Developing Research Priorities for Lake Sturgeon in the Great Lakes

Workshop Proceedings

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Executive Summary

Lake sturgeon in the Great Lakes have been the focus of targeted research and restoration efforts in recent decades. Overfishing and habitat loss resulted in the extirpation of lake sturgeon from some of its historical range, and, while recent developments in lake sturgeon restoration have shown promise, much research remains to be done. The Great Lakes Fishery Trust (GLFT) convened a workshop in August 2024 for researchers and fishery managers to share their knowledge about sturgeon restoration and research and to identify important unanswered questions in these areas. Workshop participants discussed fish passage, habitat needs throughout the sturgeon life cycle, population assessment methods, and artificial propagation of lake sturgeon. A follow-up survey was fielded to determine the importance of each research question. This survey identified investment in acoustic telemetry, which could increase the community's knowledge of both habitat use and population size, as the most important research need. Questions about how to characterize successful fish passage projects, assess restored or created spawning habitat, measure rates of passive integrated transponder (PIT) tag retention, and understand habitat use with regard to size and age rounded out the top five most important questions. Habitat needs and population assessments were determined to be the most important areas of study for advancing lake sturgeon restoration, with several questions within these categories identified as being the highest priority. The Fishery Trust will use the results of this workshop to inform its Ecological and Biological Research program.

Workshop Proceedings

Introduction

Significant resources have been expended on the restoration of lake sturgeon, a slow-growing and long-lived fish species, in the Great Lakes. Lake sturgeon are vulnerable to many environmental stressors, including dams, invasive species, and climate change, and exist at low population levels throughout most of the Great Lakes region. Managers and researchers have made advancements in lake sturgeon restoration, such as using streamside rearing facilities for stocking sturgeon and gaining a better understanding of riverine habitat use, but significant knowledge gaps remain. The GLFT identified the need to update its lake sturgeon research priorities and engaged the Great Lakes Lake Sturgeon Coordination Committee, which has historically held biennial meetings of sturgeon managers and researchers in the region, to plan a workshop that would help set research priorities for the coming years. The research priorities developed in this workshop will help guide the GLFT's Ecological and Biological Research program funding, and the results of the funded research will assist fishery managers in determining how to conserve and restore lake sturgeon across the Great Lakes basin.

Workshop Goal and Objectives

In August 2024, the Great Lakes Lake Sturgeon Coordination Committee and the GLFT held a workshop to identify the research and information gaps that limit managers' ability to restore lake sturgeon in Lake Michigan and the Great Lakes. The objectives of the workshop were:

1. Synthesize the current knowledge about lake sturgeon concerning fish passage technologies, habitat constraints throughout the life cycle, tools for assessing population status, and artificial propagation techniques.
2. Identify and prioritize a list of research and management questions that need to be answered to enhance the success of lake sturgeon restoration efforts.
3. Foster communication among lake sturgeon managers and researchers in the Great Lakes basin by providing an opportunity for formal and informal interactions.
4. Develop a report on the workshop proceedings for the GLFT that can be used to guide future funding decisions.

Presentation and Discussion Summaries

Following a review of the goals and objectives, the workshop focused on four thematic areas: fish passage, habitat constraints throughout the life cycle, population assessment tools, and artificial propagation. The time allotted to each thematic area began with presentations to ground participants in the current research related to lake sturgeon in that area. Facilitated discussions followed, allowing participants to ask questions of the presenters, share their perspectives, and raise important issues and research questions. While each thematic area was discussed independently, participants quickly pointed out connections among the areas and identified several cross-cutting areas of research.

Fish Passage

Lake Sturgeon Passage Systems and Issues—Ron Bruch

Bruch reviewed what is known about the needs and behaviors of lake sturgeon in river systems, including low recruitment and population growth rates, lack of spawning site fidelity, and need for several discrete habitat types within river systems. He described several types of upstream fish passage systems using metrics including cost, flow, slope, the number of spawning sturgeon passed per year, and cost per lake sturgeon passed. Of the systems described, the upstream projecting fishway at Eureka Dam on the Upper Fox River in Wisconsin passed the highest percentage of lake sturgeon and cost the least per fish passed. The fish elevator on the Menominee River in Michigan had the highest cost per fish passed, while two methods—capture and transfer—and the vertical slot fishway at St. Ours Dam in Quebec achieved the lowest percentage of lake sturgeon passage.

Bruch also described an evaluation of downstream sturgeon passage through dam spillways at the Shawano Paper Mill and Balsam Row Dams on the Wolf River in Wisconsin. This study found high rates of sturgeon passage downstream; 88 percent of fish observed passed through the first dam, and more than 71 percent passed through the second dam. The survival rate of fish that passed downstream through the dam was 99 percent. The study also found that juvenile (fingerling and yearling) sturgeon can successfully pass downstream in high numbers. Ninety-three to 100 percent of fingerling sturgeon survived being released into the dam turbines, as well as 91 to 98 percent of yearlings.

Bruch emphasized the need to consider fish passage needs on a case-by-case basis, evaluating the population status and habitat availability both above and below the barrier. He also urged participants to understand the cost effectiveness of different types of passage systems and to mimic patterns found in nature. Finally, he presented a list of questions for consideration when building fish passage systems, including the current system-specific population status of lake sturgeon and management objectives, the habitat quality, quantity and distribution, potential invasive species issues, and the long-term impact of passage on the sturgeon population.

Identifying Lake Sturgeon Passage Research Priorities—Kevin Kappenman

Kappenman shared design criteria for nature-like and technical fish passage systems, including slope, velocity profile, turbulence, and baffle spacing. He related his experience working on passage for pallid sturgeon, which are listed under the Endangered Species Act and therefore have well-understood criteria for flow, velocity, and channel depth in fish passage systems. Kappenman emphasized the importance of using standardized techniques to assess and monitor passage efficiency, including monitoring the approach, attraction, entrance, and exit.

In discussing research needs for fish passage, Kappenman asked workshop participants to consider developing guidelines for fishway designers who are developing passage systems for lake sturgeon, including all components of the fishway. For example, he noted that sturgeon find passage up turbulent rivers to be difficult, but that researchers and fishway designers do not know how much or what type of turbulence can be allowed in structures that successfully pass lake sturgeon. Other design constraints, like boulder or baffle spacing and minimum orifice size, are also unknown.

Discussion

Following the two presentations, workshop participants discussed research needs related to fish passage for lake sturgeon. Participants agreed that the evaluation of passage systems is important and that the data are currently insufficient to help managers prioritize where to install passage systems. Many participants were enthusiastic about the idea of developing engineering guidance for fishways but also noted that research on sturgeon behavior would need to be conducted to provide a factual basis for this guidance. Participants discussed the challenge of invasive sea lamprey in the Great Lakes region, especially since sea lamprey and lake sturgeon spawn in the same rivers. They emphasized the importance of creating fish passage for lake sturgeon that can exclude sea lamprey. Sturgeon habitat use was also discussed, as research shows that patterns of sturgeon movement between riverine and lake habitats are more complex than previously thought.

Habitat Constraints Throughout the Life Cycle

Lake Sturgeon—Habitat Constraints—Robin DeBruyne, Scott Colborne, and Dimitry Gorsky

The presenters reviewed key information about lake sturgeon habitat needs and constraints at each life stage, noting that movement is key to sturgeons’ ability to meet their habitat needs. Nonspawning adults were historically thought to spend their time in deeper parts of the Great Lakes, but more recent data show that they exhibit diverse movement patterns across rivers and the Great Lakes throughout the year. Presenters also highlighted the need for high adult survival rates to provide sufficient reproductive opportunities and for adult sturgeon to be able to exploit a variety of food sources if they can access them. However, little is known about some stressors affecting nonspawning adult sturgeon; for example, invasive species that precipitate changes in the food web or increase exposure to pathogens, and eutrophication that leads to harmful algal blooms, both of which could affect adult survival. The role that climate change could play in adult survival and habitat use is also unknown, and barriers such as dams might impede climate-induced range shifts in the Great Lakes. In addition, most nonspawning adult habitat use information exists at relatively coarse scales, which does not convey finer-scale habitat information about the habitat choices that lake sturgeon make.

For spawning adults—the best-studied sturgeon life stage—temperature range, substrate, and flow preferences are known, along with many historical spawning locations and use of artificial reefs. Presenters pointed out several remaining unknowns, including the longevity and value of reef use, spawning ecology in response to climate change, the lack of high-quality spawning habitat to use as a reference point, and several unresolved questions about potential shoal spawning subpopulations.

Far less is known about age-0 and younger sturgeon. Presenters noted that habitat selection and connectivity needs for these fish are unknown, along with what food resources they use and their recruitment variability. Climate change could also significantly impact very young sturgeon, but its effects on hatching success and nursery habitat availability have not been studied.

Juvenile sturgeon are known to use a broad range of habitats, which are highly influenced by flow rate and the available prey community. Habitat disturbances, including dredging, shipping, and the accumulation of dreissenid mussels on feeding grounds, likely affect juvenile habitat use but have not been studied. Furthermore, habitat use may be system-dependent, and fine-scale information about habitat use throughout juvenile sturgeon development, as well as the characteristics of preferred feeding habitats and productive feeding grounds, is unknown.

Finally, the presenters discussed emerging concerns and research needs around sturgeon habitat use. They stated that the recent species status assessment (SSA) completed for lake sturgeon found low population resilience on the United States side of the Great Lakes, but it is not clear what habitat constraints led to this finding. They again highlighted the importance of new research into the potential effects of climate change on habitats at all life stages, as well as research into changing conditions like dressenid mussels and the increased probability of harmful algal blooms. They noted a particular need for more fine-scale research into habitat use, using telemetry methods combined with environmental assessments and monitoring, especially for juveniles and nonspawning adults.

Discussion

Juvenile Habitat

A discussion among all participants followed this presentation, beginning with a conversation about research needs for juvenile sturgeon habitat use. Participants agreed on the importance of telemetry studies to obtain baseline data on juvenile habitat use and to guide sampling efforts, particularly in areas where visual surveys are insufficient. They also briefly discussed combining telemetry with multibeam sonar to gain a better understanding of fine-scale habitat use, especially in deeper riverine systems. Participants pointed out the importance of understanding why juvenile sturgeon move both spatially and temporally. One participant suggested combining environmental variables with food availability in a map of the sampling area. Some workshop attendees also proposed that there may be more stages in the life of a sturgeon (regarding habitat use and behavior) than scientists and managers currently recognize. For example, researchers in Milwaukee Harbor observe juvenile sturgeon younger than five or six years and older than ten years but do not know how they use habitat in the intervening time. One attendee pointed out that age-length data for sturgeon indicate a diet shift when the fish reach 30 to 36 inches in length.

There was some discussion about how to define the juvenile life stage, but participants largely seemed to think that understanding differences in behavior was more important than defining age-based parameters for juveniles. Participants shared different perspectives about the importance of investing in research into juvenile sturgeon; one stated that sturgeon over one year of age are far more likely to survive than younger fish and suggested that the community's research focus should be on egg, larval, and age-0 sturgeon. Others thought that, although survival might be high, older sturgeon could still be limited by the availability of feeding or other types of habitat.

An attendee asked whether scientists know how overwintering habitat for juvenile sturgeon is changing as the climate changes. It is important to know where juveniles overwinter so that habitat can be protected if possible. Another possible effect of climate change on sturgeon is the lower dissolved oxygen in some parts of the Great Lakes and the more prolonged periods of low dissolved oxygen. This could influence the distribution of fish across the depth gradient or potentially limit the ability of young juveniles to find food.

Spawning and Adult Habitat

Participants noted that spawning habitat needs, while relatively well-known, are also complex. Because many adults are PIT tagged, it is possible to see where they are spawning, and this varies over years and with environmental conditions. In years when adults are spawning in many different places, there are more drifting larvae than in years when adults are spawning in only a few places. This highlights the need for sufficient and variable habitat to ensure that there are many places to spawn each year. Attendees pointed out that fish passage is tied to habitat use and that building more fish passage allows fish access to a greater variety of habitats. However, another participant stated that spawning concentrations can be helpful for small populations.

One attendee brought up the topic of fishing-related disturbance. Because concentrations of lake sturgeon may appear in areas where there are also concentrations of other fish, fishing disturbance could be high in those areas. It is unknown how or to what extent fishing for other species affects lake sturgeon, but understanding both where sturgeon aggregate and the effects of fishing could lead to regulations that benefit sturgeon.

Disturbance due to climate variability was also discussed; because sturgeon use increasing temperatures and decreasing water discharge as cues for when to spawn, they are generally spawning earlier in the year. Late snowstorms or heavy rainfall events are more likely to occur after spawning, which results in lower hatching rates. Recruitment is more variable across years when the climate is more variable. Partial solutions to this issue were discussed, including research into how much larger or older the population must be to avoid a net loss from recruitment variability, and whether it would be feasible to increase stocking during those years.

Participants discussed shoal spawning in lake sturgeon, with some pointing out that it has not been observed since the 1910s. Others noted that it would be difficult to see shoal spawning if it was happening, and that it has historically been observed, but it is hard to know how significant shoal spawning is to the population. A participant suggested that an important research avenue could be examining spawning on many historical spawning sites to determine whether sturgeon are reverting to the same sites as the population rebounds. Another participant stated that there would be a need for new tagged cohorts of fish to see if shoal spawning happens, since many of the current tags are past their battery life.

There are also uncertainties regarding wintering habitat for adult sturgeon; one attendee noted that the assumptions made in long-term studies of fish from the Manistee River do not match current acoustic telemetry data, so researchers are unsure what habitat adult fish are using between spawning bouts. Participants discussed fall mortality from botulism in adult sturgeon populations, noting that the prevalence of botulism appears to depend on prey distribution, and they agreed that a botulism index would be helpful.

Attendees discussed the existence of reviews of spawning habitat projects in the Great Lakes basin. Several project-specific papers have been written; some attendees thought a synthesis paper covering many projects would be helpful. One expressed concern that artificial habitat structures might displace drifting larvae to habitats that make it harder for them to survive. Another noted that identifying which microhabitats spawning sturgeon select would help with habitat restoration projects, and that habitat restoration to encourage diverse, healthy prey communities would benefit sturgeon at all life stages.

Population Assessment Tools

Population Assessment Methods Review—Ed Baker

Baker reviewed population assessment methods, referencing the 2024 paper *A Review of the Assessment Techniques Used for Populations Monitoring at Different Life Stages of Sturgeons* by Haxton, Gessner, and Friedrich as a comprehensive look at the topic. First, he highlighted important considerations in assessment design, including the objective of the sampling, the sturgeon life stage to be sampled, and the site characteristics of the sampling area. Taking each life stage in turn, he discussed assessment techniques specific to that stage: egg mats for eggs, drift sampling for larvae, electrofishing for juveniles, and many others. He also spoke about the use of remote sensing techniques, including side-scan sonar, PIT tagging, and acoustic telemetry to determine the presence or absence of sturgeon, calculate indices of abundance, evaluate stocking outcomes, and characterize habitat use.

Baker highlighted several research needs around population assessment. He stated that PIT tagging is the technology that most hatcheries use in stocked lake sturgeon so that later surveys can use the tags to evaluate stocking success. Historically, it was thought that the rate of PIT tag loss was relatively low, but new information suggests it might be higher than 50 percent. Because of this discrepancy, updated information about PIT tag loss rates is needed, along with information about how tagging techniques can be improved. Baker also noted that many population parameters, including abundance, survival, recruitment, population age, and longevity, along with some aspects of early life history, are not well understood, and that improved assessment techniques could shed light on these important attributes of sturgeon in the Great Lakes.

Status of Lake Sturgeon Genetics—Amy Welsh

Welsh reviewed past and current uses of genetic data to assess lake sturgeon population parameters, focusing on the application of microsatellite data to evaluate stocking programs, analyze genetic diversity, and determine parentage. She then discussed the more recent development of single nucleotide polymorphism (SNP) panels, which have been shown to assign individuals to populations more accurately than microsatellite data. Finally, Welsh highlighted potential future uses of lake sturgeon genetic information, including molecular sexing to determine population sex ratios and movement differences, diet analysis through metabarcoding, disease monitoring, studying the mechanisms of imprinting, and epigenetics.

Discussion

PIT Tags

A discussion among all participants followed these two presentations, beginning with questions about PIT tag loss. Participants noted that tag loss does not appear to be related to year class, but that some evidence suggests that ten millimeter tags are less likely to be lost than 12 millimeter tags. One participant expressed surprise that PIT tag arrays showed some sturgeon using rivers where they did not originate. Baker pointed out that this is likely not the case across the Great Lakes, but that this phenomenon is more common in rivers around Green Bay that drain the same geology. Another noted that subadult stocked fish seem to move between rivers more than subadults from remnant populations. Some participants expressed enthusiasm for a central database of PIT tag information.

