conference, Cornwall, Canada, May 2012.
- Murry, B. A., T. Galarowicz, C. Fullard, G. Madel, J. Stoller, J. Chiotti, A. Ania, J. Boase, J. Leonardi, and D. B. Hayes. 2011. CMU Institute for Great Lakes Research: on-going efforts supporting Saginaw Bay restoration. USDA Saginaw Bay RC&D, Bay City, MI.
- Murry, B. A., T. Galarowicz, A. Ania, J. Boase, and J. Leonardi. 2010. Positives and potential negatives of rock ramp river restoration. Healing our Waters Coalition and Ducks Unlimited, Frankenmuth, MI.

Planned or in process:

Manuscripts

- Murry et al. Evaluation of a naturalized rock ramp fish passage for cool- and warm-water fish in a tributary of Saginaw Bay, Lake Huron. Intended outlet – River Research and Applications or Fisheries Management and Ecology.
- Stoller et al. Effects of a rock ramp structure on summer fish assemblage a Michigan Stream. Intended outlet – North American Journal of Fisheries Management or River Research and Applications.
- Stoller et al. Sampling considerations for determining fish assemblage characteristics. Intended outlet – North American Journal of Fisheries Management.
- Fullard et al. Perturbations to smallmouth bass and rock bass trophic structure and growth caused by the round goby invasion of three Great Lakes tributaries. Intended outlet – TBD.
- Fullard et al. Changes in feeding behavior and diet overlap of smallmouth bass and rock bass in three round goby invaded Great Lakes tributaries. Intended outlet – TBD.

11. Please characterize your efforts to share the findings of this research with state, federal, Tribal, and interjurisdictional (e.g., Great Lakes Fishery Commission) agencies charged with management responsibilities for the Great Lakes fishery. If other audiences were priority for this research, please characterize your outreach efforts to those audiences as well. (*Please note: you may wish to consult midterm reports in which specific audiences for the findings, and means of outreach to these audiences, were identified.*)

We have presented our results at several regional and national scientific meetings, with the goal of providing this information to fishery managers and researchers. We have also participated in annual sampling coordination meetings with Michigan DNR, U.S. Fish and Wildlife Service, and other interested resource management and conservation agencies to ensure that our results are reaching local managers and they fully understand our project sampling. We have met informally with managers from both of these groups, as well as individuals from the local community, to give them insight into our project as well as to receive their feedback to make sure that our research is responsive to their needs.

12. Please identify technical reports and materials attached to this report by name and indicate for each whether you are requesting that GLFT restrict access to the materials while you seek publication. (Please note that the maximum amount of time during which GLFT will restrict access to the results of funded research is six months, unless notified that more time is needed.)

Theses attached – access does not need to be restricted

- Fullard, C. D. J. 2014. Diet and energy pathway perturbations of rock bass and smallmouth bass in three round goby invaded Great Lakes tributaries. M.S. thesis, Central Michigan University, Mt. Pleasant, MI.
- Madel, G. M. 2014. Examining the food web structure and dynamics of temperate river fish communities using stable isotopes and size spectra analyses. M.S. thesis, Central Michigan University, Mt. Pleasant, MI.
- Stoller, J. B. 2013. Effects of a rock ramp structure on summer fish assemblage in the Shiawassee River. M.S. thesis, Michigan State University, East Lansing, MI.

13. **Manuscripts.** Grantees submitting one or more publications or pending publications in lieu of a stand-alone technical report must submit a cover memo that confirms that all aspects of the funded research are incorporated in the published work, and in cases of multiple publications, identifies or crosswalks the grant-funded objectives to the published article containing results.

All aspects of the funded research will be incorporated into pending publications. Publications are in progress and will be submitted to the Great Lakes Fishery Trust.

Manuscripts – planned or in progress

- Murry et al. Evaluation of a naturalized rock ramp fish passage for cool- and warm-water fish in a tributary of Saginaw Bay, Lake Huron. Intended outlet – River Research and Applications or Fisheries Management and Ecology. Objective 1: evaluate the success of a recently built rock ramp (Shiawassee River) for increasing upstream fish movement and reproductive success relative to a dammed (Cass River) site.
- Stoller et al. Effects of a rock ramp structure on summer fish assemblage a Michigan Stream. Intended outlet – North American Journal of Fisheries Management or River Research and Applications. Objective 2: evaluate the effect of the rock ramp on summer fish assemblages upstream and downstream of the rock ramp relative to dammed (Cass River) and free-flowing (Flint River) control sites.
- Stoller et al. Sampling considerations for determining fish assemblage characteristics. Intended outlet – North American Journal of Fisheries Management. Objective 2: evaluate the effect of the rock ramp on summer fish assemblages upstream and downstream of the rock ramp relative to dammed (Cass River) and free-flowing (Flint River) control sites.

14. **Compilation reports.** Grantees working on several related sub-projects under a single grant may submit a series of sub-project reports rather than a single, integrated report. However, grantees must submit a cover sheet or introduction that outlines and crosswalks grant objectives with the location of the results in the compilation document.

Not applicable.

Discussion

The rock ramp on the Shiawasee River and dam on the Cass River both act as barriers to upstream fish movement, and the rock ramp has not substantially improved reproductive success for migratory fish species on the Shiawasee River, contrary to project expectations. While species of interest such as Walleye, White Sucker, and Redhorse were captured upstream and downstream of the rock ramp, our recapture of tagged fish was low above the rock ramp, indicating that fish passage was lower than desired. We also did not document differences in reproduction as a result of the rock ramp. However, we did capture Walleye above the rock ramp, suggesting that there may be limited passage of this structure. Patterns of fish assemblages above and below the rock ramp tended to resemble that of the free-flowing river more than the dammed site during summer sampling; and while this could optimistically be construed as support of some level of rock ramp success, water levels were generally so low that summer fish passage is highly unlikely. Alternatively, the similarity of the patterns of upstream and downstream fish distribution could be more parsimoniously explained by lower than anticipated differentiation over the last several decades that the river reaches were separated.

During the course of our study, the rock ramp was redesigned on the Shiawasee River, which may improve the probability of fish passage by migratory species in the future. In addition, the dam on the Cass River is scheduled to be replaced by a rock ramp in 2014. Our data on the abundance of spring migratory fish, egg deposition, and larval abundance above and below the dam will provide baseline data to evaluating the success of the new rock ramp.