FishPass: Assessment Plan

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Andrew Muir – Science Director, Great Lakes Fishery Commission

Daniel Zielinski – Principal Engineer/Scientist, Great Lakes Fishery Commission

Marc Gaden – Communications Director, Great Lakes Fishery Commission

Reid Swanson – Assessment Biologist, Great Lakes Fishery Commission

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FishPass Assessment Plan

1. Introduction

The assessment plan is intended to identify and coordinate appropriate monitoring techniques to address FishPass project objectives and Biological Element goals (summarized in the Project Overview document). The assessment plan contains extensive surveys and long-term monitoring efforts that broadly collect data on fish communities, fish movement/passage, sea lamprey populations and habitat, water quality, and stream morphology at representative reaches of the Boardman River. Monitoring techniques will encompass direct (e.g. telemetry), indirect (e.g. fish surveys), and abiotic measurements.

The purpose of this assessment plan is to address broad monitoring efforts associated with overall project objectives and goals; however, it does not explicitly address monitoring requirements for individual research projects within the facility. While individualized monitoring plans will need to be developed for each research project (both internal and externally led), project leaders are encouraged to utilize the monitoring resources detailed herein.

The assessment plan is organized to provide a preliminary list of target species and current knowledge of their movement, a compendium of past assessment and monitoring efforts in the Boardman River, and a description of monitoring programs associated with project objectives and metrics.

2. Target species and known movements

There are 58 fish species known to reside in the Boardman River. However, a finite list of target species has been identified for study since not all species are relevant to fish passage studies in the lowermost reach of the river, have sufficient abundance to detect impacts, or are easily obtained and/or tagged. Target species of the assessment plan are listed in Table 2-1, and categorized by presence relative to the Union Street Dam: (1) downstream only, (3) upstream only, and (3) bi-directionally.

Lake sturgeon are a target species, but abundance is very low in the Boardman River. Only a number of individuals have been observed downstream of the Union Street Dam in the last decade. In this report lake sturgeon will be included in indirect measurement efforts (e.g., fish surveys, DIDSON), scanned for any existing tags, and released without tagging. There have been no decisions made regarding potential stocking or local rearing efforts of rare species like lake sturgeon or grayling.

The movement phenology of many target species in the Boardman River is generally understood (Fig. 2-1); however, site specific timing and movement cues are unknown. The Union Street Dam acts as a barrier to nearly all upstream movement of fish. However, sea lamprey larvae have been observed upstream and periodic lampricide treatments have occurred since 1963. The dam has a pool and weir type fishway, but velocity conditions and step heights preclude passage by most native fish; only introduced Pacific salmonids and some brown trout have been observed passing. In 2018, the lowermost step of the fishway will be blocked with a screen to prevent passage of any fish, including salmon, during the removal of Sabin Dam.

Table 2-1. Target species for study based on presence relative to Union Street Dam.

Downstream only	Upstream only	Up- and Down-stream
Lake trout (*Salvelinus namaycush*)	Brook Trout (*Salvelinus fontinalis*)	White Sucker (*Catostomus commersonii*)
Lake Sturgeon (*Acipenser fulvescens*)	American Brook Lamprey (*Lethenteron appendix*)	Brown Trout (*Salmo trutta*)
Sea Lamprey (*Petromyzon marinus*)		Walleye (*Sander vitreus)*
Rainbow Trout (*Oncorhynchus mykiss*)		Smallmouth Bass (*Micropterus dolomieu*)
Chinook Salmon (*Oncorhynchus tshawytscha*)		Yellow Perch (*Perca flavescens)*
Coho Salmon (*Oncorhynchus kisutch*)		Rock Bass (*Ambloplites rupestris)*
Common Carp (*Cyprinus carpio*)		Round Goby (*Neogobius melanostomus*)

Approximately 0.5 kilometers downstream of Union Street Dam is the James P. Price Trap-and-Transfer Facility, which is owned by Traverse City and operated by Michigan Department of Natural Resources (MIDNR). The MIDNR installs removable grates in the fall to direct migrating salmon into a fish ladder where coho and chinook salmon are harvested and rainbow and brown trout are returned to the river. Kids (Hospital) Creek is the only tributary located between Union Street Dam and the Trap-and-Transfer Facility, and has a perched culvert outlet structure.

