FishPass: Supplemental Research Project Summaries

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Project Title:	**Proof of concept test of flow velocity enhancement systems (FVES) to guide sea lamprey movement**
PI(s):	Zielinski, D.P., Great Lakes Fishery Commission Miehls, S., U.S. Geological Survey-HBBS Burns, G., Natural Solutions…A Dam Site-better LLC Coutant, C., Coutant Aquatics
Schedule:	2019
Funding:	Great Lakes Fishery Commission
Status:	Complete
Rationale:	Manipulation of water flow is a standard means to attract and guide fish. Technologies that can generate a stream-like turbulent plume and are small and easily adjusted and moved hold promise for use at sites where building significant infrastructure typically associated with water flow guidance is not possible. The Flow Velocity Enhancement System (FVES), is an emergent technology that generates a plume of turbulence with minimal effort and small footprint. The FVES has successfully guided downstream salmon smolts in low current environments, but remains untested for guidance of upstream swimming fishes in low current environments.
Project objectives:	1. Determine if the velocities and mild turbulence plume induced by the Flow Velocity Enhancement System (FVES) can direct sea lamprey and white sucker movement in a low current environment.
Deliverables:	• Zielinski, D.P., Miehls, S., Burns, G. and Coutant, C., (2020). Adult sea lamprey respond to induced turbulence in a low current system. *Journal of Ecohydraulics*, https://doi.org/10.1080/24705357.2020.1775504. • Zielinski, D.P., Miehls, S., Burns, G., and Coutant, C. (2020) Proof of concept test of flow velocity enhancement system (FVES) to guide fish movement in a low current system. Project completion report prepared for the Great Lakes Fishery Commission, Ann Arbor, MI. Link

Project Title:	**Genetic assessment of Boardman (Ottaway) River fish populations prior to dam removal**
PI(s):	Larson, W., National Oceanic and Atmospheric Administration (formerly UW-Stevens Point)
Schedule:	2018-2020
Funding:	Great Lakes Restoration Initiative
Status:	Complete
Rationale:	Population genetic assessments can reveal previously undetected subpopulations of fish that may exist across small spatial scales, even without physical barriers to movement, and can provide insight into unique life history variations within a species. Understanding biodiversity in aquatic systems is critical to management and conservation efforts, but accurately measuring species richness using traditional methods can be challenging.
Project objectives:	1. Characterize the genetic structure for five fish species (walleye, smallmouth bass, yellow perch, common white sucker, rock bass) up- and down-stream of the Union Street Dam to determine if these populations are significantly differentiated and/or show differences in genetic diversity. 2. Determine the utility of eDNA for investigating species diversity and distribution patterns in the Boardman (Ottaway) River.
Deliverables:	• Gehri, R.R., Larson, W.A., Gruenthal, K., Sard, N.M. and Shi, Y., 2020. eDNA metabarcoding outperforms traditional fisheries sampling and reveals fine-scale heterogeneity in a temperate freshwater lake. *Environmental DNA.* https://doi.org/10.1002/edn3.197. • Gehri, R.R., Gruenthal, K. and Larson, W.A., In Press. It's complicated: Heterogenous patterns of genetic structure in five fish species from a fragmented river suggest multiple processes can drive differentiation. *Evolutionary Applications.* https://doi.org/10.1111/eva.13268. • Gehri, R.R., 2020. Genetic Assessment of Boardman River Fish Populations Before Dam Removal (MS Thesis, College of Natural Resources, University of Wisconsin-Stevens Point). Link.

