FISH PASS
GIIGOOK MAH-JOWAG

SUPPLEMENTAL RESEARCH PROJECT SUMMARIES

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Project Title:	Space use of resident and migratory fishes in the lower Boardman 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 Holbrook, C., U.S. Geological Survey-HBBS
Schedule:	2018-Present
Funding:	Great Lakes Fishery Commission & Great Lakes Restoration Initiative
Status:	Ongoing
Rationale:	Very little is known about the composition and movement of the fish community in the lower Boardman (Ottaway) River with the exception of Pacific salmon, which are not native to the Great Lakes. This project gives FishPass researchers the first glimpse of how both native and non-native fish enter and/or reside in the river downstream of the future site of FishPass.
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 each selective fish passage treatment and identify ways to increase efficacy
Deliverables:	• Swanson, R.G., McCann, E.L., Johnson, N.S., and Zielinski, D.P, In press. Environmental factors influencing entry of fishes into a Great Lakes tributary during spring and summer using a Dualfrequency Identification Sonar (DIDSON). *Journal of Great Lakes Research*. https://doi.org/10.1016/j.jglr.2021.04.003.

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 River, Traverse City, MI.
Deliverables:	N/A

Project Title:	Genetic assessment of Boardman 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 ecological research 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 diversity 2. Determine the utility of eDNA for investigating species diversity and distribution patterns
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., 2021. 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 River
PI(s):	Gerig, B., Northern Michigan University Patterson, G., Michigan Technological University
Schedule:	2018-2021
Funding:	Great Lakes Restoration Initiative
Status:	Ongoing
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 fish 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 bioenergeticsbioaccumulation 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 • Diedrich, C.J., Gerig, B.S., Paterson, G., 2022. Spatial Comparison of Persistent Organic Pollutants in the Boardman River Following Impoundment Removal and Channel Restoration. Bulletin of Environmental Contamination and Toxicology. https://doi.org/10.1007/s00128-022-03619-y.

Project Title:	Determining Connectivity Between the Boardman 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 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 River; and 3. the variables that cue the timing of river entry/exit
Deliverables:	N/A

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 schemes 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 an assortment of fishes. 2. Determine if species can be grouped into sortable guilds on the basis of their attributes.
Deliverables:	N/A

Project Title:	Boardman River Energy and Nutrient Dynamics
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 Fishery Commission & Great Lakes Restoration Initiative
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 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:	N/A

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 Eickholt, J., Central Michigan University
Schedule:	2019-2020
Funding:	Great Lakes Fishery Commission & Whooshh Innovations
Status:	Complete
Rationale:	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 however, 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 FishLTM 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:	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:	2019-2021
Funding:	U.S. Geological Survey & U.S. Fish and Wildlife Service
Status:	Complete
Rationale:	Fish passage technologies that selectively pass desirable species while blocking undesirable species are needed. Image based sorting tools like the Whoosh FishLTM 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 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:	Zielinski, D.P., Miehls, S., Lewandoski, S. 2022. Test of a screwstyle fish lift for introducing migratory fish into a selective fish passage device. *Water.* 14(15), p. 2298. https://doi.org/10.3390/w14152298.

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 smolt in low current environments, but remains untested for guidance of upstream swimming fish 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:	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-Present
Funding:	Great Lakes Fishery Commission
Status:	Ongoing
Rationale:	Prior to any translocation of fish upstream of the future FishPass site, the Michigan Department of Natural Resources has recommended that individuals of each species by screened for VHS using qPCR. While fish health screening will identify presence/absence of the virus, questions remain over the susceptibility of migratory suckers to VHSv.
Project objectives:	1. To assess the susceptibility to VHSV-IVb in juvenile white suckers via controlled laboratory experimental challenges.
Deliverables:	N/A

Project Title:	Instantaneous river-wide hydrodynamic measurements at fine scales for use in fish movement study at FishPass
PI(s):	Schweitzer, S, Cornell University Cowen, E. Cornell University Goodwin, R.A., U.S. Army Engineer Research & Development Center Zielinski, D., Great Lakes Fishery Commission
Schedule:	2022
Funding:	Great Lakes Fishery Commission
Status:	Ongoing
Rationale:	Hydrodynamics often influence fish movement, yet no technology exists that can measure river-wide hydrodynamics at a detailed scale for the durations that it takes fish to transit the area. This project is aimed at evaluating a new technology, Infrared Quantitative Image Velocimetry (IR-QIV), which uses infrared imagery to measure actual, instantaneous hydrodynamics over relatively long durations across the width of a river at centimeter scale. The goal of this work is to determine whether IR-QIV can be implemented at FishPass.
Project objectives:	1. Pilot test of using high resolution infrared cameras to measure water velocity at the water surface in real-time.
Deliverables:	N/A