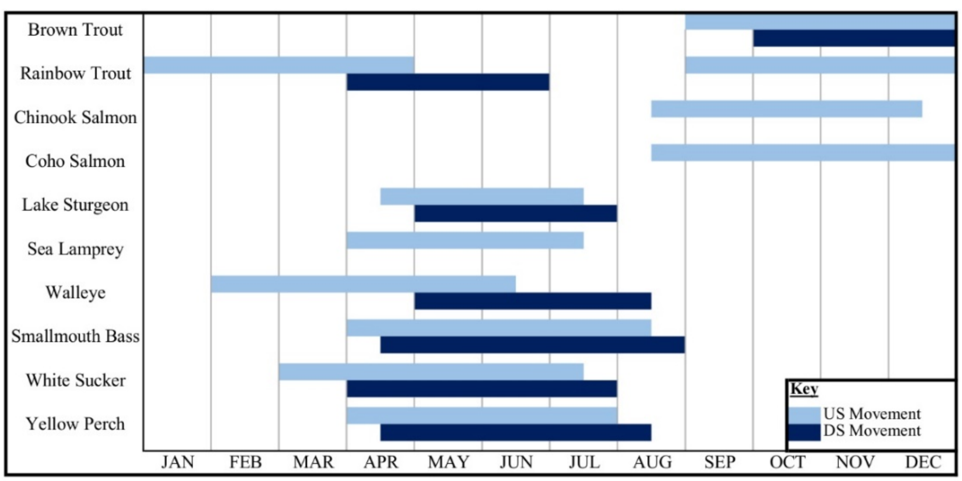

Figure 2-1. Migration timing of select target species in the Boardman River. Timing data adapted from Goodyear et al. (1982), Biette et al. (1981) and Velez-Espino et al. (2011).

3. Existing assessment database

The Boardman River has been well studied, especially upstream of the Union Street Dam where a series of dam removals are underway, has been well studied. Monitoring programs established by the Boardman River Implementation Team and conducted by the Grand Traverse Band of Chippewa and Ottawa Indians (GTB), MIDNR, and non-government organizations (NGOs) have collected data on fish community, amphibian and reptile populations, macroinvertebrate community, and stream mechanics (i.e., flow and sediment transport). A preliminary FishPass database has compiled all available biological and environmental data on the Boardman River (Table 3-1).

Table 3-1. List of existing assessment database items, years of record, and data source.

Description	Years of Record	Source
List of species present up- and down-stream of Union Street Dam	NA	MIDNR Boardman River Assessment 2014
Catch of salmon and trout at Boardman Weir (DS of Union Street Dam)	1987-current	MIDNR Boardman River Assessment 2014
Average total length-at-age and growth (relative to state average) for brook and brown trout	2005-2006	MIDNR Boardman River Assessment 2014
Chapman-Pedersen population estimate for brown trout, brook trout, and rainbow trout	2005-2006	MIDNR Boardman River Assessment 2014
Boardman lake walleye population estimate	2014	Little Traverse Bay Band of Odawa Indians
Boardman River creel survey data	NA	MIDNR
Sea lamprey trap catches and water temp by day and trap number	April - June 1980-current	U.S. Fish and Wildlife Service, Sea Lamprey Control Program
Lampricide treatment years	1963-2012	U.S. Fish and Wildlife Service, Sea Lamprey Control Program
Sea Lamprey Larval survey results (downstream of Union Street Dam)	1960-current	U.S. Fish and Wildlife Service, Sea Lamprey Control Program
Sea Lamprey Larval survey results (upstream of Union Street Dam)	1960-2014	U.S. Fish and Wildlife Service, Sea Lamprey Control Program
Mollusk documentation within the Boardman River watershed	1930-1998	MI DNR Boardman River Assessment 2014
Union Street Dam components	NA	Various
Daily average flow	1952-current	USGS Gauge
Water surface elevation rating	NA	Stanley Consultants Hydraulic Analysis 2013

4. Monitoring program

The current monitoring program for FishPass is focused on establishing baseline data prior to construction. The program consists of five major categories: (1) long-term monitoring; (2) sea lamprey assessment; (3) movement studies; (4) genetic and eDNA sampling; and (5) contaminant transfer. Table 4-1 indicates the data that will be collected within each monitoring effort and the project objectives and biological element goals it addresses. Where individual study plans were previously developed, the study plan objectives and methods will be provided.

Table 4-1. Monitoring program efforts, data collected, and corresponding project objectives and biological element goals.

Effort	Data Collected	Project Objectives	Biological Element Goals
Long-term monitoring	Species composition, abundance, biomass, and size Water quality Habitat and stream morphology	1, 2, 3	B2
Sea lamprey assessment	Larval abundance through whole river Adult abundance downstream of Union Street Dam	1, 2, 3	B1
Movement studies	Number of fish approaching, entering, and exiting When, where, and how fish move	1, 2	B1, B2
Genetic and eDNA sampling	Sequence genotypes Presence of rare species	2, 3	B1, B2
Contaminant transfer	Type and amount of contaminants moving in system	2, 3	B2

The following sections provide details on what monitoring techniques will be employed, by whom, when, and how the data collected will be evaluated with reference to project objectives and biological element goals. A summary of all fish sampling required for each monitoring effort is provided in Appendix 1.

4.1. Long-term monitoring

The purpose of a long-term monitoring (LTM) plan is to quantitatively document changes in fish community and habitat over time at stationary sites located throughout the Boardman River. Six monitoring sites have been identified, two downstream of Union Street Dam and four upstream (Fig. 4-1). Routine measurements of fish community, water quality, and habitat and stream morphology will be collected at each site over a period of no less than 10 years. The upstream sites were selected based on existing MIDNR monitoring plans and monitoring efforts associated with dam removals. Specifically, the Brown Bridge Road site is a MIDNR index site and fisheries surveys have been conducted regularly since 1985. The downstream sites are new monitoring locations in the Boardman River. Monitoring techniques planned for each LTM site is provided in Table 4-2.