Project Title:	**Predicting contaminant transfer following re-establishment of controlled connectivity in the Boardman (Ottaway) River**
PI(s):	Gerig, B., Northern Michigan University Patterson, G., Michigan Technological University
Schedule:	2018-2022
Funding:	Great Lakes Restoration Initiative
Status:	Complete
Rationale:	Dams fragment longitudinal connectivity in tributary networks and are increasingly targeted for removal or modification to restore ecosystem structure and function. However, legacy contaminants can accumulate in both Great Lakes fishes and sediments retained behind dams, such that dam removal can inadvertently facilitate both contaminant transport upstream by migratory fishes and downstream via sediment flushing. Such biologically and physically transported contaminants can negatively impact ecosystems, fisheries, and human health. These risks must be evaluated in scope and weighed against the positive ecosystem benefits of re-establishing connectivity.
Project objectives:	1. Assess the contaminant burden of Great Lakes spawners to inform future fish passage decisions. 2. Evaluate the background contaminant burdens of resident fishes prior to dam removal. 3. Measure background contaminant levels of water within the Boardman River watershed. 4. Couple empirically collected diet data to a lifetime bioenergetics-bioaccumulation model to determine the impact of various fish passage scenarios on resident fish growth and bioaccumulation.
Deliverables:	• Diedrich, C.J. Spatial and temporal comparison of persistent organic pollutants in the Boardman River. M.S. Thesis Michigan Technological University. December 2021. Link

Project Title:	**Collection of fish images to be used in development of autonomous fish identification and sorting tool.**
PI(s):	Miehls, S., U.S. Geological Survey-HBBS Zielinski, D.P., Great Lakes Fishery Commission
Schedule:	2019-2020
Funding:	Great Lakes Fishery Commission & Whooshh Innovations
Status:	Complete
Rationale:	Native fish passage remains unrealized in Great Lakes tributaries due to the threat of infestation by invasive species and cost of "safe" options such as trap-and-sort. A selective, autonomously operated passage device using imaged based sorting could provide the cost-effective solution fishery managers need to make fish passage a reality. The first step in developing a fish identification tool is collecting images of the fish species to be used by a machine learning approach.
Project objectives:	1. Obtain ~1000 images of walleye, steelhead, suckers, northern pike, sea lamprey, common carp, Asian carps (silver, black, bighead, as available), and other Great Lakes fishes as available with the Whoosh FishL™ Recognition scanner to begin development of a fish ID classifier. 2. Create a database containing fish images identified by species, location, and date collected for those species as well as algorithms for identifying sea lamprey images.
Deliverables:	• Bravata, N., Kelly, D., Eickholt, J., Bryan, J., Miehls, S. and Zielinski, D., 2020. Applications of deep convolutional neural networks to predict length, circumference, and weight from mostly dewatered images of fish. *Ecology and Evolution*, 10(17), pp.9313-9325. https://doi.org/10.1002/ece3.6618. • Eickholt, J., Kelly, D., Bryan, J., Miehls, S. and Zielinski, D., 2020. Advancements towards selective barrier passage by automatic species identification: applications of deep convolutional neural networks on images of dewatered fish. *ICES Journal of Marine Science*, 77(7-8), pp.2804-2813. https://doi.org/10.1093/icesjms/fsaa150. • Eickholt, J. (2020), "FishL Low Resolution Images of Fish from the Great Lakes Region", OSF, 7 June, available at: https://doi.org/10.17605/OSF.IO/KQVG8. • Eickholt, J. (2020), "Tools to Apply Deep Convolution Neural Networks to Predict Species in Great Lakes Region", OSF, 17 July, available at: https://doi.org/10.17605/OSF.IO/BFHYN. • Meihls, S. (2020), "Image and biometric data for fish from Great Lakes tributaries collected during spring 2019", ScienceBase, available at: https://doi.org/10.5066/P90BIDOL.