One participant asked whether PIT tag data could be matched with genetic information. Participants noted that programs collect genetic material in the form of a fin clip from all stocked fish but that there is no centralized location where this material or the data from it is stored. The cost of getting genetic information from a fin clip varies significantly depending on how many markers are analyzed, the question asked, and the lab processing the samples. Participants agreed that understanding PIT tag loss is important.

Population Trends

One participant asked whether it is more important to know population size or trajectory. Others stated that abundance is important because of the restoration targets set by agencies to consider the population recovered, but that the recent SSA demonstrated how much remains unknown about both population abundance and trajectory, along with carrying capacity and other metrics. Another participant asked whether some metrics could be used to address gaps on a multisystem basis. Some participants noted the high cost in time and money of this approach; this brought up the topic of rapid assessment methods. Participants thought that a rapid assessment tool that is transferable between systems would be a high research priority because recovery plans rely on assessing population abundance and trajectory.

Participants discussed techniques for studying juvenile population trends because juvenile trends can provide managers data without needing to wait for the fish to mature. Participants observed that researchers and managers do not use consistent techniques for population assessment throughout the basin. However, some research has shown differences between lakes in terms of how well techniques work; for example, juveniles may be more widespread in Lake Erie, which is relatively shallow, and more concentrated in certain areas (and thus more vulnerable to fishing gear) in Lake Superior and Lake Michigan. This brought the conversation to the importance of acoustic telemetry, which can help researchers locate fish in deeper water than where they are able to set nets.

Genomic Tools

Participants briefly discussed SNP and microsatellite data, noting that genetic data from one sample can be used for both techniques. SNPs further allow researchers to use a smaller sample size in their analysis because there are a large number of potential SNP markers in each sample.

Genetic techniques can be used to locate hotspots that attract individuals from many populations. One participant said that hotspot location could be important if researchers are able to uncover what draws sturgeon to those regions.

One participant suggested using simulation modeling to assess some assessment tools. Another noted the possibility of using genomic tools to examine population resilience under climate change, with the goal of identifying which populations will be most vulnerable. Epigenetic research in fish has mostly been conducted in labs rather than on wild populations, but it has the potential to eventually help answer questions like this.

A short discussion of eDNA followed, with participants wondering whether eDNA can detect spawning populations and whether the presence of adult versus larval fish could be detected through eDNA. Some agencies are using eDNA to confirm whether there are sturgeon in a river, but participants were unsure if they could distinguish between adult and juvenile fish. One participant noted that testing for eDNA can take significant effort and that it can be challenging to interpret the results, and others called for more research on how to determine whether a sample containing eDNA is a false positive.

Technological Needs

One participant encouraged the group to look for opportunities in fish technology, saying that very little of the technology that biologists use in the field has been purpose-built for fisheries. For example, a fish finder that could detect spawning behavior through the movement of an individual sturgeon could be helpful in deep or turbid environments. In addition, participants noted that alternative ways to determine fish age could be helpful, which is a potential avenue for epigenetic research or research into the microchemistry of fin rays. The discussion concluded with one participant encouraging others to use mortality data from commercial fisheries to supplement data from other sources.

Artificial Propagation

Tribal Cultural Importance of Nmé and Propagation—Archie Martell

Martell explained the cultural importance of nmé (lake sturgeon) to the Anishinabek people and the Little River Band of Ottawa Indians (LRBOI) in particular, both as a source of food and as a symbol of their culture. He quoted tribal members who said that the decline of nmé coincided with the decline in families belonging to the sturgeon clan, and that bringing the fish back means bringing back their cultural heritage. He also described the importance of the connection between the tribe and the fish and the importance of nmé restoration to tribal healing and sovereignty. LRBOI's management goal is to restore the population of nmé to pre-1836 levels or to the current carrying capacity of the Big Manistee River. Toward this goal, LRBOI maintains streamside rearing facilities for young nmé that keep the fish in their natal water, which increases the likelihood of imprinting on the river. Production of nmé in streamside rearing facilities also helps supplement the recruitment of wild populations and provides a source of fish to reintroduce to systems where they have been extirpated. LRBOI's streamside operation is one of several around the Great Lakes, and they host nmé release events, which are open to the public every year.

Black River Streamside Rearing Facility—Doug Larson

Larson summarized work that has been done on lake sturgeon at the Black River Streamside Rearing Facility, including advantages of streamside rearing such as imprinting and spawning site fidelity, flexibility, and the ability to use wild-captured broodstock, as well as disadvantages such as the remote locations of most streamside rearing facilities and sediment from the use of surface water. He addressed the genetic benefits of capturing and raising drifting sturgeon larvae instead of collecting gametes from captive adult fish: drifting larvae have lower relatedness than fish produced through direct gamete collection. However, drifting larvae cannot be disinfected in the same way that eggs can, so sturgeon in hatcheries that were captured as drifting larvae may be more vulnerable to disease outbreaks. He detailed an experiment by Kimmel et al. (funded by the GLFT) in which young sturgeon were exposed to different sources of water to evaluate whether they exhibited imprinting on their natal water. The experiment found that lake sturgeon exposed to certain water sources during early life stages are attracted to those sources (as shown by their movement patterns) later in life.

Larson reviewed research on the best feeding practices and prescriptions for streamside-reared juveniles. Survival was highest when fed live feeds, and it is difficult to transition between foods. Feeding is most efficient when done episodically early in life. He also reviewed the available information on sex bias in hatchery facilities, which found that streamside facilities release approximately a 50:50 ratio of male to female sturgeon. Larson concluded that most of the streamside rearing community's information needs regarding feeding and sex ratios have been fulfilled.

Fish health, Larson stated, is less well understood in streamside facilities and is an area of emerging interest. A novel herpesvirus has been isolated from sturgeon in Black Lake, and researchers found that mortality in exposed fish is high. Larson noted that most streamside facilities experience mortality events in the middle of the summer and that, while disease could be the cause, he does not have the tools to address these events or to find out the cause. The streamside facility has determined that the best way to reduce mortality is to grow fish faster, which has led to lower mortality rates over the past two years.

Egg disinfectants have been found to be effective in killing viruses, including the novel herpesvirus. However, as previously stated, these are not available for use in facilities that use drifting larvae as their broodstock. Treatments for dealing with diseases in the hatchery are largely unavailable, but gear disinfection is available and somewhat effective at reducing disease.

Artificial Propagation—Orey Eckes

Eckes stated that many of the questions around artificial propagation have been answered. He discussed the choice of broodstock source, whether collecting gametes from spawning fish in the wild (which is highly uncertain and dependent on weather and location) or broodstock collection and induction (which requires significant time and infrastructure). He detailed some newer technologies involved in induction, including advances in ultrasound technology for determining a fish's sex, egg extraction, and hormones that can be injected to assist in gamete collection.

Eckes also discussed the genetic considerations in propagation and stocking, stating that there is a shift in hatcheries to stock fewer fish from a given year class with more adults contributing gametes, thereby maximizing the number of parents for each generation. However, this leads to space constraints in the hatcheries, as current best practices are to keep different strains separate during the first part of the life cycle. He noted that many streamside facilities, which tend to be smaller than traditional hatcheries, cannot meet stocking objectives with their current capacities, but expansion is difficult and expensive.

Eckes raised issues regarding fish rearing densities, noting that higher densities lead to slower growth and more risks to fish health, and the hatchery's goal is to get the fish to be as big as possible before stocking them because bigger size leads to higher survival rates. He also discussed the problem of "surplus fish" from hatcheries. Options include culls and stocking fish early, without tags or markings. Early stocking requires a 30-day fish health certificate and a decision on how many fish should be stocked. Eckes opined that these issues should be written into management plans, so decision-makers and partners can take them into consideration.

With more demand for stocking, Eckes noted that it is not clearly understood how many tributaries can or should be stocked with fish from a single year class; hatcheries also may have difficulty meeting the requests for eggs that they receive. For example, the Wisconsin Department of Natural Resources received requests for gametes from eight different organizations in one year.

Hatcheries could benefit from more cost-effective methods of feeding sturgeon in hatcheries; sturgeon are picky eaters and traditional diets (brine shrimp, krill, and bloodworms) mimic wild diets but are very expensive. Formulated diets are cheaper but lead to lower survival rates. Eckes asked whether it would be possible to raise sturgeon in hatcheries without bloodworms, and suggested further research into the heavy metal and other contaminant content of bloodworms.

Survival increases with stocking size; according to one study, when sturgeon are stocked at a length of about 18 cm, 80 percent survive. However, little is known about how the location of stocking influences survival rates, or whether traditional hatchery and streamside-raised juvenile sturgeon have similar survival rates. Eckes pointed out that management decisions rely heavily on the estimated survival rates of stocked sturgeon, so more research into location-specific and facility-specific survival could change how sturgeon are managed. He mentioned an ongoing experiment to test whether streamside-raised sturgeon have higher site fidelity (a proxy for imprinting) than sturgeon from a traditional hatchery. In this experiment, scientists release equal numbers of juvenile sturgeon raised in each type of hatchery into the Maumee River. When these fish begin to return to rivers to spawn, they will be able to evaluate whether one group has higher site fidelity than the other, providing managers with valuable insight into the benefits of the different types of hatcheries.

Finally, Eckes noted that reproductive-aged fish with hatchery origins have been observed spawning in some rivers. This provides research opportunities including looking at the success of hatchery fishes' offspring.

Discussion

Disease

The discussion following these presentations began with participants talking about fish health studies that could isolate the causes of hatchery mortality events. Some mortality events in hatcheries happen around the same time each year and in multiple hatcheries, but it is unknown whether mortality events happen in the wild at the same time. The die-offs in hatcheries do not appear to be density-dependent, and several managers agreed that more studies of herpes viruses in sturgeon could be helpful. It is also unknown whether transmission of disease in sturgeon is primarily vertical (parent to offspring) or horizontal (between conspecifics).

Feeding

One manager shared that his hatchery uses formulated feed relatively successfully, with about 50 percent survival and larger fish at the point of stocking. The feed is more cost-effective than the standard diet and allows for the use of automatic feeders so that fish can eat a small amount of feed more frequently, even when hatchery staff are not present (which is currently not possible using the traditional diet). Another manager raised the question of whether there is a genetic component to survival on formulated feed, and if hatcheries could lose rare alleles in the stocked populations by using this feed. Because growth rate in sturgeon is known to be heritable, there is potential for feeding habits to be heritable as well. If research is designed to study sturgeon survival on formulated feeds, the family of each fish should be considered in the analysis. One participant suggested isolating amino acid profiles of naturally produced juvenile sturgeon so that a feed matching those profiles could be formulated. Another noted the importance of making sure fish can convert from feed to a wild diet.

Imprinting
The discussion moved to imprinting and whether river water could be used in traditional hatcheries. Because memory imprinting has been shown to happen early in the sturgeon life cycle, fish could potentially be raised in river water early on and then moved to a more traditional hatchery system later. Participants discussed whether this system would work, and whether it might be applicable across river systems. Several noted that, because of questions like this, it would be beneficial to have a community of streamside facility managers who could meet to share issues and advice, and to coordinate research needs.

Research Priority Survey

Following the workshop, GLFT staff and the Great Lakes Lake Sturgeon Coordination Committee used the future research questions identified during the workshop as the basis for a survey to determine the relative importance of each question. The survey was sent to all 26 participants in the workshop and received 19 responses, a healthy response rate but a small overall sample size. Because of the small sample size, survey results should be interpreted with caution.

Survey respondents were asked to rank the importance of each question within the topic areas used in the workshop as well as within an “Other” category (Exhibits 1-5). Because there are different numbers of questions in each category, the importance of questions cannot be compared across categories and is intended solely to gauge relative importance within each category. Participants were asked to choose the five most important questions, regardless of topic area, and to rank those five in order of importance. This exercise allows for comparison of the importance of questions across topic areas and resulted in one research priority—investment in acoustic telemetry to assess populations and habitat use—being ranked in the top five by 69 percent of respondents. Survey respondents were also asked to rank the topic areas in order of importance for sturgeon restoration. Answers to this exercise indicated that the two most important topic areas for restoration (habitat use and population assessment) were also the topic areas from which the most important research questions came.

Survey Results: Questions Within Each Topic Area

Fish Passage

Respondents were asked to rank five research questions related to fish passage in order of importance. Exhibit 1 shows the questions and their average rankings; lower numbers represent higher importance in this survey. More than half of the questions in this section scored between two and three, indicating a lack of consensus among respondents regarding which question is the highest priority, while the lowest priority question was clearer.

EXHIBIT 1. Relative Importance of Research Questions on Fish Passage

Research Question—Fish Passage	Average Ranking*
4. What attributes characterize fish passage projects where fish regularly pass upstream and successfully spawn? How can passage systems be built that allow sturgeon to move upstream and exclude sea lamprey?	2.2
5. On what types of sites should fish passage structures be built for lake sturgeon and what criteria could be used to determine the type of passage system that should be built?	2.5
2. On sites where passage has been built, to what extent are fish passing upstream and successfully spawning when they get there?	2.7
1. On sites where dams have been removed, to what extent are fish passing upstream and successfully spawning when they get there?	3.2
3. What are the effects of climate change (flood and low water years) on sturgeon use of fish passage structures?	4.4

*Lower numbers indicate that more respondents thought the topic was important
Source: GLFT survey

Habitat Constraints Throughout the Life Cycle

In this section, respondents ranked 11 questions in order of importance (Exhibit 2). The highest average ranking was 4.35 (“How does habitat use vary with size and age?”), and six questions scored between five and six, again indicating a lack of consensus among respondents regarding the higher-scoring questions, with more consensus about which questions were the least important.

EXHIBIT 2. Relative Importance of Research Questions on Habitat Constraints Throughout the Life Cycle

Research Question—Habitat Constraints Throughout the Life Cycle	Average Ranking*
8. How does habitat use vary with size and age?	4.35
12. How might the quantity, quality, and spatial distribution of habitats limit the recovery of lake sturgeon (Daugherty et al. 2008)?	4.75
14. At sites where spawning habitat has been created or restored in the Great Lakes, what are the spawning, hatching, and recruitment rates?	5
16. What type of spawning sites/habitats does recruitment come from?	5.25
11. Can habitat suitability models be used to predict the success of reintroduction efforts?	5.35
15. In areas where artificial habitat structures have been built, how are drifting larvae distributed and what are their recruitment rates? What microhabitats are fish selecting when it comes to spawning hotspots?	5.4
6. How does habitat use vary seasonally?	5.7
7. How often and to what extent do mature and juvenile fish move between tributaries?	5.9
10. What are the effects of fishing, dredging, or other disturbances on spawning and habitat use?	6.4
13. How does low dissolved oxygen affect fish distribution? Does low dissolved oxygen limit the ability of young juveniles to find food?	8.75
9. What was/is the distribution of juvenile sturgeon before, during, and after round goby invasion?	9.15

*Lower numbers indicate that more respondents thought the topic was important
Source: GLFT survey

Population Assessment Methods

Respondents were asked to rank eight questions related to population assessment methods in order of importance, from most to least important (Exhibit 3). Rankings in this section again showed little consensus regarding the order of the higher-ranked questions and greater certainty about which questions are least important.

EXHIBIT 3. Relative Importance of Research Questions on Population Assessment Methods

Research Question—Population Assessment Tools	Average Ranking*
19. What are the survival rates for various life stages, both in terms of abundance and trajectory?	3.42
23. Investment in acoustic telemetry to assess populations and habitat use (especially in deeper water)	3.84
22. What techniques can be used to consistently evaluate juvenile populations, including determining fish age?	4.16
21. What techniques can be used to develop a rapid sturgeon assessment that is comparable across lake or river systems?	4.79
17. What are the rates of PIT tag retention in juvenile sturgeon?	4.95
18. What are the standard operating procedures for the process of using genetics for population assessments in the Great Lakes?	5
20. What metrics of population size can be applied across systems?	5.11
25. How reliable is eDNA as a method for detecting the presence or absence of spawning sturgeon?	6.63
24. To what extent can simulation modeling be used to compare and evaluate various assessment methods?	7.11

*Lower numbers indicate that more respondents thought the topic was important
Source: GLFT Survey

Artificial Propagation

Within this section, respondents were asked to rank four questions, and all four ranked within 0.53 of one another (Exhibit 4), indicating a lack of consensus among the group regarding their top priorities.

EXHIBIT 4. Relative Importance of Research Questions on Artificial Propagation

Research Question—Artificial Propagation	Average Ranking*
29. At what age do fish imprint on their natal water? If fish are raised past the imprinting age in streamside facilities and then moved to traditional hatcheries, what is their rate of return to their natal streams?	2.21
27. What mortality events for juvenile sturgeon occur in the wild and how do they compare to the mortality events seen in rearing facilities?	2.42

Research Question—Artificial Propagation	Average Ranking*
26. What can we do to improve fish health in rearing facilities?	2.63
28. What are the best methods for feeding fish in rearing facilities, and what is the best type of feed? How could the amino acid profiles from genetic data help formulate feed?	2.74

*Lower numbers indicate that more respondents thought the topic was important
Source: GLFT survey

Other

Several research questions were raised that did not fit within any of the topic areas of the workshop. For the purposes of the survey, these questions comprised the topic area "Other" and primarily deal with issues around climate variability and climate change. Respondents were asked to rank five questions in this section (Exhibit 5), and there appeared to be some agreement regarding the most important question, while the two ranked the least important had scores relatively close to one another.