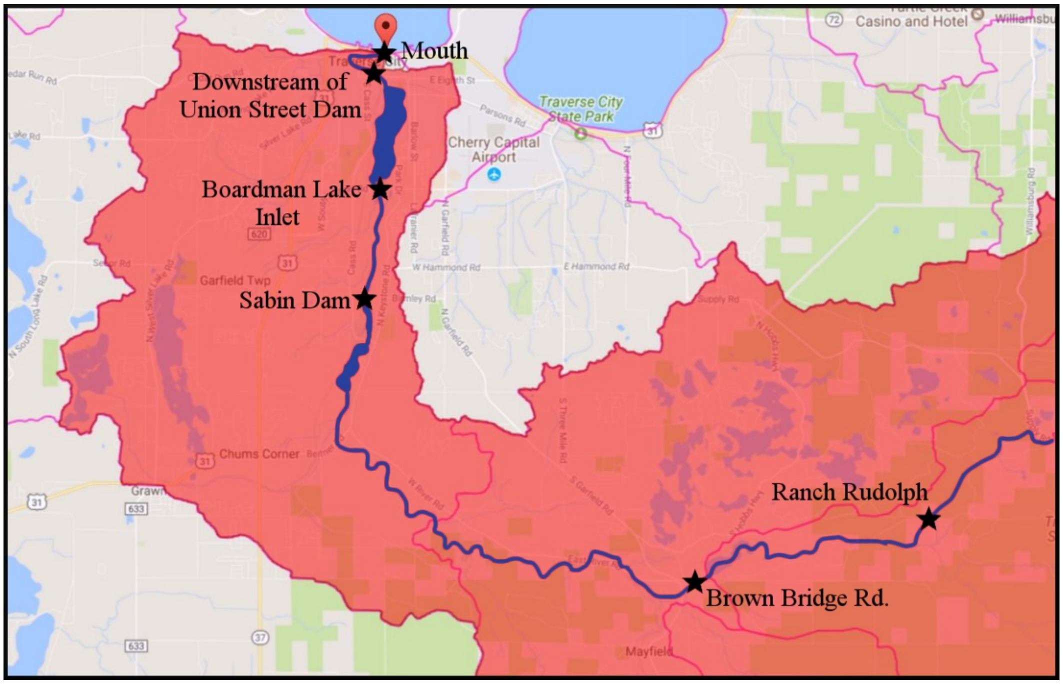

Figure 4-1. Locations of six long-term monitoring sites in the Boardman River.

Table 4-2. Monitoring techniques used at each LTM site. Agencies tasked with the effort are listed in parentheses.

LTM Site	Monitoring techniques
Mouth	• Quarterly electrofishing transects and habitat survey (MIDNR, GTB) • Water level gauge (TC)
Downstream of Union Street Dam	• Quarterly electrofishing transects and habitat survey (MIDNR, GTB) • Water level gauges above and below dam (TC) • Water quality sensor at Trap-and-Transfer Facility (GLFC)
Boardman Lake Inlet/ S. Airport Road	• 2 Pass electrofishing survey (MIDNR) • Water quality sensor at YMCA (GLFC)
Sabin Dam	• 2 Pass electrofishing survey (MIDNR) • Water quality sensor at Beitner Rd. (GLFC)
Brown Bridge Road	• 1 Pass electrofishing survey and habitat survey (MIDNR)
Ranch Rudolph	• 1 Pass electrofishing survey and habitat survey (MIDNR)

Electrofishing Surveys: Electrofishing surveys are conducted in the Boardman River. Surveys are conducted by the GTB and MIDNR staff. Surveys will follow the MIDNR electrofishing sampling protocols (Wills et al., 2011). Surveys downstream of Union Street Dam consist of a single pass with a boomshocking electrofishing boat and fish collection using 3/16 inch delta mesh dip nets. Fish less than 1in long are ignored. Backpack electrofishers are used in sections where a boomshocking electrofishing boat cannot access. The species and length identification of all remaining fish are recorded and fish are released. Electrofishing surveys provide data to identify species composition, relative abundance, biomass, and size.

Habitat Survey: In conjunction with electrofishing surveys, measurements of the local habitat are collected. Habitat surveys will again follow MIDNR habitat sampling protocols (Wills et al., 2011). Generally, habitat surveys will document: (1) riparian zone conditions; (2) width, depth, and substrate (i.e., stream morphology); (3) large woody material; and (4) discharge. Discharge in the Boardman River is continuously monitored by USGS gauges at Beitner Road (04127200) and Brown Bridge Road (04126970), and can be adjusted for sampling location through direct drainage area ratio adjustment.

Water level gauges: River stage (feet relative to sea level) data are collected from three HOBO data loggers (model: MX2001-04) installed on the US-31 Highway Bridge over the Boardman River mouth, Union Street Bridge (downstream of Union Street Dam), and Cass Street Bridge (upstream of Union Street Dam) are maintained by Traverse City.