Project Title:	**The consequences of connectivity**
PI(s):	Robinson, K., Michigan State University Flinn, S., Michigan State University
Schedule:	2019-Present
Funding:	Great Lakes Restoration Initiative
Status:	Ongoing
Rationale:	Understanding the extent to which connectivity can affect fishery production and ecosystem function is important for fishery management. Fishery managers also need to understand stakeholder views to make viable management decisions about fish passage and fishway operations.
Project objectives:	1. Modify and expand an existing operating model (Jones et al 2009) to evaluate the economic and ecological tradeoffs of various connectivity scenarios including maintaining an existing barrier, removing a barrier, and providing selective passage and determining the optimal level of passage. 2. Use structured decision making to evaluate strategies and tactics for addressing questions about connectivity in the Great Lakes basin, using the Boardman (Ottaway) River, Traverse City, MI. as a case study.
Deliverables:	In preparation

Project Title:	**Space use of resident and migratory fishes in the lower Boardman (Ottaway) River before installation of a selective fish passage facility**
PI(s):	Swanson, R.G., Great Lakes Fishery Commission Zielinski, D.P., Great Lakes Fishery Commission Castro-Santos, T., U.S. Geological Survey-CAFRL
Schedule:	2018-Present
Funding:	Great Lakes Fishery Commission & Great Lakes Restoration Initiative
Status:	Ongoing
Rationale:	Little is known about the composition and movement of the fish community in the lower Boardman (Ottaway) River with the exception of Pacific salmons, which are not native to the Great Lakes. This project gives FishPass researchers the first glimpse of how both native and non-native fishes enter and/or reside in the river downstream of the future FishPass site.
Project objectives:	1. Establish a baseline understanding of fish movement in the Boardman River, especially below Union Street Dam. 2. Identify changes in movement in response to selective passage. A baseline fish movement monitoring program will eventually help distinguish the relative effectiveness future selective fish passage treatments and identify ways to increase efficacy.
Deliverables:	• Swanson, R.G., McCann, E.L., Johnson, N.S., and Zielinski, D.P, 2021. Environmental factors influencing annual sucker (Catostomus sp.) migration into a Great Lakes Tributary. *Journal of Great Lakes Research* 47:1159-1170. https://doi.org/10.1016/j.jglr.2021.04.003.

Project Title:	**Determining connectivity between the Boardman (Ottaway) River, Grand Traverse Bay, and Lake Michigan proper in support of FishPass**
PI(s):	Swanson, R.G., Great Lakes Fishery Commission Zielinski, D.P., Great Lakes Fishery Commission Muir, A.M., Great Lakes Fishery Commission Hondorp, D., U.S. Geological Survey-GLSC Fisk, A., University of Windsor
Schedule:	2020-Present
Funding:	Great Lakes Fishery Commission
Status:	Ongoing
Rationale:	An improved understanding of tributary-bay-lake habitat coupling will not only aid in predicting the consequences of selective fish passage on the re-establishment of energy and nutrient pathways, but also provide practical data including a baseline of current movement rates to facilitate future assessment of restoration, and site-specific information on river entry cues and timing that will facilitate sorting of desirable and non-desirable species.
Project objectives:	Determine 1. the proportion of fish tagged (steelhead, smallmouth bass, common white suckers, longnose suckers, lake trout) and released in the Boardman (Ottaway) River that are subsequently detected elsewhere in Grand Traverse Bay and the outer-bay/Lake Michigan ecosystem; 2. the extent and timing of fish movement into and out of the Boardman (Ottaway) River; and 3. the ecosystem variables that cue the timing of river entry/exit.
Deliverables:	In preparation

Project Title:	**Characterization of fish guilds by attributes that can be sorted in a selective fish passage system**
PI(s):	Benoit, D., University of Toronto Jackson, D., University of Toronto Zielinski, D., Great Lakes Fishery Commission Swanson, R., Great Lakes Fishery Commission Muir, A., Great Lakes Fishery Commission
Schedule:	2021-Present
Funding:	Great Lakes Fishery Commission
Status:	Ongoing
Rationale:	Developing selective passage solutions for a mixed assemblage of fish requires an approach that accounts for variability within the assemblage by grouping species into guilds on the basis of their sortable attributes. Passage and blockage scenarios can then be formulated on the basis of differences and commonalities among guilds as opposed to the less efficient prospect of sorting individual species.
Project objectives:	1. Identify key phenological, morphological, behavioral, and physiological attributes of Great Lakes fishes that can be used to sort a mixed assemblage of migratory fishes. 2. Determine if species can be grouped into sortable guilds on the basis of their attributes.
Deliverables:	In preparation