EXHIBIT 5. Relative Importance of Research Questions on Other Topics

Research Question—Other	Average Ranking*
30. How do historical presence/absence data for sturgeon compare to historical and present-day spawning data? What genetic, physiological, or behavioral differences are there between remnant versus artificially reared populations?	2
33. How many more sturgeon would need to be stocked to make up for the loss of natural reproduction due to climate variability?	2.83
31. Are there physiological/behavioral differences in southern-edge populations compared to northern populations?	3
32. How much larger or older does the population have to be to not have net loss from climate variability?	3.5
34. How can epigenetics be used to identify sturgeon populations that are more or less vulnerable to climate change?	3.67

*Lower numbers indicate that more respondents thought the topic was important
Source: GLFT survey

Survey Results: Top Five Questions

Respondents were asked to choose the five most important questions from a list of all research questions, regardless of topic area, and then rank those five questions in order of importance (Exhibits 6–8). One research priority emerged among the top five questions for 69 percent of respondents: the need for more investment in acoustic telemetry to assess populations and habitat use. Four questions appeared in 31–32 percent of respondents' top five questions (Exhibit 6). Questions that are not included in Exhibits 6–8 were not included in the top five most important by any survey respondent.

EXHIBIT 6. The Ten Questions Appearing Most Often in Survey Respondents' Top Five Most Important Questions

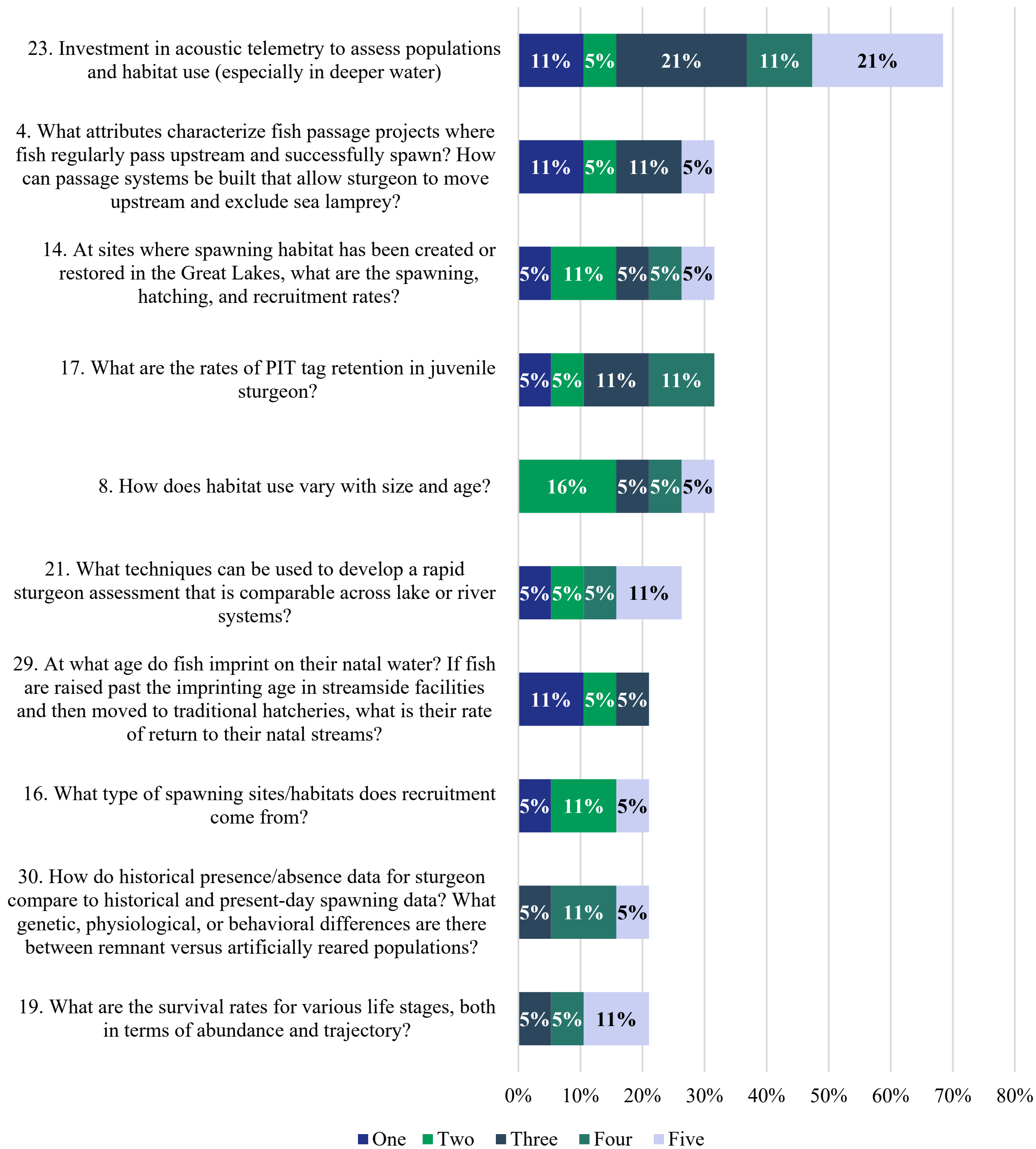


EXHIBIT 7. The Questions Ranked 11–20 in Order of Appearance in Survey Respondents' Top Five Most Important Questions

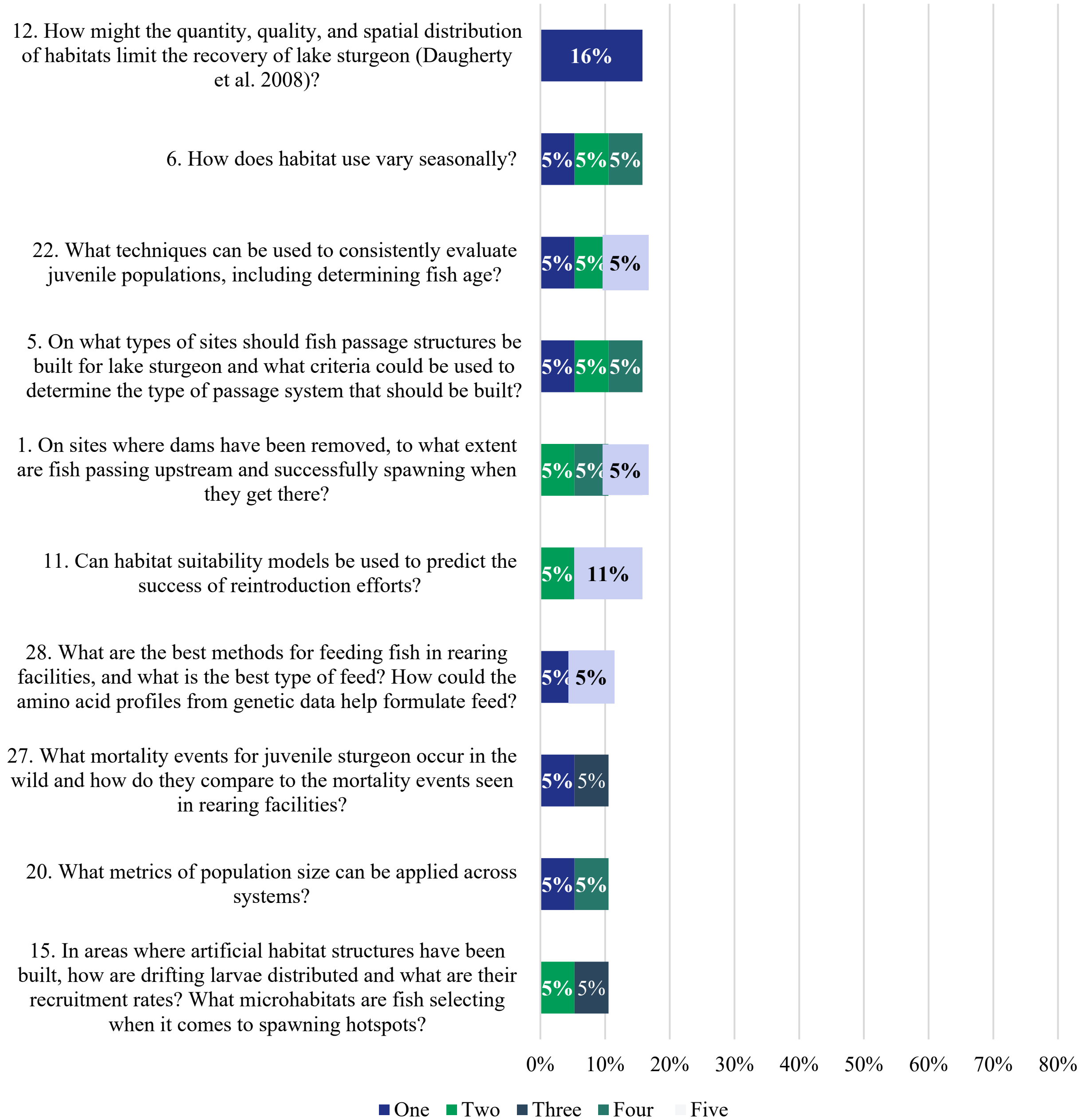
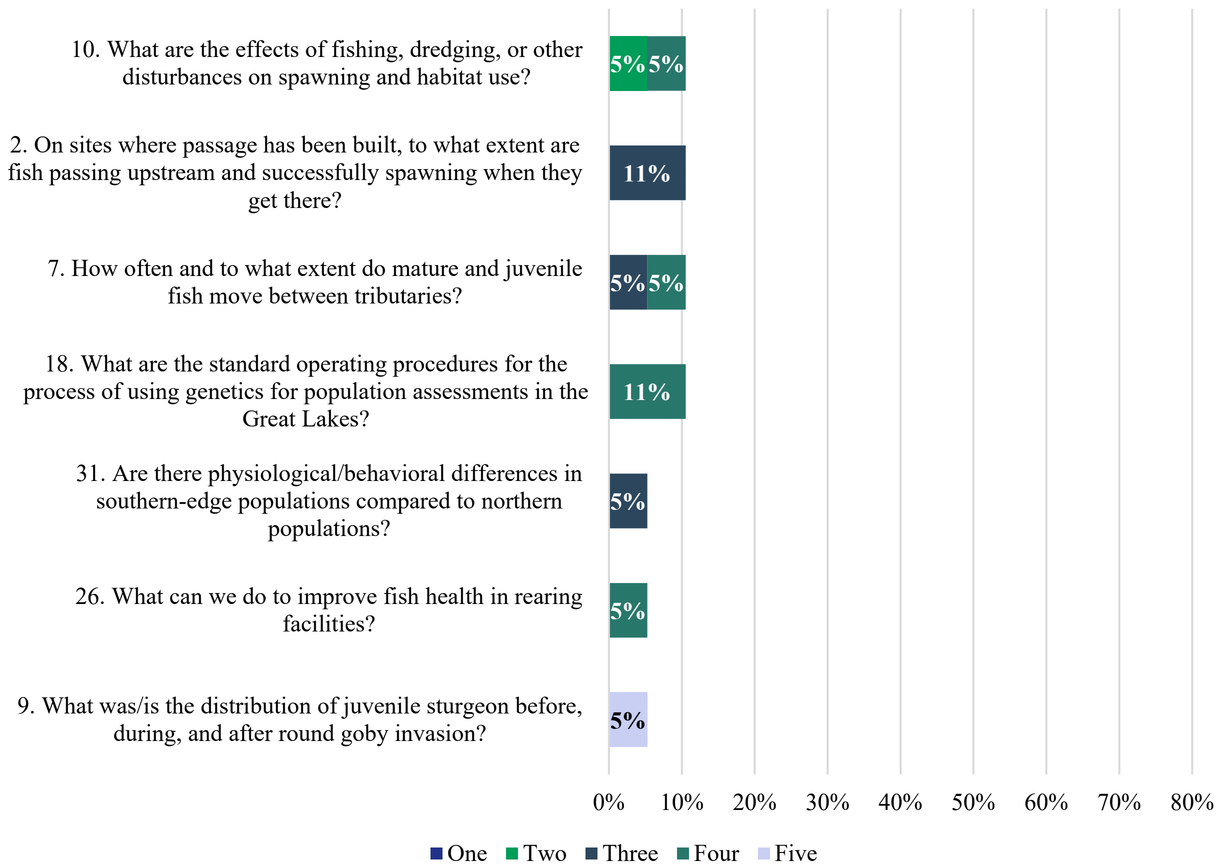


EXHIBIT 8. The Questions Ranked 21–27 in Order of Appearance in Survey Respondents' Top Five Most Important Questions



Source: GLFT survey

Survey Results: Ranking the Topic Areas by Importance to Future Restoration Efforts

Respondents were asked to rank the importance of each topic area from the workshop, as well as the "other" topic area, to future sturgeon restoration efforts. The results of this question are shown in Exhibit 9. The two most important topic areas (habitat constraints and population assessment methods) ranked close to one another, with a larger spread between the two least important areas.

EXHIBIT 9. Relative Importance of Each Topic Area to Future Lake Sturgeon Restoration Efforts

Topic Area	Average Ranking*
Habitat constraints throughout the life cycle	2
Population assessment methods	2.06
Artificial propagation	2.94
Fish passage	3.28
Other	4.72

*Lower numbers indicate that more respondents thought the topic was important.
Source: GLFT survey

In 2020, the GLFT fielded a lake sturgeon research survey to practitioners across the Great Lakes, asking them to identify which topic areas were the most important for research funding. Respondents to this survey indicated that fish passage was the most important topic for research funding, followed by the effectiveness of management plans and activities, and habitat constraints.

There are several possible reasons why fish passage was considered the most important topic for research funding in the 2020 survey, but less important for future restoration efforts in the present survey. First, seeing that fish passage is expensive and difficult to build or evaluate, participants may have concluded that better understanding of sturgeon habitat use and habitat restoration could be more effective in advancing sturgeon recovery. Second, the presentations in this workshop, by highlighting the many aspects of sturgeon habitat use that remain unknown, may have influenced the results of the survey. Third, the change in the wording of the question from the 2020 survey to the 2025 survey—the 2020 survey asked about the importance of each topic for research funding and the 2025 survey asked about the importance of the topic to restoration efforts—may have confounded the results. Fourth, the 2020 survey had a larger sample size with a different composition. Because of all these differences, care should be taken in interpreting and comparing the results of the two surveys.

Next Steps

The GLFT has incorporated, and will continue to incorporate, the results of this workshop into its Ecological and Biological Research to Inform Management program. This document will be distributed to the workshop attendees and the Great Lakes Lake Sturgeon Coordination Committee.

Appendix A: Workshop Attendees

Workshop Attendees

Aaron Schiller, Wisconsin Department of Natural Resources
Amy Welsh, West Virginia University
Andrew Briggs, Michigan Department of Natural Resources
Archie Martell, Little River Band of Ottawa Indians
Brad Eggold, Wisconsin Department of Natural Resources
Carl Ruetz, Grand Valley State University
Corey Jerome, Little River Band of Ottawa Indians
Dawn Dittman, United States Geological Survey
Dimitry Gorsky, United States Fish and Wildlife Service
Doug Larson, Michigan State University
Ed Baker, Michigan Department of Natural Resources
Erik Olsen, Grand Traverse Band of Ottawa and Chippewa Indians
Gary Michaud, Little Traverse Bay Band of Odawa Indians
Jay Wesley, Michigan Department of Natural Resources
Justin Chiotti, United States Fish and Wildlife Service
Kevin Kappenman, United States Fish and Wildlife Service
Kevin Kapuscinski, Lake Superior State University
Kim Scribner, Michigan State University, Emeritus
Margaret Stadig, Wisconsin Department of Natural Resources
Marty Holtgren, Encompass LLC
Orey Eckes, United States Fish and Wildlife Service
Robert F Elliot, United States Fish and Wildlife Service, retired
Robin DeBruyne, United States Geological Survey
Ron Bruch, Wisconsin Department of Natural Resources, retired
Scott Colborne, Michigan State University
Susan Wells, United States Fish and Wildlife Service

Appendix B: Survey Questions

The sturgeon workshop research questions fall into five topic areas: fish passage, habitat constraints, population assessment, artificial propagation, and other.

Please drag and drop the topics below to put them in order from most important to least important as they relate to lake sturgeon restoration efforts.

a. Fish passage

b. Habitat constraints

c. Population assessment

d. Artificial propagation

e. Other

On the following pages, each topic area is listed with associated research questions. For each topic area, please drag and drop the research questions to rank them from most important to least important as they relate to lake sturgeon restoration efforts.