Water quality sensors: Continuous water quality data are collected using a YSI multiparameter water quality sondes (model: 6600V2-4) installed at the Trap-and-Transfer facility, near the YMCA (upstream of Boardman Lake inlet), and Beitner Road (between Sabin Dam and Brown Bridge Road) and are maintained by the Great Lakes Fishery Commission (GLFC). The sondes record water temperature, conductivity, turbidity, and dissolved oxygen levels every hour.

4.1.1. Link to project objectives and goals

Overall the LTM efforts will provide measures of species composition, habitat type, and environmental data (e.g. water level and quality), as well as long-term trends of species composition and abundance response to selective fish passage. Together, these measures address all project objectives and biological element goal B2.

4.2. Sea lamprey assessment

Assessment of sea lamprey populations downstream of the Union Street Dam and larval assessments upstream of the dam are conducted under the direction of the U.S. Fish and Wildlife Service. Two sea lamprey traps are installed on the downstream side of Union Street Dam during the spring to capture and remove migrating adult sea lamprey. The Boardman River is an index site, so a portion of trapped sea lamprey are tagged and released back downstream to provide an estimate of abundance. Upstream of the dam, larval assessments include backpack electrofishing at two LTM sites annually in Jul-Aug. Upstream production potential of sea lamprey will be examined using quantitative assessment (QAS) of native lamprey, used as surrogates, at each LTM site prior to construction of FishPass.

4.2.1. Link to project objectives and goals

Sea lamprey assessment efforts will determine sea lamprey production potential of the Boardman River above Union Street Dam and detect passage of sea lamprey upstream, which directly addresses all project objectives and biological element goal B1.

4.3.Movement studies

Space-use patterns of fish downstream of FishPass and movement (approach and passage) rates upstream are expected to change in response to the increased connectivity provided by FishPass (once constructed). A fish movement monitoring plan has been created to assess if and how fish movement and space use change in response to selective fish passage. The monitoring plan utilizes telemetry to (1) establish a baseline understanding of fish movement using in the Boardman River, especially below Union Street Dam, and (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.

Telemetry techniques provide direct measurement and observation of fish passage and movement. The three primary telemetry options under consideration at FishPass are acoustic, radio, and passive integrated transponder (PIT) technologies. Each system is generally comprised of a transmitter (tag) that is implanted or otherwise attached to fish and sends out a signal that is detected by a receiver (e.g., antenna, hydrophone), and the detection event is recorded. Sonar technologies such as Dual-frequency Identification Sonar (DIDSON) cameras also provide indirect measurement of fish movement. Brief descriptions of each system are provided below:

Acoustic telemetry: Acoustic telemetry systems are able to measure fish movement at both coarse and fine scales and are ideal for high conductivity or deep water. A system comprised of stand-alone hydrophones can provide presence/absence information or used to manually track fish as a mobile unit. A system with a coordinated hydrophone array can provide near continuous tracks of fish movement. There are numerous vendors of acoustic telemetry gear (Lotek, HTI, ATS), but VEMCO (Nova Scotia, CAN) telemetry systems have proven to be an effective and dependable tool for fish movement observations throughout the Great Lakes and are a key component of the Great Lakes Acoustic Telemetry Observation System (GLATOS). VECMO can deliver coded acoustic transmitters of various sizes, that operate at 69 kHz and 180 kHz. All tags transmit an acoustic pulse train that encodes a specific ID number for the tag, and larger tags can be customized to transmit temperature and depth information if necessary. The detection range and battery life of the tag depends on environmental conditions (e.g., depth, water temperature), size, and interval time between transmissions. VEMCO receivers can be deployed in an array using the VEMCO positioning system (VPS) that allows for precise positioning of the fish in time and space. VPS systems are ideal for open water applications (i.e., Grand Traverse Bay) where there are few signal obstructions. While a VPS system could be deployed in the river, signal reflections caused by shallow water and instream structures could be problematic. Acoustic telemetry is a viable tool for monitoring fish movement outside of the FishPass facility, but the confined dimensions of the fish sorting channels (~1 m depth x 5-10 m wide) will likely preclude their use within the FishPass facility.

Radio telemetry: Radio telemetry systems are able to measure fish movement at coarse scales and are ideal for sites with shallow water, low conductivity, high turbidity, and turbulence. Radio antennas deployed from the air (e.g., Yagi, hoop antennas) typically have greater range than antennas underwater (e.g., dipole antenna); however, detection range is a product of environmental conditions, depth, and transmitter antenna. SigmaEight (Ontario, CAN) radio telemetry gear was determined to be the most cost effective for FishPass based on expert opinion. SigmaEight can deliver radio tags of various sizes and can operate at frequencies between 148-174 MHz. The Orion Broadband Receiver/Datalogger system is capable of switching between multiple antennas and scanning across multiple frequencies, which allows for detection of large groups of tagged fish. The system selected for the Boardman River operates at 164.48 MHz, a frequency with little background noise within the study area. Pairs of Yagi antenna can be used as gates to detect tag presence and direction of movement. Due to their smaller detection range, a row of underwater dipole antenna can be used to identify cross-sectional distributions of fish pathways. While aerial antennas are fabricated by SigmaEight, dipole antenna can be construct onsite by stripping the shielding from an appropriately sized section of coaxial cable. Radio telemetry is also ideal for manual tracking since aerial antenna can be used to scan multiple frequencies and have greater detection range than acoustic receivers in shallow river environments without needing to be in the water.