Project Title:	Automated spillway surveillance for risk assessment at FishPass
PI(s):	Eickholt, J., Central Michigan University Zielinski, D., Great Lakes Fishery Commission
Schedule:	2022-Present
Funding:	Great Lakes Fishery Commission
Status:	Ongoing
Rationale:	A risk analysis of steelhead leaping ability using an established ballistic fish leaping model, predicts steelhead to be blocked at FishPass up to the 25-year flood event with a slight risk of passage possible at flows as low as the 5-year flood event. Based on these results, the FishPass Advisory Board recommended monitoring passage over the weir structures using video surveillance when river flows exceed the 5-year flood event. However, video surveillance generates an immense amount of data that needs to be reviewed. This project is aimed at developing an economical video capture and analysis platform that will permit timely, comprehensive screening of video surveillance data.
Project objectives:	1. Determine the initial jumping speed and angle for leaping steelhead at a fish weir to further validate robustness of FishPass barrier design to block leaping fishes. 2. Develop a computer program to streamline the collection and analysis of fish leaping video to monitor for unintended fish passage at FishPass.
Deliverables:	N/A

Project Title:	Models for fish movement past migratory barriers: an overview of current methods and future directions
PI(s):	Silva, A.T., Norwegian Institute for Nature Research Bærum, K., Norwegian Institute for Nature Research Goodwin, R.A., U.S. Army Engineer Research & Development Center Kerr, J., University of Guelph Zielinski, D., Great Lakes Fishery Commission
Schedule:	2022-Present
Funding:	Great Lakes Fishery Commission
Status:	Ongoing
Rationale:	Modelling environmental conditions and fish movement in and around FishPass is anticipated to be a major component in planning sorting configurations, rapidly analyze experimental data, and eventually export sorting processes to new systems / species. High-resolution computational fluid dynamics models have already been developed that can be integrated with telemetry data to analyze and possibly forecast fish behavior in the future. This work will summarize the current state of the science and identify what key attributes of fish movement and environmental data and analysis methods that will give researchers the best opportunity to develop and implement predictive and explanatory fish movement models at FishPass and beyond.
Project objectives:	1. Collect and compile the breadth of available knowledge on different alternative methods to model fish movement in the vicinity and passing migratory barriers to help support future model development and implementation at FishPass
Deliverables:	N/A

Project Title:	Spatio-temporal drift patterns of larval fish in the Boardman/Ottaway River
PI(s):	Roseman, E.F., U.S. Geological Survey DeBruyne, R.L., U.S. Geological Survey Hettinger, H.A., Michigan Department of Natural Resources
Schedule:	2023-Present
Funding:	Great Lakes Fishery Commission
Status:	Ongoing
Rationale:	The broad goal of the proposed work is to collect information on the magnitude, composition, and phenology of larval fish drift in the Boardman/Ottaway River from sites above Boardman Lake to Lake Michigan. This work will inform future sampling strategies and protocols to measure effects of fish passage on fish communities following a barrier removal. Specifically, data from this first-ever larval drift survey can be compared to subsequent surveys to assess changes in community composition, magnitude of abundance and outmigration, and effects of selective fish passage through the lower reaches
Project objectives:	1. Determine the taxonomic composition of fish embryo and larval drift. 2. Quantify the magnitude of temporal and spatial drift patterns. 3. Determine the ontogeny, size structure, and condition of drifting larvae. 4. Identify sample site variables including flow velocity, water temperature, dissolved oxygen, conductivity, pH, turbidity, and river discharge that relate to spatio-temporal patterns of drift.
Deliverables:	N/A

ABOUT FISHPASS

FishPass is the capstone of a ~20y restoration project on the Boardman (Ottaway) River, Traverse City, Michigan, re-connecting the river with Lake Michigan. FishPass will replace the deteriorating Union Street Dam with a new, complete barrier to all fish that will have the ability to sort and selectively pass desirable fishes while blocking harmful invaders like sea lamprey. While fully automated selective passage is the long-term goal of the project, passage of any fish during the initial 10-yrs will be coordinated with fishery management agencies, limited in number, and restricted to fishes native to the upper Great Lakes.