Fish Passage

Drag and drop the following research questions to rank them from most important to least important as they relate to lake sturgeon restoration efforts.

1. On sites where dams have been removed, to what extent are fish passing upstream and successfully spawning when they get there?
2. On sites where passage has been built, to what extent are fish passing upstream and successfully spawning when they get there?
3. What attributes characterize fish passage projects where fish regularly pass upstream and successfully spawn? How can passage systems be built that allow sturgeon to move upstream and exclude sea lamprey?
4. What are the effects of climate change (flood and low water years) on sturgeon use of fish passage structures?
5. On what types of sites should fish passage structures be built for lake sturgeon, and what criteria could be used to determine the type of passage system that should be built?

Habitat Constraints

Drag and drop the following research questions to rank them from most important to least important as they relate to lake sturgeon restoration efforts.

1. How does habitat use vary seasonally?
2. How often and to what extent do mature and juvenile fish move between tributaries?
3. How does habitat use vary with size and age?
4. What was/is the distribution of juvenile sturgeon before, during, and after round goby invasion?
5. What are the effects of fishing, dredging, or other disturbances on spawning and habitat use?
6. Can habitat suitability models be used to predict the success of reintroduction efforts?
7. How might the quantity, quality, and spatial distribution of habitats limit the recovery of lake sturgeon (Daugherty et al 2008)?
8. How does low dissolved oxygen affect fish distribution? Does low dissolved oxygen limit the ability of young juveniles to find food?
9. At sites where spawning habitat has been created or restored in the Great Lakes, what are the spawning, hatching, and recruitment rates?
10. In areas where artificial habitat structures have been built, how are drifting larvae distributed and what are their recruitment rates? What microhabitats are fish selecting when it comes to spawning hotspots?
11. What type of spawning sites/habitats does recruitment come from?

Population Assessment

Drag and drop the following research questions to rank them from most important to least important as they relate to lake sturgeon restoration efforts.

1. What are the rates of PIT tag retention in juvenile sturgeon?
2. Standard operating procedures/cookbook on the process for using genetics for population assessments in the Great Lakes
3. What are the survival rates for various life stages, both in terms of abundance and trajectory?

4. What metrics of population size can be applied across systems?
5. What techniques can be used to develop a rapid sturgeon assessment that is comparable across lake or river systems?
6. What techniques can be used to consistently evaluate juvenile populations, including determining fish age?
7. Need investment in acoustic telemetry to assess populations and habitat use (especially in deeper water)
8. To what extent can simulation modeling be used to compare and evaluate various assessment methods?
9. How reliable is eDNA as a method for detecting the presence or absence of spawning sturgeon?

Artificial Propagation

Drag and drop the following research questions to rank them from most important to least important as they relate to lake sturgeon restoration efforts.

1. What can we do to improve fish health in rearing facilities?
2. What mortality events for juvenile sturgeon occur in the wild and how do they compare to the mortality events seen in rearing facilities?
3. What are the best methods for feeding fish in rearing facilities, and what is the best type of feed? How could the amino acid profiles from genetic data help formulate feed?
4. At what age do fish imprint on their natal water? If fish are raised past the imprinting age in streamside facilities and then moved to traditional hatcheries, what is their rate of return to their natal streams?

Other

Drag and drop the following research questions to rank them from most important to least important as they relate to lake sturgeon restoration efforts.

1. How does historical presence/absence data for sturgeon compare to historical and present-day spawning data? What genetic, physiological, or behavioral differences are there between remnant versus artificially reared populations?
2. Are there physiological/behavioral differences in southern-edge populations compared to northern populations?

3. How much larger or older does the population have to be to not have net loss from climate variability?
4. How many more sturgeon would need to be stocked to make up for the loss of natural reproduction due to climate variability?
5. How can epigenetics be used to identify sturgeon populations that are more or less vulnerable to climate change?

Please select the five research questions you feel are most important to answer as they relate to lake sturgeon restoration efforts regardless of research topic.

1. On sites where dams have been removed, to what extent are fish passing upstream and successfully spawning when they get there?
2. On sites where passage has been built, to what extent are fish passing upstream and successfully spawning when they get there?
3. What attributes characterize fish passage projects where fish regularly pass upstream and successfully spawn? How can passage systems be built that allow sturgeon to move upstream and exclude sea lamprey?
4. What are the effects of climate change (flood and low water years) on sturgeon use of fish passage structures?
5. On what types of sites should fish passage structures be built for lake sturgeon, and what criteria could be used to determine the type of passage system that should be built?
6. How does habitat use vary seasonally?
7. How often and to what extent do mature and juvenile fish move between tributaries?
8. How does habitat use vary with size and age?
9. What was/is the distribution of juvenile sturgeon before, during, and after round goby invasion?
10. What are the effects of fishing, dredging, or other disturbances on spawning and habitat use?
11. Can habitat suitability models be used to predict the success of reintroduction efforts?
12. How might the quantity, quality, and spatial distribution of habitats limit the recovery of lake sturgeon (Daugherty et al 2008)?

13. How does low dissolved oxygen affect fish distribution? Does low dissolved oxygen limit the ability of young juveniles to find food?
14. At sites where spawning habitat has been created or restored in the Great Lakes, what are the spawning, hatching, and recruitment rates?
15. In areas where artificial habitat structures have been built, how are drifting larvae distributed and what are their recruitment rates? What microhabitats are fish selecting when it comes to spawning hotspots?
16. What type of spawning sites/habitats does recruitment come from?
17. What are the rates of PIT tag retention in juvenile sturgeon?
18. Standard operating procedures/cookbook on the process for using genetics for population assessments in the Great Lakes
19. What are the survival rates for various life stages, both in terms of abundance and trajectory?
20. What metrics of population size can be applied across systems?
21. What techniques can be used to develop a rapid sturgeon assessment that is comparable across lake or river systems?
22. What techniques can be used to consistently evaluate juvenile populations, including determining fish age?
23. Need investment in acoustic telemetry to assess populations and habitat use (especially in deeper water)
24. To what extent can simulation modeling be used to compare and evaluate various assessment methods?
25. How reliable is eDNA as a method for detecting the presence or absence of spawning sturgeon?
26. What can we do to improve fish health in rearing facilities?
27. What mortality events for juvenile sturgeon occur in the wild and how do they compare to the mortality events seen in rearing facilities?
28. What are the best methods for feeding fish in rearing facilities, and what is the best type of feed? How could the amino acid profiles from genetic data help formulate feed?

29. At what age do fish imprint on their natal water? If fish are raised past the imprinting age in streamside facilities and then moved to traditional hatcheries, what is their rate of return to their natal streams?

30. On sites where dams have been removed, to what extent are fish passing upstream and successfully spawning when they get there?

31. On sites where passage has been built, to what extent are fish passing upstream and successfully spawning when they get there?

32. What attributes characterize fish passage projects where fish regularly pass upstream and successfully spawn? How can passage systems be built that allow sturgeon to move upstream and exclude sea lamprey?

33. What are the effects of climate change (flood and low water years) on sturgeon use of fish passage structures?

34. On what types of sites should fish passage structures be built for lake sturgeon, and what criteria could be used to determine the type of passage system that should be built?

35. How does habitat use vary seasonally?

36. How often and to what extent do mature and juvenile fish move between tributaries?

Now, please rank those top five in order of importance.

Appendix C: Agenda

Great Lakes
Fishery Trust

Agenda

Lake Sturgeon Coordination Committee Meeting
Amway Grand Plaza, Emerald Meeting Room
187 Monroe Ave NW, Grand Rapids, MI 49503

Tuesday, August 13

Time	Agenda Item	Facilitator
12:00	Lunch	
1:00	Welcome	Susan Wells
1:15	Fish passage speakers	Kevin Kappenman Ron Bruch
1:45	Fish passage discussion	Susan Wells
3:00	Break	
3:15	Habitat constraints speakers	Robin DeBruyne Scott Colborne Dimitry Gorsky
3:45	Habitat constraints discussion	Susan Wells
5:00	Adjourn	
6:00-8:00	Reception at the B.O.B.	

Wednesday, August 14

Time	Agenda Item	Facilitator
7:00	Breakfast	
8:00	Convene	Susan Wells
8:05	Population assessment methods speakers	Ed Baker Amy Welsh
8:35	Population assessment methods discussion	Susan Wells
9:50	Break	
10:00	Artificial propagation speakers	Archie Martell Orey Eckes Doug Larson
10:30	Artificial propagation discussion	Susan Wells
11:30	Wrap-up	Jon Beard
12:00	Adjourn	
12:00	Lunch	

Appendix D: Great Lakes Fishery Trust Background

The Great Lakes Fishery Trust (GLFT) was created in 1996 as a result of a settlement agreement to mitigate the unavoidable fish losses from the operation of the Ludington Pumped Storage Plant (LPSP), a hydroelectric facility located on Lake Michigan near Ludington, Michigan, which is co-owned by Consumers Energy and DTE Energy utilities. Grant funds awarded under the agreement give preference to Lake Michigan projects. Since its inception, the GLFT has granted about $85 million with a focus on the following activities:

- Research directed at increasing the benefits associated with Great Lakes fishery resources
- Rehabilitation of lake whitefish, lake trout, lake sturgeon, and other fish populations
- Protection and enhancement of fisheries habitat, including Great Lakes wetlands
- Public education concerning the Great Lakes fisheries
- Provide public access to the Great Lakes fisheries

As provided in the settlement agreement, the GLFT was established as a private, nonprofit corporation directed by a board of trustees comprised of representatives from the Michigan Department of Natural Resources, the Office of the Michigan Attorney General, the Michigan National Wildlife Federation, Grand Traverse Band of Ottawa and Chippewa Indians, the Michigan United Conservation Clubs, and the U.S. Fish and Wildlife Service. Using funds derived from the settlement, the GLFT contracts administrative and management support services through Public Sector Consultants Inc., a firm based in Lansing, Michigan.

Mission and Vision Statements

The mission of the Great Lakes Fishery Trust is to enhance, protect, and conserve Great Lakes fishery resources to benefit all residents of Michigan.

The GLFT envisions a future where the Great Lakes support a vibrant and sustainable fishery for generations to come. This thriving fishery will serve the diverse needs of the Great Lakes community, providing nourishing food, ample and equitable access to recreational opportunities, employment, commerce, and the preservation of cultural heritage. The GLFT will cultivate and practice collaboration as it advances scientific research, protects and restores habitat, and enhances the health and vitality of the fishery for all.

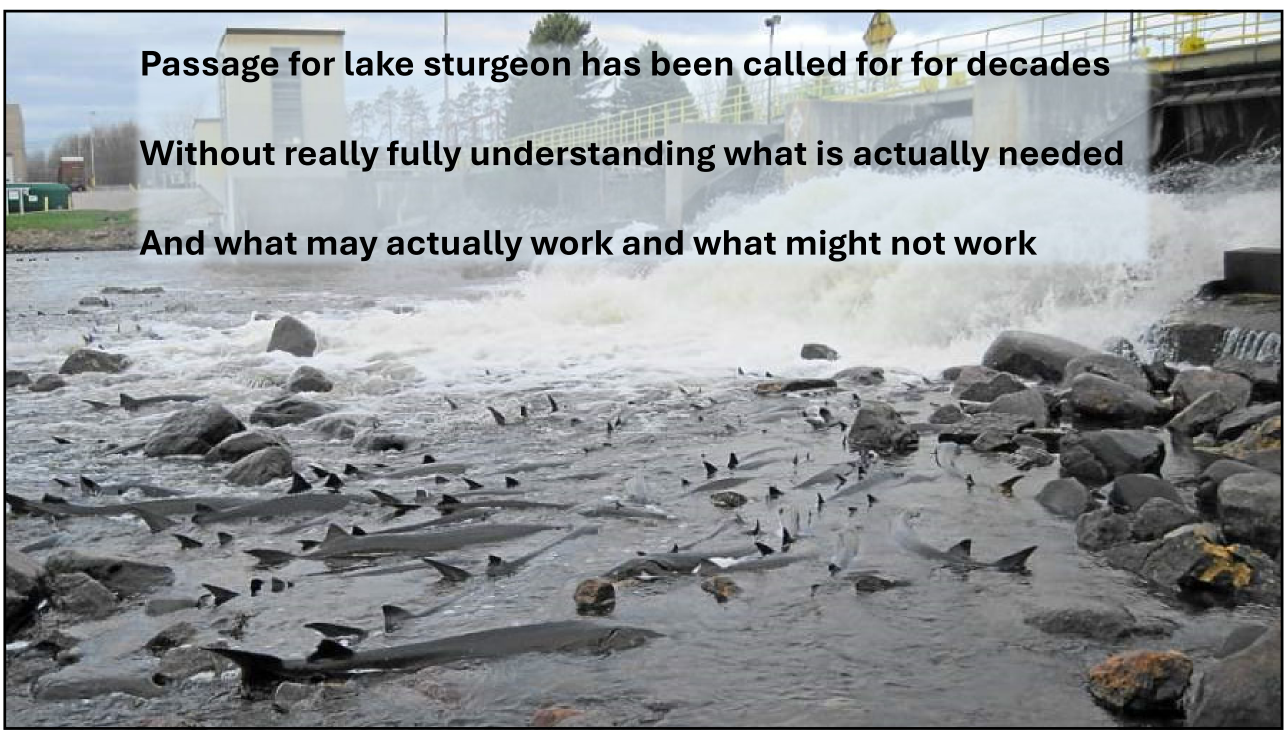
At the heart of this vision is a shared commitment to stewardship—a determination to protect this invaluable resource from current and future harm. Michigan's residents will understand and appreciate the profound benefits of the fishery for people and will understand that Great Lakes waters and ecosystems are of irreplaceable and intrinsic value.

Appendix E: Speaker Presentations

Presentations


Lake Sturgeon Passage Systems and Issues
Ronald M. Bruch, PhD
Bruch Environmental Consulting
UW Milwaukee School of Freshwater Sciences

1

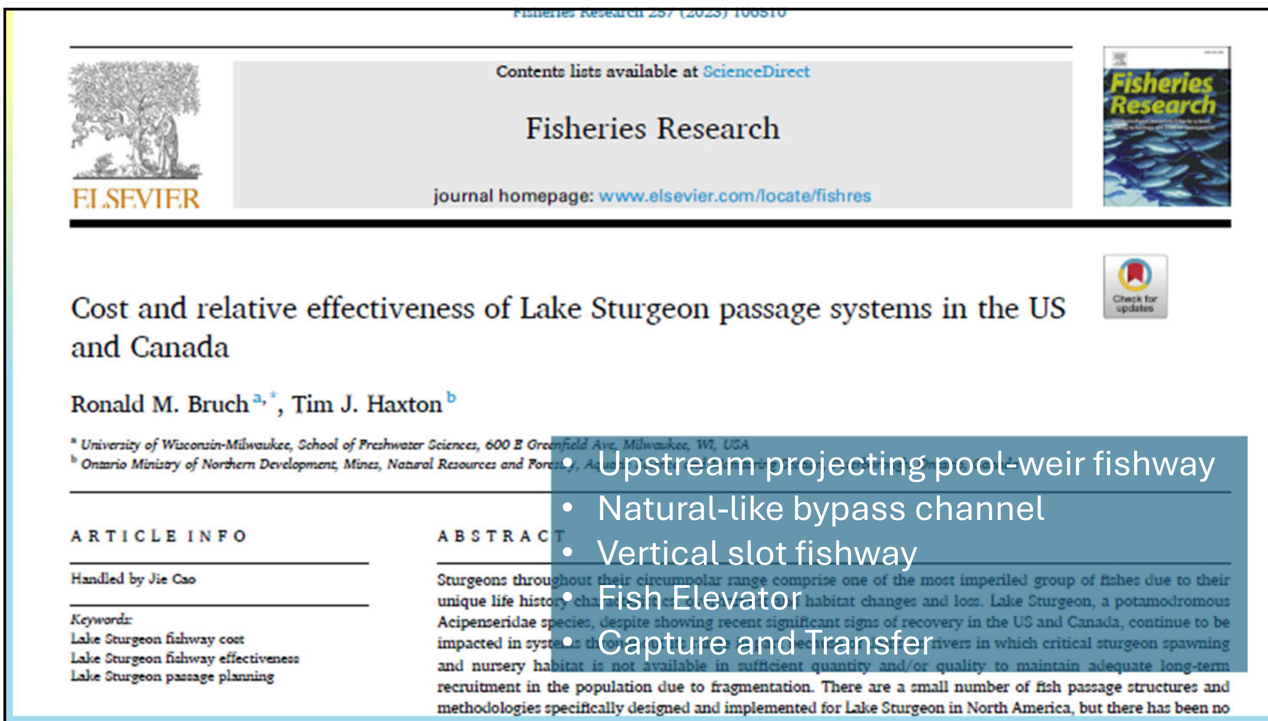

Passage for lake sturgeon has been called for for decades
Without really fully understanding what is actually needed
And what may actually work and what might not work

2

What do we know about lake sturgeon, and what they actually need in river systems to be successful?