Radio-frequency identification telemetry: RFID (Radio-frequency identification) passive integrated transponder (PIT) tags have been used to automatically identify and track animals and/or objects since the early 1970's and are known as robust and reliable monitoring technique for fish passage evaluation (Castro-Santos et al., 1996). The tags transmit a unique identifying number that can be read at short distances by a matching antenna. These systems are ideal to continuously monitor fish movement at a stationary location. Because the PIT tags are charged by the reader via a properly tuned antenna, the tags can remain operational for decades. A PIT tag interrogation system is comprised of four components: datalogger, antennas, power source, and PIT tags. Half-duplex (HDX) systems are the easiest to deploy for aquatic systems (full-duplex systems require antennas that are water-tight). Oregon RFID (Portland, OR) PIT telemetry systems have proven to be an effective and dependable tool for studying sea lamprey and other non-target fish passage in field studies throughout the Great Lakes. Oregon RFID PIT tags are far less expensive than radio and acoustic tags and are available in 12, 23, and 32 mm length. PIT tags do not have a battery, but are charged enough by the electromagnetic field generated by the antenna to transmit a radio signal (134.2 kHz) that is, in turn detected by the antenna. Antennas can be made of a loop of wire that is mounted with the plastic shielding exposed or housed within a non-metallic enclosure/frame. Antennas are easier to construct to work with large PIT tags since their signals are relatively strong. Antennas to be used with smaller PIT tags (12 mm) usually require a better designed antenna. The choice of wire (size and stranding) have a direct effect on how well the antenna will perform. PIT telemetry is ideal for tracking passage of many fish at fixed locations in the Boardman River and within the FishPass facility.

Sonar (DIDSON): Dual-frequency Identification Sonar (DIDSON) cameras produce near video quality data that allow for monitoring fish movement at much finer temporal and spatial scales than traditional monitoring techniques (Hateley and Gregory, 2006). DIDSON cameras are produced by Sound Metrics (Seattle, WA) and along with newer ARIS models, have been proven an effective tool to view fish under low light and high turbidity. The DIDSON imagery can be manually examined to quantify fishes as they swim through the field of view using DIDSON software. In general, fish species cannot be easily discerned from the footage, but lengths and behaviors can be documented. Species identification could be developed via image analysis software provided adequate training data sets can be developed in conjunction with other monitoring techniques (e.g., telemetry, fish surveys). DIDSON cameras are highly mobile and can be deployed for short observations or long term monitoring; however, this generates large data files that need to be reviewed and stored.

4.3.1. Space use of resident and migratory fishes in the lower Boardman River before installation of a selective fish passage facility

R. Swanson, D. Zielinski, C. Holbrook, T. Castro-Santos, R. Goodwin, H. Hettinger, F. Dituri, A. Muir

This plan will focus on monitoring movement of five species (i.e., white sucker, rainbow trout, smallmouth bass, walleye, common carp) representing the typical assemblage of large-bodied fishes above and below the current Union Street Dam and invasive sea lamprey using a combination of telemetry gear. All fish collected during MIDNR and GTB fishing surveys below Union Street Dam will be implanted with a passive integrated transponder (PIT; 23 mm half duplex). PIT antennas will be installed at the entrance of the existing fishway at the Union St. Dam to document fishway encounter and entry rates and the MIDNR trap-and-transfer weir (Fig. 4-2). There will be no need to monitor passage through the fishway because all passage will be blocked by a screen while Sabin Dam is being removed (2018-2019).

Figure 4-2. Locations of radio receivers with aerial directional Yagi and underwater omnidirectional dipole radio antennas, and PIT antennas in the existing Union St. Dam fishway and trap-and-transfer facility weir.

All fish collected during LTM sampling downstream of Union Street Dam or collected during operation of the trap-and-transfer facility will be scanned for PITs. A sample of each target species (N=10 of each fish in Year 1, 60 total; N=40 in Year 2) will also be anesthetized (AQUI-S 20E per USFWS INAD), implanted with a coded radio transmitter, weighed, measured, sexed, and released. A radio receiver with two directional Yagi antennas (one pointed upstream, one pointed downstream) will be installed at the river mouth (E. Grandview Parkway bridge) to document movement in and out of the river. Two radio receivers with an underwater dipole antenna array will be placed along the river width at the S. Union St. Bridge to document entry into the future project area and cross-channel distribution. The study area (between E. Grandview Parkway and Union Street Dam) will be searched from a small boat or shore once every two weeks using a handheld radio receiver and Yagi antenna. Location (long., lat.), strength, and bearing of each detection will be recorded and location of each fish during each survey will be estimated. Movement data will be compiled with daily measurements of streamflow, water level (above dam, below dam, and at river mouth), and water quality. Water velocity profiles at each monitoring site will also be characterized (across a range of river discharges) using ADV or ADCP. A camera installed near the Union Street bridge will provide time-lapse images of recreational boating and fishing activity at the Union Street Dam.