Project Title:	**Boardman (Ottaway) River energy and nutrient dynamics (END project)**
PI(s):	Jacobs, G. Cornell University McIntyre, P., Cornell University Fisk, A., University of Windsor Zielinski, D., Great Lakes Fishery Commission Swanson, R., Great Lakes Fishery Commission Muir, A., Great Lakes Fishery Commission
Schedule:	2021-Present
Funding:	Great Lakes Restoration Initiative & Great Lakes Fishery Commission
Status:	Ongoing
Rationale:	If energy and nutrients limit fish productivity in the upper Boardman (Ottaway) River, passing migratory fishes, upstream of the lowermost barrier (Union Street Dam & future site of FishPass) for the first time in a century, may enhance primary, secondary, and ultimately fishery production in the river. Understanding energy and nutrient connectivity between the river, bay, and Lake Michigan proper and how it influences fishery production will be critical to measuring the success of FishPass and ultimately establishing passage objectives that align with management objectives.
Project objectives:	Determine if 1. nutrients limit fish productivity in the upper Boardman River; 2. enhanced connectivity between the Boardman River, Grand Traverse Bay, and Lake Michigan will reestablish energy and nutrient transfer enhancing energy and nutrient availability; and 3. passage of fishes (particularly longnose and white sucker) above FishPass will provide bio-available lake-derived energy and nutrient subsidies that will increase primary productivity along an upstream longitudinal gradient resulting in enhanced upstream fishery production (particularly for brown and brook trout) and downstream fishery production resulting from larval transport out of the system.
Deliverables:	In preparation

Project Title:	**Test of a screw-style fish lift for introducing migratory fish into a selective fish passage device**
PI(s):	Miehls, S., U.S. Geological Survey-HBBS Zielinski, D.P., Great Lakes Fishery Commission Lewandoski, S., U.S. Fish and Wildlife Service
Schedule:	2019-present
Funding:	U.S. Geological Survey & U.S. Fish and Wildlife Service
Status:	Ongoing
Rationale:	Fish passage technologies that selectively pass desirable species while blocking undesirable species are needed. Image based sorting tools like the Whoosh FishL™ Recognition scanner combined with newly developed computer learning algorithms could be used to identify and potentially isolate sea lamprey from an assortment of Great Lakes fishes. While early results are promising, fish must be lifted out of the water and directed through the image scanner. The Archimedes screw, a device originating from 234 BC, offers the potential to continuously lift fish and water across the small vertical differential required to pass fish through the scanner.
Project objectives:	1. Test the efficacy of a field scale prototype Archimedes screw to autonomously capture and lift fish out of a sea lamprey trap enclosure.
Deliverables:	In preparation

Project Title:	**Assessment of susceptibility to VHSV-IVB in juvenile white suckers (*Catostomus commersonii*) via controlled laboratory experimental challenges**
PI(s):	Loch, T., Michigan State University Whelan, G., Michigan Department of Natural Resources
Schedule:	2022
Funding:	Great Lakes Fishery Commission
Status:	Ongoing
Rationale:	Prior to any translocation of fishes upstream of the future FishPass site, the Michigan Department of Natural Resources has recommended that individuals of each species be screened for VHS using qPCR. While fish-health screening will identify presence/absence of the virus, questions remain over the susceptibility of migratory white and longnose (*Catostomus catostomus*) suckers to VHSv.
Project objectives:	1. Assess the susceptibility to VHSV-IVb in juvenile white suckers via controlled laboratory experimental challenges.
Deliverables:	In preparation