- Very low intrinsic rate of population growth (0.05)
- Very low recruitment rate ~ <1 to 10 yearlings produced for each spawning female/year ***(Ricker SR relationship)***
- Little to no spawning site fidelity
- Need adequate spawning habitat/sites, nursery grounds, "fattening-up" areas, overwintering areas ***(at least 20 miles of river system)***
- Possess an innate "wanderlust"
- Highly adaptable
- *What passage systems are out there; how much do they cost; what works and what doesn't work*

3



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Cost and relative effectiveness of Lake Sturgeon passage systems in the US and Canada

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[b] Ontario Ministry of Northern Development, Mines, Natural Resources and Fore

ARTICLE INFO

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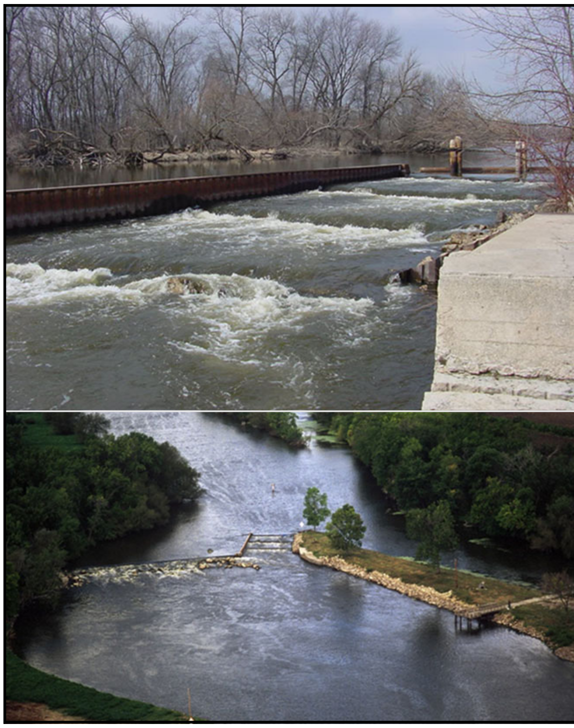
Keywords:
Lake Sturgeon fishway cost
Lake Sturgeon fishway effectiveness
Lake Sturgeon passage planning

ABSTRACT

Sturgeons throughout their circumpolar range comprise one of the most imperiled group of fishes due to their unique life history cha habitat changes and loss. Lake Sturgeon, a potamodromous Acipenseridae species, despite showing recent significant signs of recovery in the US and Canada, continue to be impacted in syste rivers in which critical sturgeon spawning and nursery habitat is not available in sufficient quantity and/or quality to maintain adequate long-term recruitment in the population due to fragmentation. There are a small number of fish passage structures and methodologies specifically designed and implemented for Lake Sturgeon in North America, but there has been no

- Upstream projecting pool-weir fishway
- Natural-like bypass channel
- Vertical slot fishway
- Fish Elevator
- Capture and Transfer

4



Eureka Upstream Projecting Plunge-Pool Fishway, Eureka Dam, Upper Fox River, Eureka, Wisconsin, USA

Dam Height (m)	0.9
Ave Annual Flow (cms)	33.0
Year Passage Implemented	1988
Total Cost (2020 USD)	**$275 000**
Cost/meter of Head	**$305 600**
Fishway entrance (m below dam)	**0**
Slope of Fishway	**3.3%**
Annual Operating Cost	**$0**
Days operated/year	**365**
Est Total Spawners below dam/Year	500
Total LS passed per year	250
Est. % spawners passed/year	**50% (100%)**
Projected LS passed/year	300
Projected Ave $/LS passed – 40 yrs	**$12**

5

Winter Dam Nature-Like Riffle-Pool Bypass Channel Fishway, Chippewa River, Winter, Wisconsin, USA.

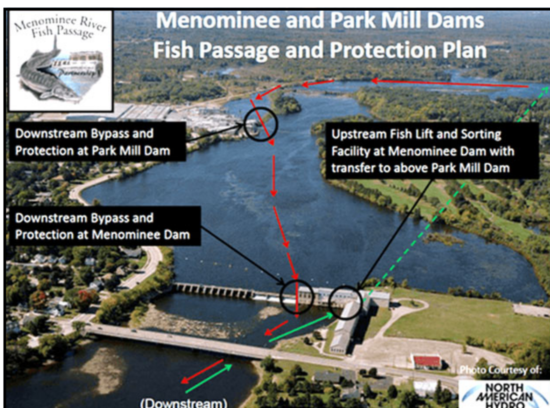
Dam Height (m)	2.1
Ave Annual Flow (cms)	11.7
Year Passage Implemented	2011
Total Cost (2020 USD)	**$520 650**
Cost/meter of Head	**$248 000**
Fishway entrance (m below dam)	**15.2**
Slope of Fishway	**2.7%**
Annual Operating Cost	**$0**
Days operated/year	**61**
Est Total Spawners below dam/Year	176
Total LS passed per year	48
Est. % spawners passed/year	**27%**
Projected LS passed/year	78
Projected Ave $/LS passed – 40 yrs	**$159**

6

Vianney-Legendre Vertical Slot Fishway, St. Ours Dam, Richelieu River, Quebec, Canada

Dam Height (m)	3.4
Ave Annual Flow (cms)	362
Year Passage Implemented	2001
Total Cost (2020 USD)	$3 580 000
Cost/meter of Head	$1 054 000
Fishway entrance (m below dam)	32.0
Slope of Fishway	2.5%
Annual Operating Cost	$7800
Days operated/year	92
Est Total Spawners below dam/Year	3000
Total LS passed per year	28
Est. % spawners passed/year	1%
Projected LS passed/year	70
Projected Ave $/LS passed – 40 yrs	$1660

7



Menominee Fish Elevator, Menominee River, Menominee, Michigan, USA

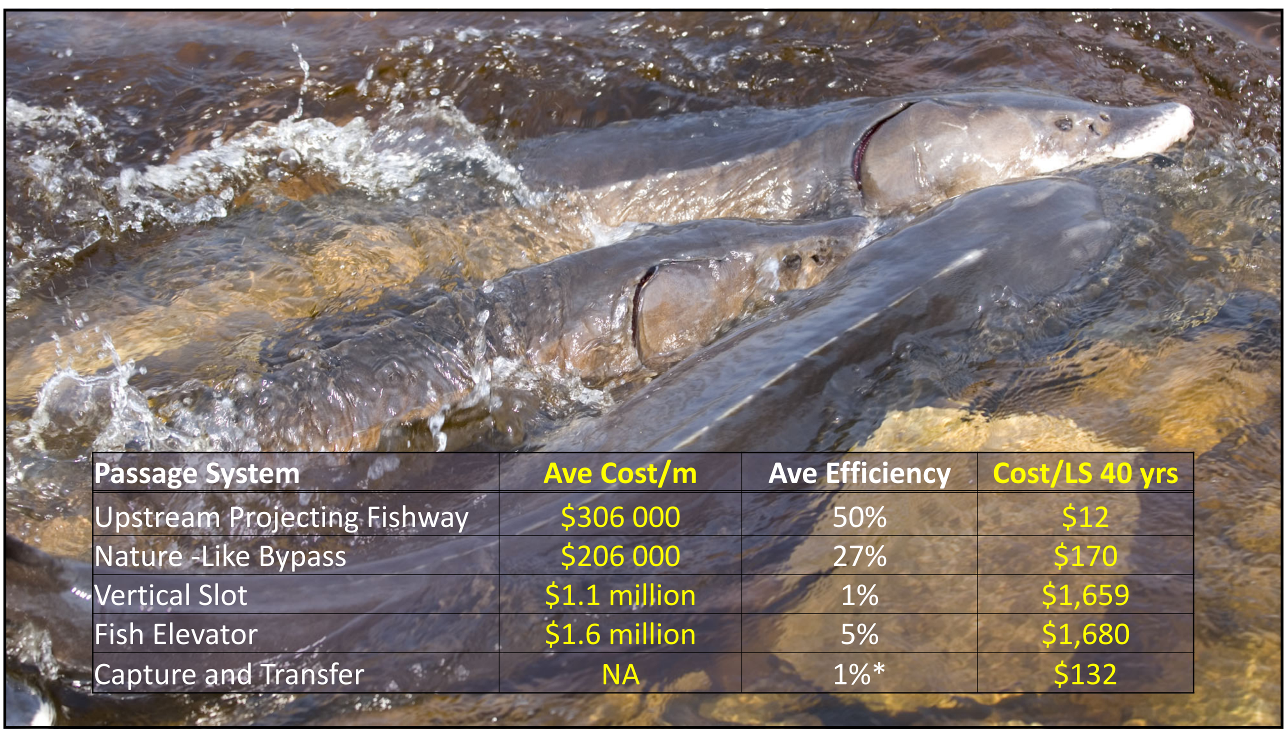
Dam Height (m)	7.6
Ave Annual Flow (cms)	93.7
Year Passage Implemented	2014
Total Cost (2020 USD)	$12 100 000
Cost/meter of Head	$1 600 000
Fishway entrance (m below dam)	6
Slope of Fishway	NA
Annual Operating Cost	$22 500
Days operated/year	105
Est Total Spawners below dam/Year	1750
Total LS passed per year	90
Est. % spawners passed/year	5%
Projected LS passed/year	140
Projected Ave $/LS passed – 40 yrs	$1680

8

Lake Sturgeon Capture and Transfer, Wolf River, Shawano, Wisconsin, USA

Dam Height (m)	4.3, 3.2
Ave Annual Flow (cms)	39.0
Year Passage Implemented	2011
Total Cost (2020 USD)	**$11 000/yr**
Cost/meter of Head	**NA**
Fishway entrance (m below dam)	NA
Slope of Fishway	**NA**
Annual Operating Cost	**$11 000**
Days operated/year	**3**
Est Total Spawners below dam/Year	24 000
Total LS passed per year	124
Est. % spawners passed/year	**1%**
Projected LS passed/year	**110**
Projected Ave $/LS passed – 40 yrs	**$132**

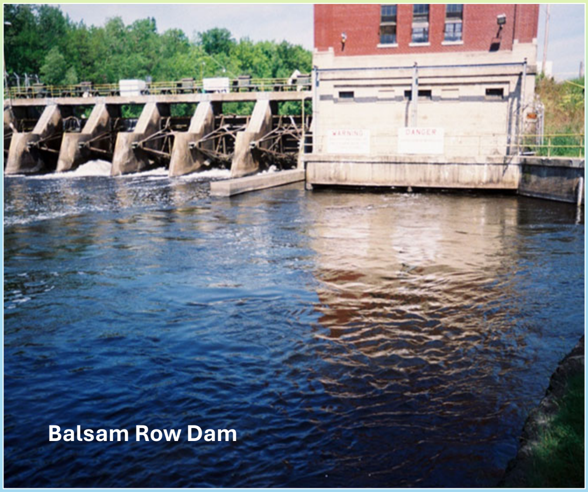
9

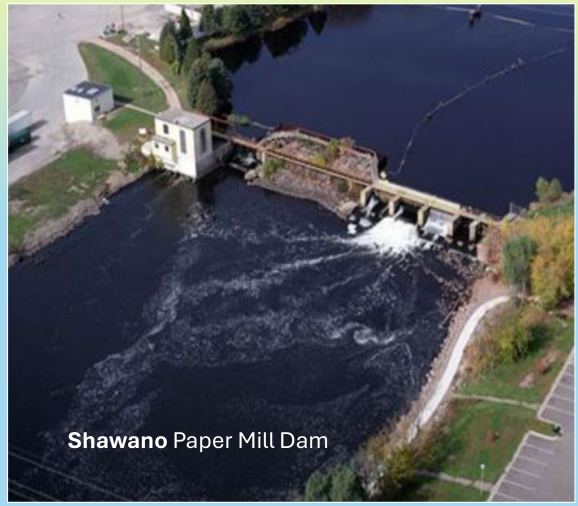


Passage System	Ave Cost/m	Ave Efficiency	Cost/LS 40 yrs
Upstream Projecting Fishway	$306 000	50%	$12
Nature -Like Bypass	$206 000	27%	$170
Vertical Slot	$1.1 million	1%	$1,659
Fish Elevator	$1.6 million	5%	$1,680
Capture and Transfer	NA	1%*	$132

10

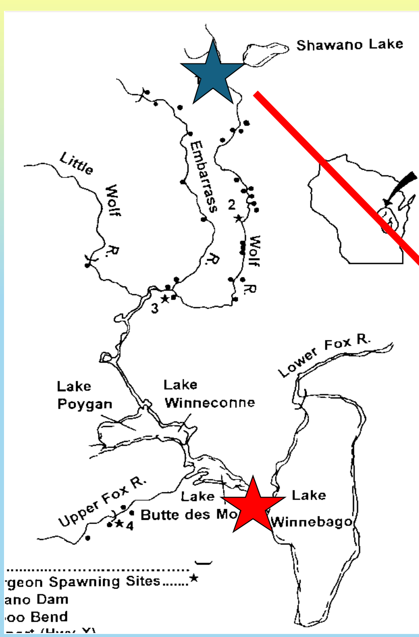
Downstream Passage Survival of Lake Sturgeon at the Shawano Paper Mill and Balsam Row Dams, Wolf River, Wisconsin