The study will be conducted in two phases:

- Phase 1 (Summer 2018) will be a pilot level study with the goal of installing the telemetry systems and troubleshooting any unexpected issues. A small number of radio tags will be deployed (N=10 of each fish, 60 total). All fish weighing more than 30 g (no more than 50 per species) captured during LTM surveys or trap-and-transfer facility operation (e.g., steelhead and brown trout) will be implanted with PITs.
- Phase 2 (Fall 2018 – Spring 2020) will expand the study plan. New research questions will be identified as part of the FishPass research plan and adjustments to the telemetry system will be made. More radio tags will be deployed, and PIT tagging will continue. The project team will develop a proposal in collaboration with the Great Lakes Acoustic Telemetry Observation System (GLATOS) to incorporate acoustic telemetry into the fish movement monitoring plan.

4.3.2. DIDSON survey plan

R. Swanson, E. McCann, N. Johnson, D. Zielinski

A DIDSON was deployed in 2017 on the north bank of the Boardman River at the James P. Price Trap-and-Transfer Facility to capture high resolution video of fish movement and behavior in conjunction with environmental variables collected as part of the LTM plan. The DIDSON data is used to evaluate the environmental triggers for stream entry of three size classes of migratory fishes in the Lower Boardman River.

The DIDSON field of view is positioned horizontally and perpendicular to stream flow at a downward tilt of -4.7º with a viewing window spanning from 1.67 m to 11.67 m (Fig. 4-3). DIDSON data are manually examined to quantify fishes as they swim through the field of view using the DIDSON V5.25 software

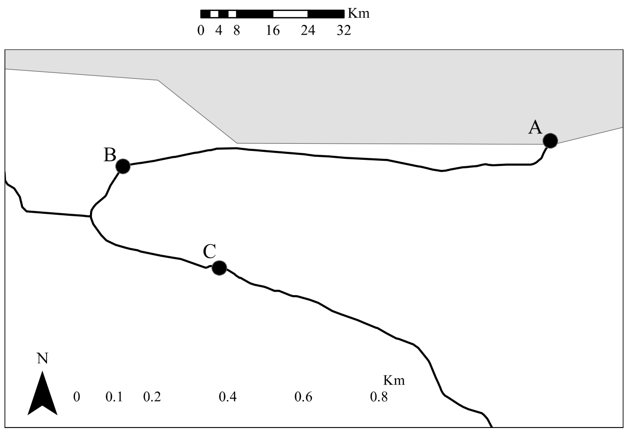

Figure 4-3. *Panel A: Map of the Boardman River watershed; Panel B: Map of the Boardman River study site showing A) the Boardman River mouth, B) the location of the DIDSON, and C) the location of the Union Street Dam; Panel C: General diagram (aerial view) of the DIDSON setup.*

(Sound Metrics Corps.). Fish are sorted into three size classes: small (< 30 cm), medium (>30 cm and < 50 cm), and large (> 50 cm). While fish species cannot be determined for most fusiform fish, sea lamprey can be identified because of their unique body shape and sinusoidal swimming behavior. Fish observed in the field of view are measured and assigned a general size range. Fish appearing on the cusp of a size class are measured using the measuring tool in the DIDSON software. Total counts of fish in the field of view are recorded, but due to the complex variability in swimming behaviors, direction of travel cannot be determined. Data are subsampled daily into four, two-minute DIDSON clips at sunrise, sunset, the midpoint between sunrise and sunset (i.e., mid-day) and the midpoint between sunset and sunrise (i.e., mid-night). All clips from all days are randomized prior to manual inspection. Increased subsampling may be required during peak sea lamprey migration to assess stream entry timing. Stream temperature, river stage, and stream discharge are measured as part of the LTM plan and used to determine their relative influence on the presence of the three size classes of fishes.

Daily passage and environmental conditions are assessed using a hazard analysis to evaluate environmental cues that predict passage of fishes of a given size class within the Lower Boardman River. A hazard analysis is used to estimate the "cumulative hazard" for each individual to determine what environmental trigger(s) most influence fish passage. The covariates used during the initial run of the hazard analysis on 2017 data included time of day, stream temperature, river stage, stream discharge, and 24-hour time delays of stream temperature, river stage, and stream discharge. Akaike's information criterion (AIC) is then used to rank several subsets of the full model to determine which variables most influence fish movement for each size class. Results from the 2017 data concluded that stream temperature, 24-hour time delayed river stage, and time of day were the best predictors of stream entry for all three size classes.