11

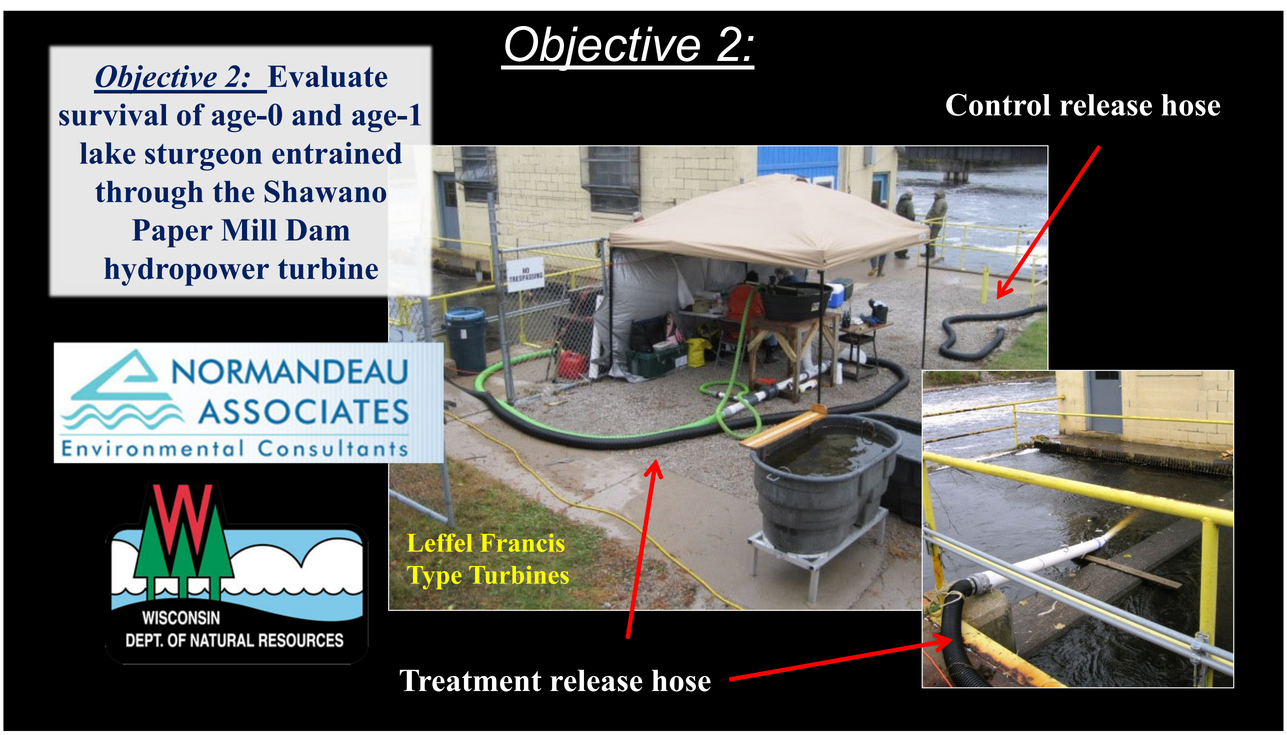
Study Area



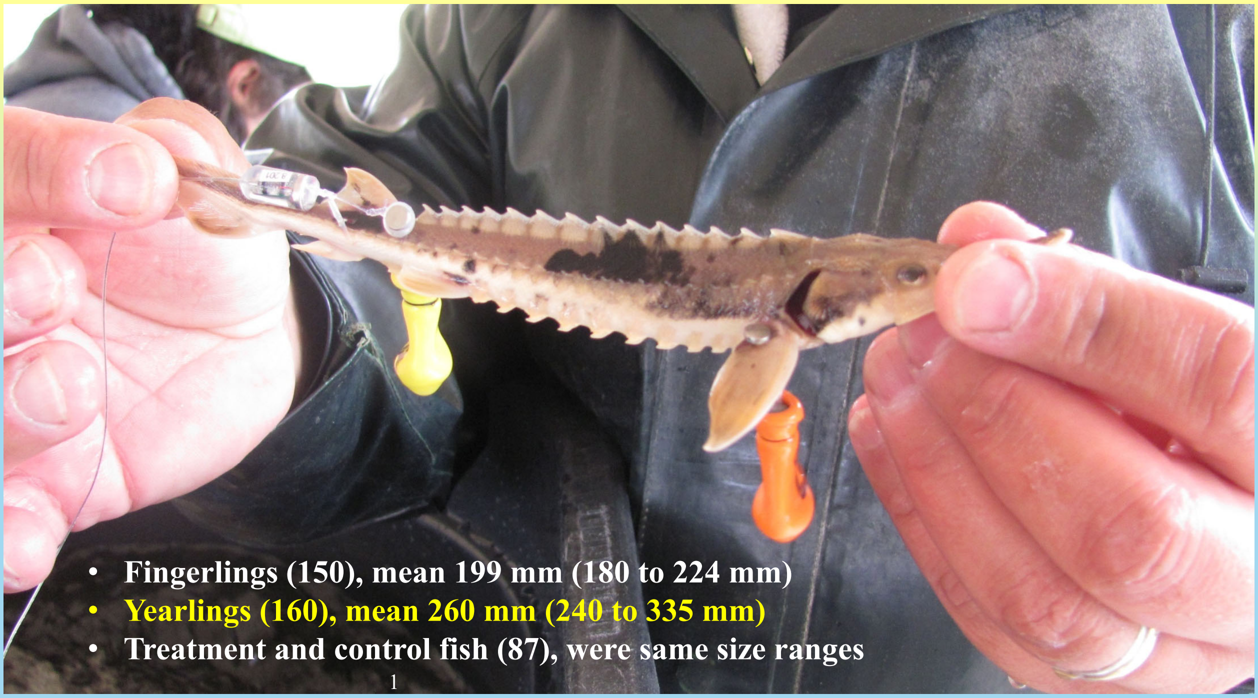
12


Objective 1: Assess survival of sub adult and adult lake sturgeon
passing downstream through spillway gates
red and
Adult and su
both dams
ough
ough

13


Objective 2:
Objective 2: Evaluate survival of age-0 and age-1 lake sturgeon entrained through the Shawano Paper Mill Dam hydropower turbine
Control release hose
NORMANDEAU ASSOCIATES
Environmental Consultants
WISCONSIN DEPT. OF NATURAL RESOURCES
Leffel Francis Type Turbines
Treatment release hose

14

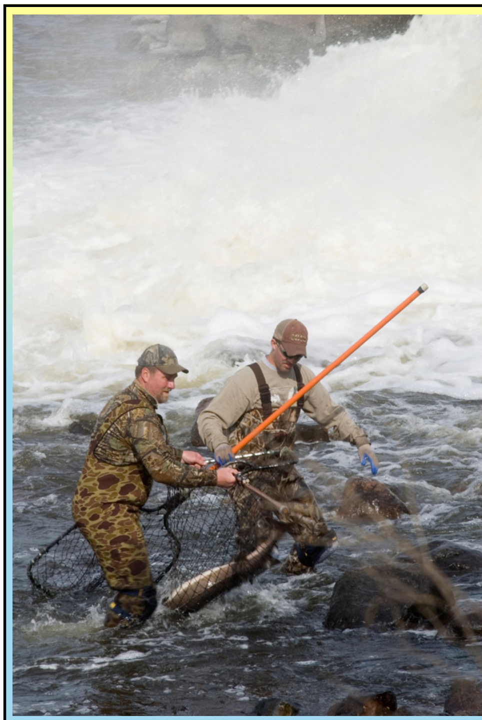


15

Fish Recovery

16

17



Lake Sturgeon passage questions and research issues:

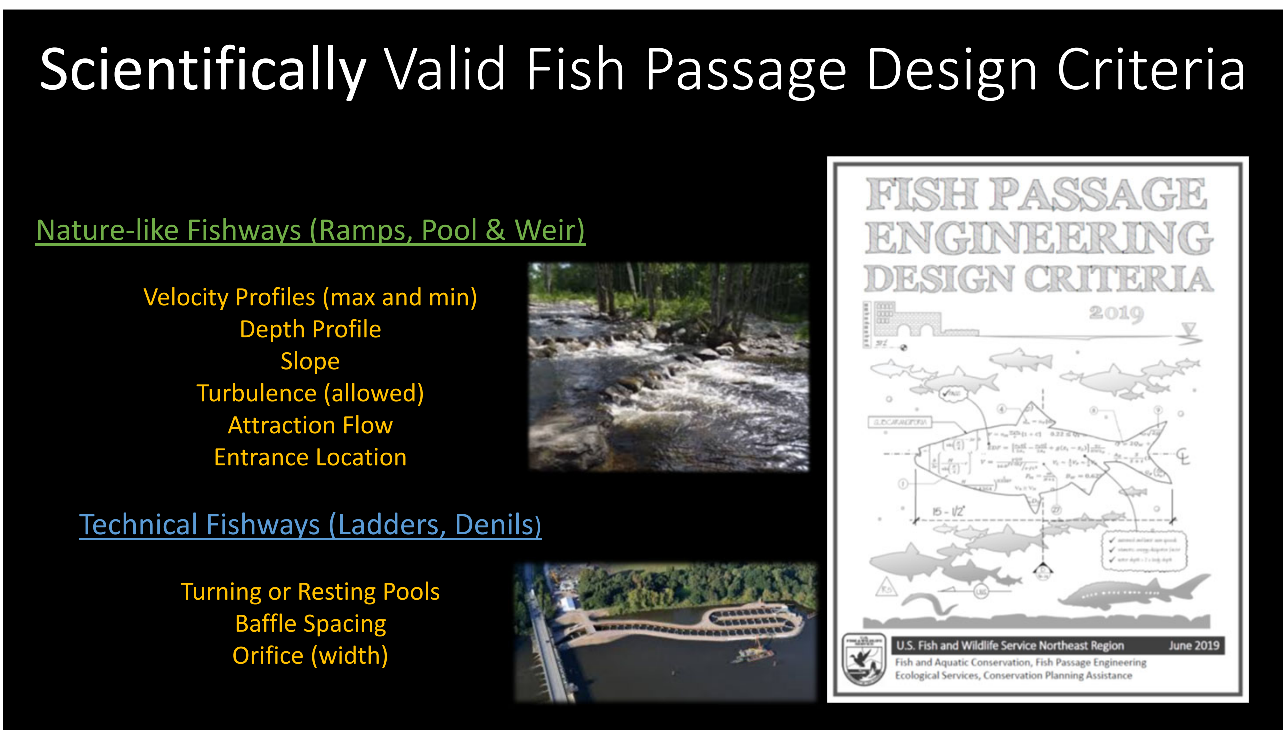
- Current system-specific LS population status, distribution, and mgmt objectives on system
- **LS habitat quality, quantity, and distribution**
- Historic range of LS in the system
- **AIS issues**
- Potential passage systems, costs, and expected relative efficiency and long-term impact on LS population
- **Status of FERC license on dam in question**
- Status and importance of infrastructure and fisheries on impoundment created by dam in question
- **Actual need for passage**

18

19


Identifying Lake Sturgeon Passage Research Priorities
Bozeman Fish Technology Center –
Fish Passage Research - 2009
Kevin Kappenman
USFWS Research Biologist

1


Scientifically Valid Fish Passage Design Criteria
Nature-like Fishways (Ramps, Pool & Weir)
Velocity Profiles (max and min)
Depth Profile
Slope
Turbulence (allowed)
Attraction Flow
Entrance Location
Technical Fishways (Ladders, Denils)
Turning or Resting Pools
Baffle Spacing
Orifice (width)
FISH PASSAGE ENGINEERING DESIGN CRITERIA
2019
U.S. Fish and Wildlife Service Northeast Region
June 2019
Fish and Aquatic Conservation, Fish Passage Engineering
Ecological Services, Conservation Planning Assistance

2

Pallid **Sturgeon** Passage Experiences

3

Yellowstone River Fishway Design Criteria

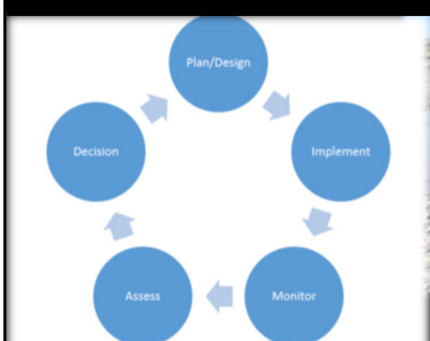
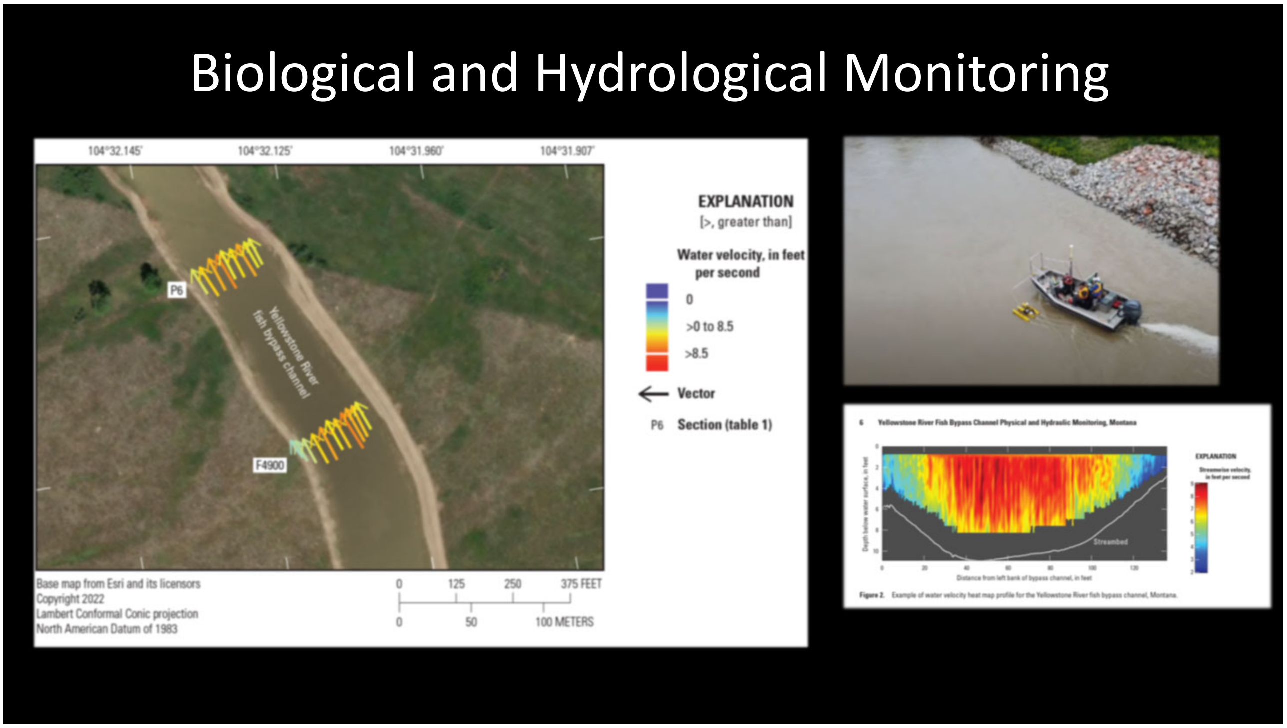


Figure 2: Adaptive Management Process

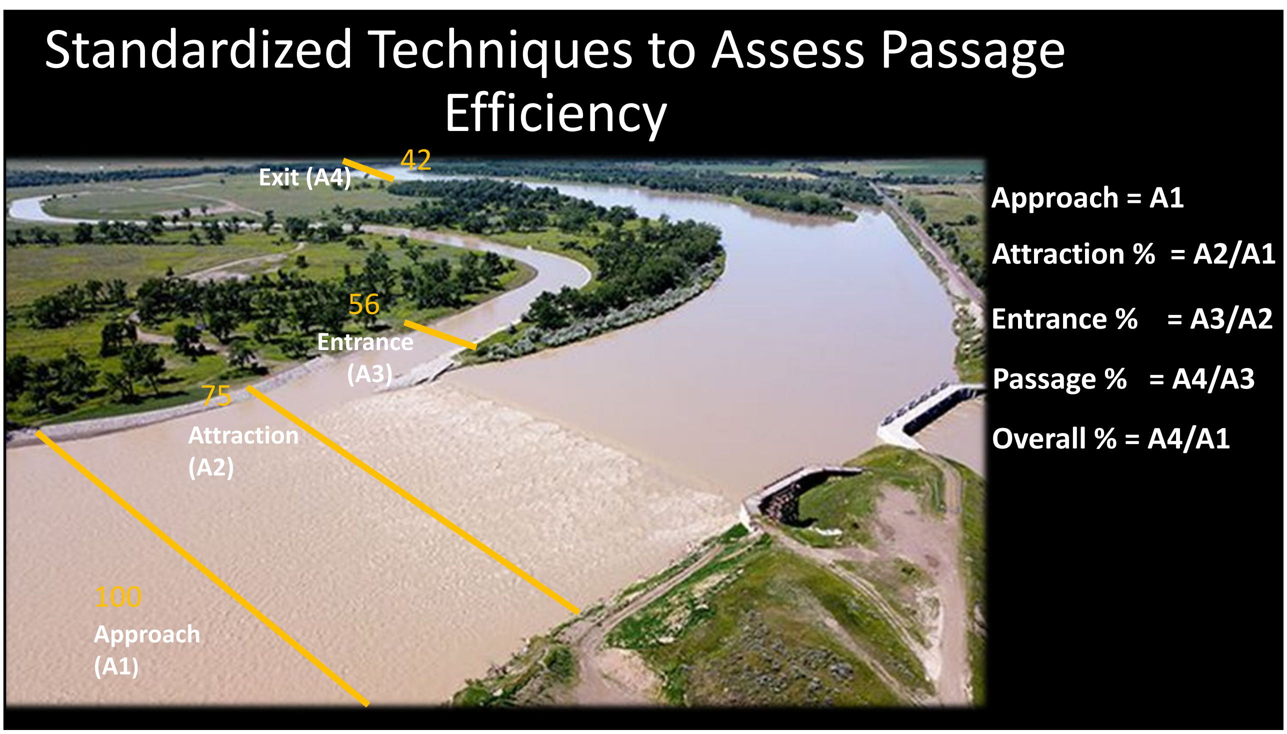
Table 2: Biological Review Team Physical and Hydraulic Design Criteria of the Bypass Channel

Discharge at Sidney, Montana USGS Gauge	7,000 – 14,999 ft^3/s	15,000 – 63,000 ft^3/s
Bypass Channel Flow Split	≥ 12%	13% to ≥ 15%
Bypass Channel cross-section velocities (measured as mean column velocity)	2.0 – 6.0 ft/s	2.4 – 6.0 ft/s
Bypass Channel Depth (minimum cross-sectional depth for 30 contiguous feet measured cross-section)	≥ 4.0 ft	≥ 6.0 ft
Bypass Channel Fish Entrance (measured as mean column velocity at HEC-RAS Station 136)	2.0 – 6.0 ft/s	2.4 – 6.0 ft/s
Bypass Channel Fish Exit (measured as mean column velocity)	≤ 6.0 ft/s	≤ 6.0 ft/s

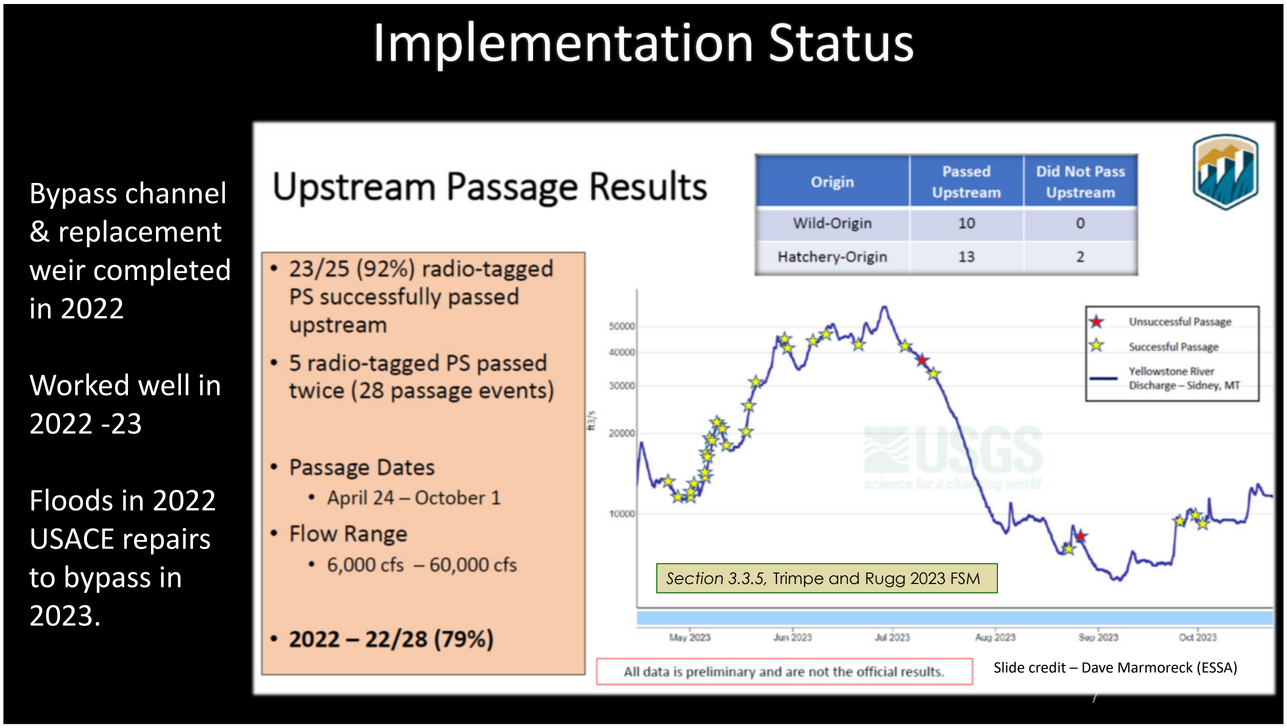
4


Biological and Hydrological Monitoring
104°32.145'
104°32.125'
104°31.960'
104°31.907'
P6
Yellowstone River fish bypass channel
F4900
EXPLANATION
[>, greater than]
Water velocity, in feet per second
0
>0 to 8.5
>8.5
Vector
P6 Section (table 1)
Base map from Esri and its licensors
Copyright 2022
Lambert Conformal Conic projection
North American Datum of 1983
0 125 250 375 FEET
0 50 100 METERS
Yellowstone River Fish Bypass Channel Physical and Hydraulic Monitoring, Montana
EXPLANATION
Streambed
Figure 2. Example of water velocity heat map profile for the Yellowstone River fish bypass channel, Montana.

5


Standardized Techniques to Assess Passage Efficiency
Exit (A4)
42
56
Entrance (A3)
75
Attraction (A2)
100
Approach (A1)
Approach = A1
Attraction % = A2/A1
Entrance % = A3/A2
Passage % = A4/A3
Overall % = A4/A1

6


Implementation Status
Bypass channel & replacement weir completed in 2022
Worked well in 2022 -23
Floods in 2022 USACE repairs to bypass in 2023.
Upstream Passage Results
Origin | Passed Upstream | Did Not Pass Upstream
Wild-Origin | 10 | 0
Hatchery-Origin | 13 | 2
• 23/25 (92%) radio-tagged PS successfully passed upstream
• 5 radio-tagged PS passed twice (28 passage events)
• Passage Dates
• April 24 – October 1
• Flow Range
• 6,000 cfs – 60,000 cfs
• 2022 – 22/28 (79%)
Unsuccessful Passage
Successful Passage
Yellowstone River Discharge – Sidney, MT
Section 3.3.5, Trimpe and Rugg 2023 FSM
All data is preliminary and are not the official results.
Slide credit – Dave Marmoreck (ESSA)

7

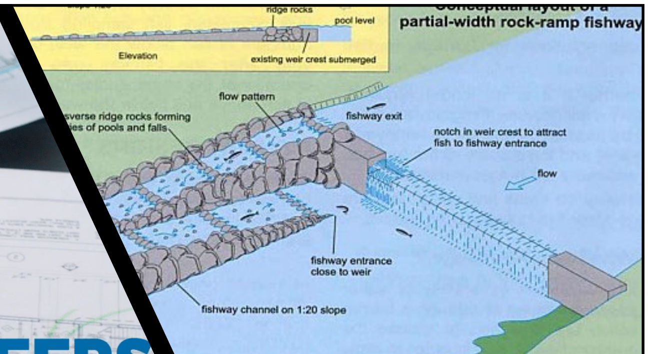

Tongue River Diversion and Muggli Fishway
Est. 2007
2007 - Present No Shovelnose have passed
2022 – Present No Pallid Sturgeon have passed

8

Data Gaps and Research Needs

WE THINK LIKE **ENGINEERS**

What criteria do we need to know to.... design nature-like and technical fishways?



9

Data Gaps and Research Needs

Develop a Design Criteria For Lake Sturgeon Fishways (Guidelines)

Nature like fishways (rocky ramps, pool and weir)

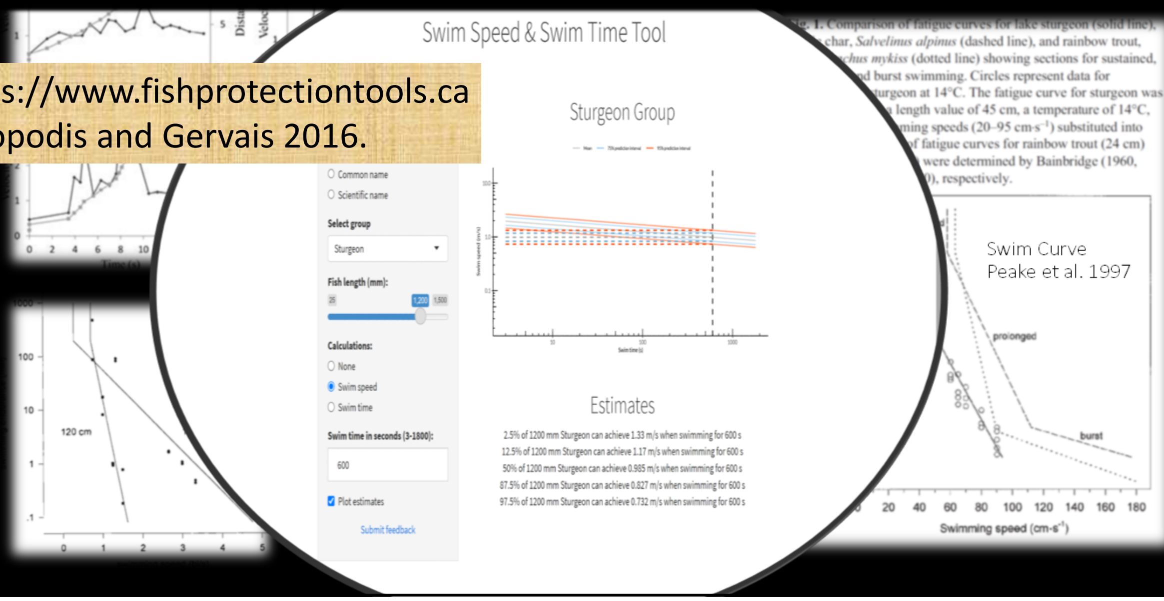
Velocity Profile & Attraction Flow
Turbulence
Slope
Entrance Location
Channel Width, Length, and Depth

Technical Fishways (ladders, Denils)

Weir Width, Length, and Depth
Turning Pools
Baffle Spacing
Orifice

10

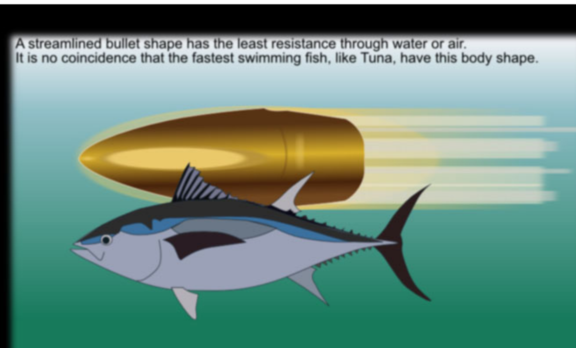
Velocity Profile…. ~ Sturgeon Swimming Ability

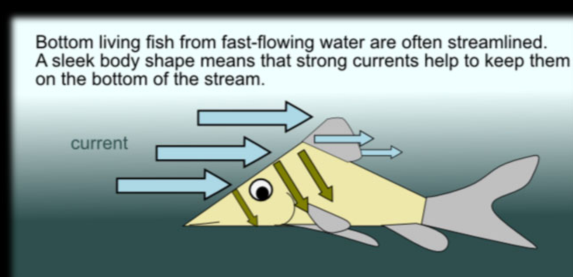


11

Sturgeon uniqueness

- Heterocercal tail – swim slower
- Long & Narrow, Flat Ventrally, Angled Rostrum
- Less visual ability
- Motivation
- Most fish able to move backward using pectoral fins

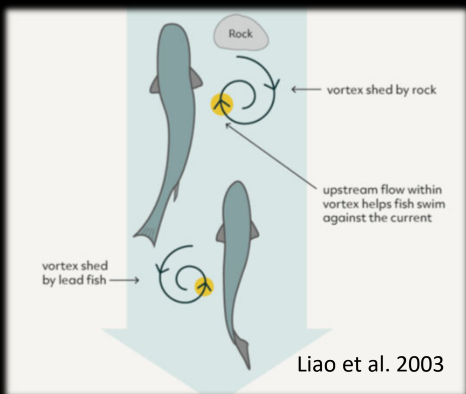




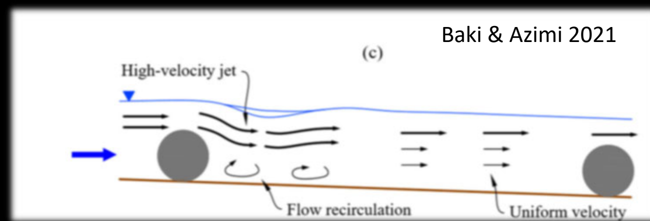
12

Data Gaps and Research Needs

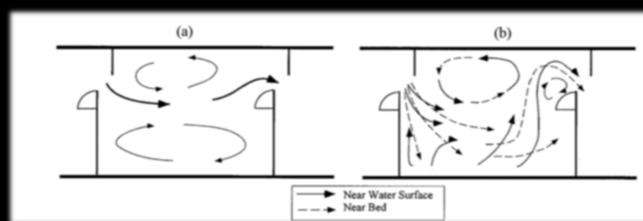
- Turbulence – path selection, flow patterns, and limitations



Liao et al. 2003



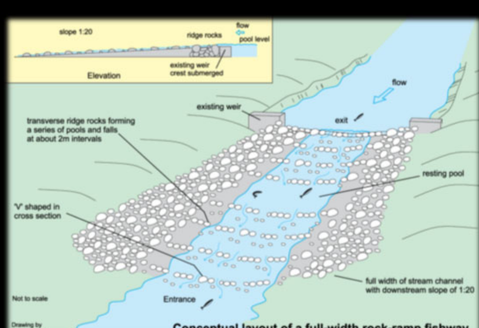
Baki & Azimi 2021

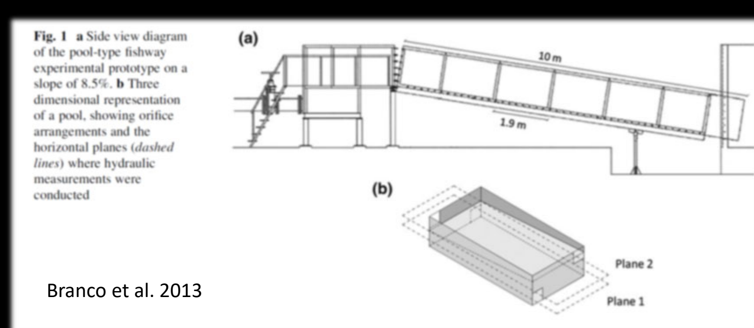


13

Data Gaps and Research Needs

- Slope





Branco et al. 2013

14

Data Gaps and Research Needs

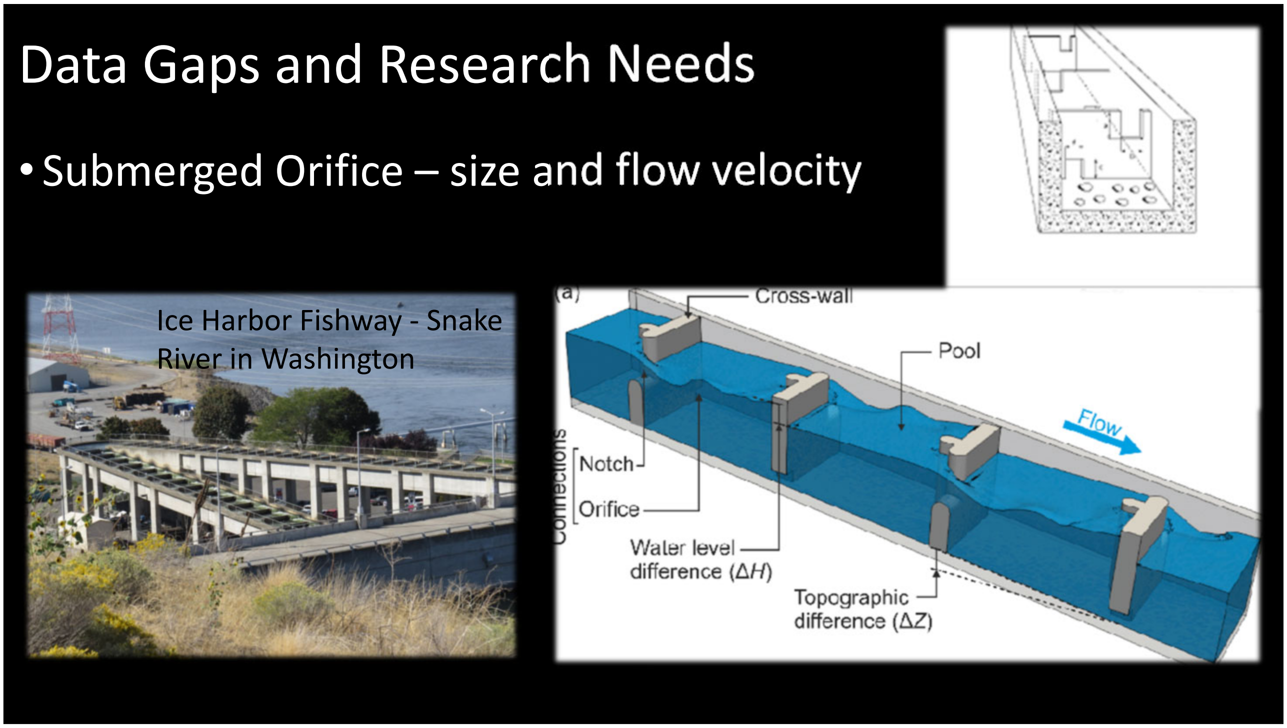
- Boulder spacing - width between boulders and chevrons
- Minimum Depth in the “swim path”

15

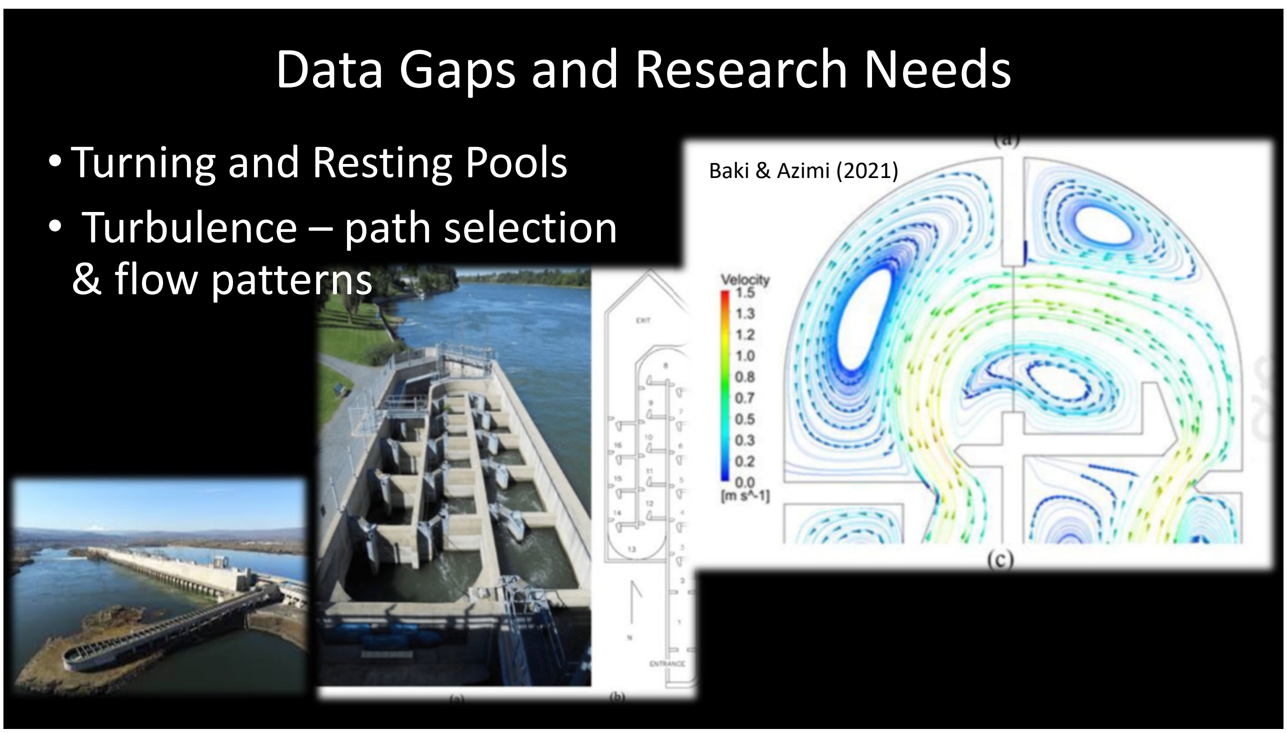
Data Gaps and Research Needs

- Baffle spacing - width and distance between
- Minimum Depth in the “swim path”