4.3.3. Link to project objectives and goals

Overall, the telemetry plan will determine (1) longitudinal space use (utilization distributions) of individuals in the lower Boardman River (between Lake Michigan and the Union Street Dam), (2) the rate that individuals enter the future project site (pass the S. Union St. bridge), (3) the lateral (cross-channel) distribution of individuals that enter the future project site, (4) the rate that individuals encounter and pass the existing Union St. Dam, and (5) if site approach rates, spatial distributions (lateral and longitudinal), dam encounter and passage, differ among species, life stages, season, recreational boating, fishing, or environmental conditions. The DIDSON survey also evaluates the environmental triggers for stream entry of migratory fishes in the Lower Boardman River without needing to tag fish. Combined, these outcomes directly address project objectives #1 and #2 and biological element goals B1 and B2.

4.4. Genetic and eDNA sampling

Collecting baseline genetic data from species such as walleye, smallmouth bass, yellow perch, white sucker, and rock bass as well as eDNA water samples from sites up- and down-stream of the Union Street Dam will allow us to determine the genetic impact of fish passage on fish populations upstream of the dam and investigate distribution patterns of species that are being passed.

4.4.1. Genetic assessment of Boardman River fish populations prior to dam removal

W. Larson, W. Stott, H. Hettinger, F. Dituri, D. Zielinski, A. Muir

We hypothesize that decreases in genetic differentiation between populations up- and down-stream of the Union Street Dam and increases in genetic diversity of populations upstream of the dam will be detectable 5-10 years after fish passage has been initiated. However, it is likely that these effects will vary substantially by species due to differences in life history. We also hypothesize that eDNA will represent a useful tool for monitoring species diversity and distribution patterns.

The plan objectives are to (1) collect baseline genetic data on five fish species up- and down-stream of the Union Street Dam to determine if these populations are significantly differentiated and/or show differences in diversity and (2) collect eDNA samples from existing monitoring sites and pair these data with traditional surveys to determine the utility of eDNA for investigating species diversity and distribution patterns.

Objective 1: We will use restriction-site-associated DNA (RAD) sequencing to genotype thousands of genetic markers in five fish species sampled above and below the Union Street Dam as part of LTM efforts. The five species that will be included in this project are white sucker, smallmouth bass, walleye, yellow perch, and rock bass. These species display variation in a number of life history parameters that may influence their genetic response to habitat fragmentation including size, age at maturity, population size, propensity to migrate, spawning behavior, and fecundity. Baseline sampling will occur over two years, and 50 samples from up- and down-stream of the dam will be collected for each species in each year (200 total samples per species). We will then conduct standard genetic analyses to determine whether significant differentiation and differences in diversity exist between populations up- and down-stream of the dam. Genetic differentiation between populations is likely to be low since populations up- and down-stream of the dam have only been isolated for 10 – 20 generations. We chose RAD sequencing for this reason because RAD data provide substantially more power to detect population structure compared to data from 10-15 microsatellites and also facilitate individual based analyses and detection of markers that may be under selection.

Objective 2: Aquatic species constantly slough DNA from skin cells, excrement, and other sources; this DNA, termed environmental or eDNA, can be collected and used to determine which species are present in a given section of river. A rapidly growing body of literature suggests that eDNA sampling can provide a cost effective alternative to traditional sampling and can often detect species that may not be detectable with these traditional methods. We will use eDNA metabarcoding to investigate species diversity at the LTM sites in the Boardman River. The MIDNR will collect water samples for eDNA analysis from these sites at the same time that they conduct traditional backpack electrofishing surveys for species diversity. Samples will be taken in the river thalweg as well as on both sides of the river to determine whether similar species are detected across a single river section. Samples will also be taken throughout the year to determine whether temporal differences in species composition exist. eDNA metabarcoding involves using polymerase chain reaction to amplify regions of the mitochondrial genome such as cytochrome oxidase subunit I (COI) that are commonly used to conduct species identification then sequencing those amplified fragments on a high-throughput sequencer. The Larson lab has developed primers from COI sequences that can be used to differentiate over 80 fish species; these primers should be useful for identifying nearly all the species found in the Boardman River. Once eDNA sampling is completed, we will compare the results to traditional field surveys to determine the strengths and weaknesses of each method.

4.4.2. Link to project objectives and goals

Overall genetic assessment of fish communities up- and down-stream of the Union Street Dam, and eventually the FishPass facility, will allow for evaluation of the genetic impact of fish passage on fish populations upstream of the dam and investigate distribution patterns of species that are being passed, including rare species. These outcomes directly address project objectives #2 and #3 and biological element goal B2.

4.5. Contaminant transfer

A suite of Lake Michigan migratory fish will be measured for contaminants to assess risk of contaminant transfer to resident fishes prior to and following implementation of selective fish passage. The Boardman River, MI, Union Street Dam removal (2019-2020) and replacement with FishPass will be used as a case study to inform issues related to fish passage and contaminant biotransport.

4.5.1. Predicting contaminant transfer following re-establishment of controlled connectivity in the Boardman River

B. Gerig, G. Paterson, D. Chaloner, D. Zielinski, A. Muir

Legacy contaminants can accumulate in both 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. Prior studies have shown that the contaminant burden of resident fish in Great Lakes tributaries relates strongly to the flux of contaminants supplied by spawning non-native Pacific salmon. At present, little is known about contaminant transport by the other ~50 Great Lakes fish species that migrate with varied frequency to tributaries to spawn, including many historically found in the Boardman River. As such, future policy related to fish passage and potential impact on human consumption limits after re-establishing connectivity would be greatly informed by understanding which migrants pose the greatest risk for contaminant transfer.

In this project, we propose to assess the potential for migratory fish to act as a vector for contaminant transfer in the Boardman River watershed. The project objectives are to: (1) assess the contaminant burden of Great Lakes spawners to inform future fish passage decisions; (2) evaluate the background contaminant burdens of resident fish prior to dam removal; (3) measure background contaminant levels of water within the Boardman River watershed; and (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 to inform consumption advisories. Future research following fish passage will evaluate the overlap in distribution between Great Lakes migrants and stream-resident fish to further infer benefits of restored connectivity and risk of contaminant transfer.

Objective 1: To establish risk of contaminant transfer through selective passage, we will measure the contaminant burden of whole fish and egg samples for a subset of Great Lakes migrants including Chinook salmon, Coho salmon, lake trout, steelhead trout, brown trout, white sucker, longnose sucker, walleye, yellow perch, smallmouth bass, and rock bass. We will focus on migrants that are common to the Boardman River, which exhibit species-specific traits with respect to life history (semelparous, iteroparous), origin (native, introduced), spawning mode (broadcast, redd building), fecundity (gonadosomatic index), phenology (spring, summer, fall), abundance (run size), and biochemical makeup (lipid content, contaminant burden) that might mediate contaminant transfer. A total of 10 fish (5 male, 5 female) of each species and of similar size (> 20 g) will be collected. All migrants will be measured for polychlorinated biphenyls (PCBs dichloro-diphenyl-trichloroethylene (DDT) metabolites, chlorinated pesticides, and total mercury (THg). We will relate contaminant burden to individual fish variables including stable isotope ratios of nitrogen (δ15N) and carbon (δ13C), lipid content, fish age, fish size, gonadosomatic index, and species traits to identify factors that increase the likelihood of contaminant transfer. Migratory fish will be captured during their respective spawning run to the Boardman River as part of LTM.

Objective 2: Resident fish will be sampled from 5 LTM stations throughout the Boardman River watershed along with one site in Boardman Lake. Stream-resident fish, including brook and brown trout, and other species of interest will be measured for the same suite of contaminants and biological variables as Great Lakes migrants. Fish diet composition will be measured using standard survey methods including gastric lavage. These data will establish a baseline for background contaminant levels in the Boardman River prior to dam removal and FishPass construction.

Objective 3: Dissolved concentrations and potential sources of persistent organic contaminants (PCBs, DDT, chlorinated pesticides) will be characterized at 5 LTM stations throughout the Boardman River watershed along with one site in Boardman Lake using semi-permeable membrane passive sampling devices (SPMDs). SPMDs will also be used to determine contaminant concentrations in the Boardman River prior to and following the removal of the Union Street Dam and construction of FishPass. An additional SPMD deployment will be completed in Grand Traverse Bay to act as a reference location where atmospheric deposition is the predominant contaminant source. SPMDs will provide evidence of spatial variability in the sources of anthropogenic contaminants, which can increase bioaccumulation in resident fish.

Objective 4: Empirical and literature data on migratory and resident fishes will be integrated to parameterize an individual-based bioenergetics-bioaccumulation model that has already been developed to predict the impacts of migratory fish on resident fish growth and contaminant bioaccumulation under different fish passage scenarios. The model will be parameterized with system-specific empirical data based upon background resident fish contaminant concentrations, diet composition, prey contaminant concentration, and stream water temperature. The model will be validated using empirical data collected from sites without migratory fishes. After validation, a simulation will be run for multiple fish passage scenarios to predict the individual and combined impact of migratory fish spawners on growth and contaminant burden of resident species in the Boardman River watershed.

4.5.2. Link to project objectives and goals

Overall study of contaminant biotransport in the Boardman River to assess risk of contaminant transfer to resident fishes prior to and following implementation of selective fish passage. The conceptual model, rooted in fish traits, will be used to evaluate the "axes of risk" which govern contaminant biotransport by migratory fishes. In addition, the bioenergetics-bioaccumulation model will disassemble the process of contaminant biotransport to address how background contamination and fish migrations interact to influence resident fish bioaccumulation. Further, legacy contaminants of concern (fat-bound PCBs and muscle-bound Hg) will be modeled simultaneously so potential differences in their fluxes from fatty (salmon, steelhead) vs. lean (suckers) species can be evaluated. The model will provide managers with a simple yet powerful decision-support tool to manage migratory fish in the Boardman River. These outcomes directly address project objectives #2 and #3 and biological element goal B2.

5. References

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