16


Data Gaps and Research Needs
• Submerged Orifice – size and flow velocity
Ice Harbor Fishway - Snake River in Washington
(a)
Cross-wall
Pool
Flow
Connections
Notch
Orifice
Water level difference (ΔH)
Topographic difference (ΔZ)

17

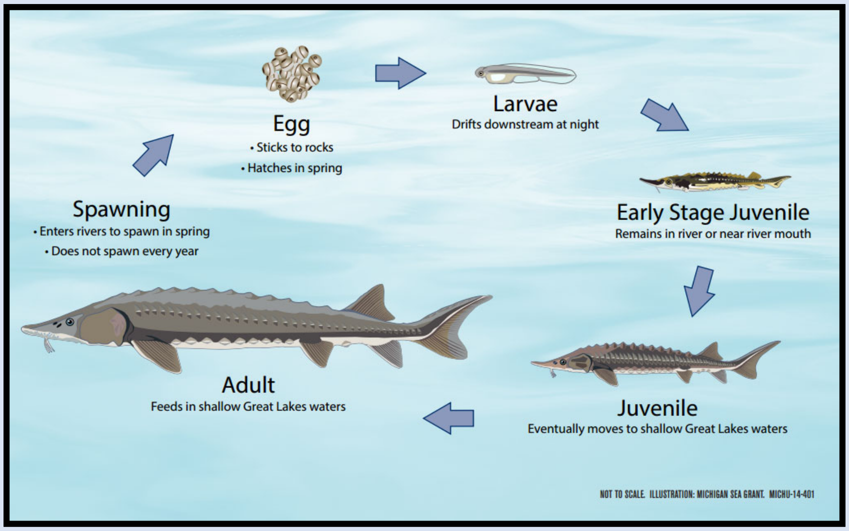

Data Gaps and Research Needs
• Turning and Resting Pools
• Turbulence – path selection & flow patterns
Baki & Azimi (2021)
Velocity
1.5
1.3
1.2
1.0
0.8
0.7
0.5
0.3
0.2
0.0
[m s^-1]
(c)

18

19

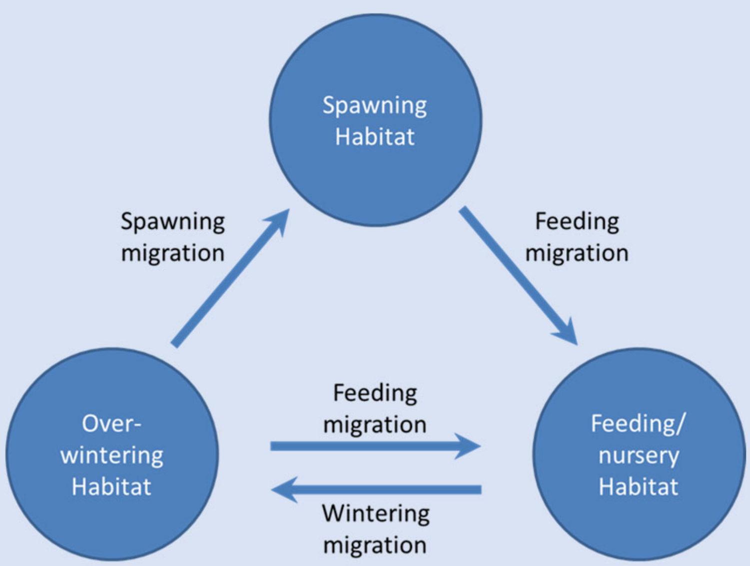
Lake Sturgeon – Habitat Constraints

Robin DeBruyne, Scott Colborne, Dimitry Gorsky



1

Lake Sturgeon & Habitat - Conceptual Framework



2

Spawning (adults)

- Lack of high-quality spawning areas
  - Uncertainty about range of habitat requirements
- Artificial reefs
  - Uncertainty about longevity
- Shoal spawning
  - Identify and look for spawning on historic or newly identifies lake shoal habitats
    - Uncertainty if shoal spawning populations exist. What are shoal habitat requirements?
- Spawning ecology in response to Climate Change
  - Uncertainty surrounding recent observations of reduced or failed spawning seasons due to strange temperature and flow patterns in spring.
- What are the effects on spawning habitat downstream of dams/water regulation on egg survival, larval retention and survival.

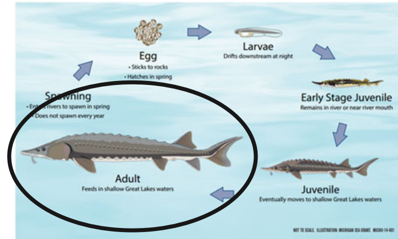
3

Juvenile and Subadult/Adult

- What habitats do juvenile sturgeon occupy through ontogeny?
- What are preferred juvenile feeding habitats?
  - What is the impact of accumulating dressenid hash on feeding grounds?
  - What are the effects of dredging on water quality (DO) and food availability for juvenile and subadult sturgeon?
  - What are the effects of shipping on age-0 and juvenile retention in preferred habitats?
- Monitoring need of feeding preferences
  - Identify diet preference and characteristics of productive feeding grounds.

4

Life Stage Hab Use Topic



Knowns

- Blah Blah

Unknowns

- Blah Blah

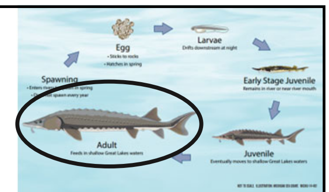
5

Adults – *Non-spawning*

Knowns

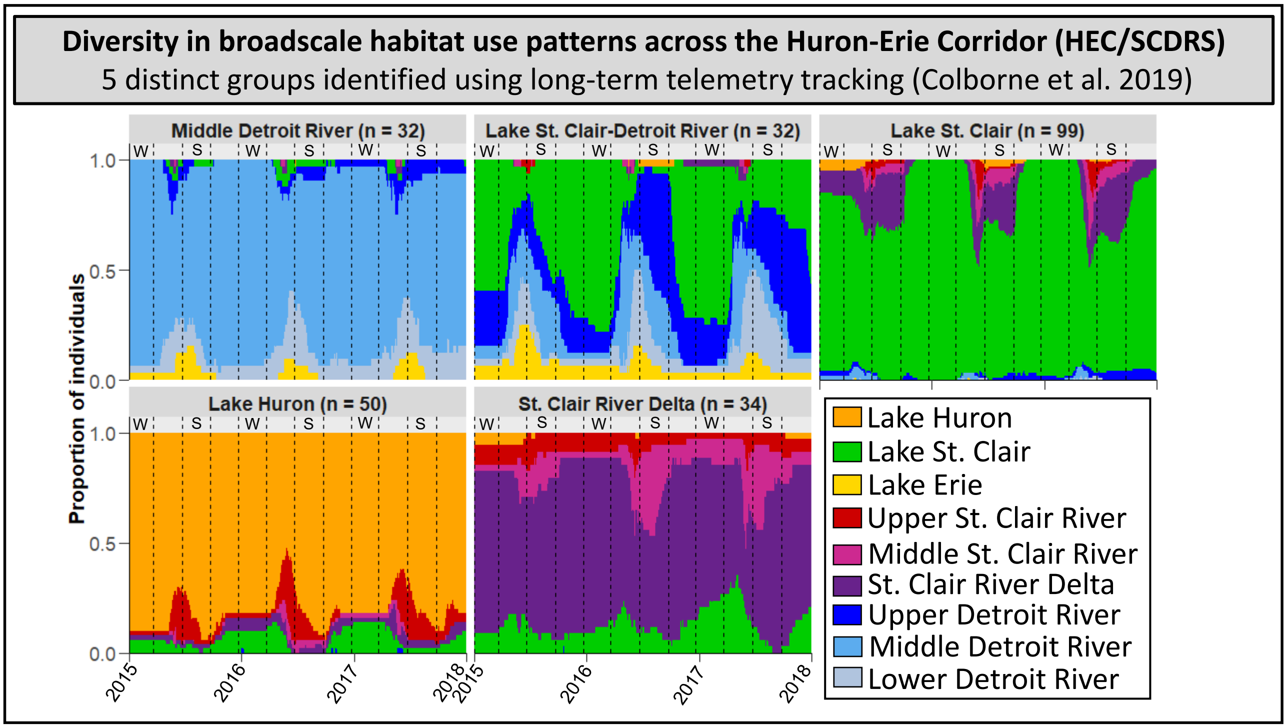
- Majority of sturgeon lifetime is in this stage/phase of the life cycle
- Historical perception that adult sturgeon spend non-spawning period in deeper areas of lakes
  - River and lake use by adults (Rusak and Mosindy 1997, Colborne et al. 2019)
  - Consistency in use patterns across years (Colborne et al. 2019)
- High adult survival necessary to provide enough reproductive opportunities (Bruch 2009, Hayes & Carrofino 2012, Colborne et al. 2021)
  - Concerns have been raised about mortality (e.g., ship strikes – Hondorp et al. 2017)
- Adult sturgeon are able to exploit a diversity of food sources (Bruestle et al. 2019), accessing resources the critical factor

Unknowns

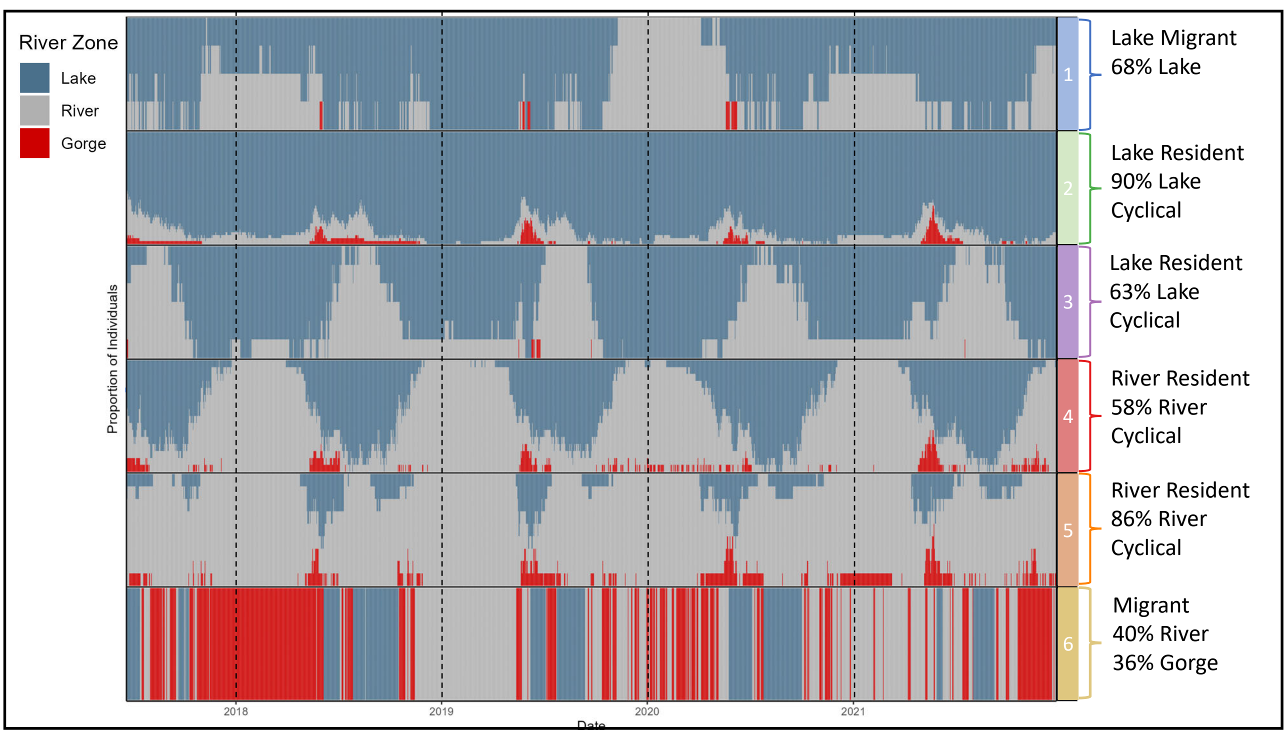


- How to support diversity in habitat use across regions and historical portfolio of habitat use patterns
- How barriers could impede range shifts (climate change impacts)
- Eutrophication and associated stressors, e.g., HABs
- Invasive species – food web changes, pathogen exposure (e.g., round goby & botulism; USFWS 2023 SSA report)
- Most adult habitat use information is relatively coarse scale

6

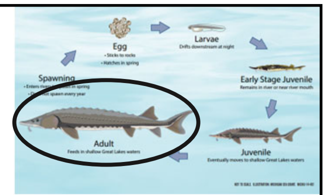

Diversity in broadscale habitat use patterns across the Huron-Erie Corridor (HEC/SCDRS)
5 distinct groups identified using long-term telemetry tracking (Colborne et al. 2019)
Middle Detroit River (n = 32)
Lake St. Clair-Detroit River (n = 32)
Lake St. Clair (n = 99)
Lake Huron (n = 50)
St. Clair River Delta (n = 34)
W
S
Proportion of individuals
1.0
0.5
0.0
2015
2016
2017
2018
Lake Huron
Lake St. Clair
Lake Erie
Upper St. Clair River
Middle St. Clair River
St. Clair River Delta
Upper Detroit River
Middle Detroit River
Lower Detroit River

7


River Zone
Lake
River
Gorge
Proportion of Individuals
2018
2019
2020
2021
Date
1
2
3
4
5
6
Lake Migrant
68% Lake
Lake Resident
90% Lake
Cyclical
Lake Resident
63% Lake
Cyclical
River Resident
58% River
Cyclical
River Resident
86% River
Cyclical
Migrant
40% River
36% Gorge

8

Adults – *Non-spawning*



Knowns

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- Historical perception that adult sturgeon spend non-spawning period in deeper areas of lakes
  - River and lake use by adults (Rusak and Mosindy 1997, Colborne et al. 2019)
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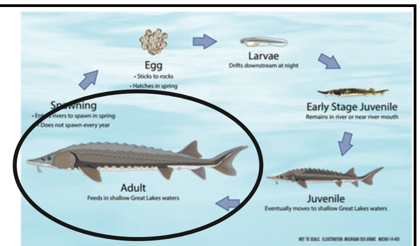
- Adult sturgeon are able to exploit a diversity of food sources (Bruestle et al. 2019), accessing resources the critical factor

Unknowns

- How to support diversity in habitat use across regions and historical portfolio of habitat use patterns
- How barriers could impede range shifts (climate change impacts)
- Eutrophication and associated stressors, e.g., HABs
- Invasive species – food web changes, pathogen exposure (e.g., round goby & botulism; USFWS 2023 SSA report)
- Most adult habitat use information is relatively coarse scale

9

Adults - *Spawning*



Knowns

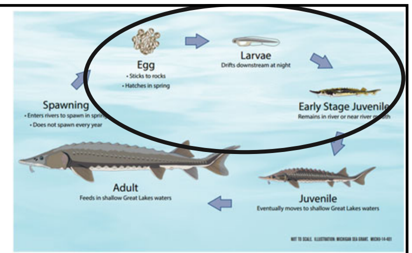
- Spawning temperature preference range
- Substrate preference
- Flow preference range
- Known to use artificial reefs
- Historical spawning locations

Unknowns

- Lack of high-quality spawning habitat as a reference point
- What is the longevity of reef use and value
- Do shoal spawners exist
- Role of shoal spawning to meta-population
- What are the requirements for shoal spawners
- Spawning ecology in response to climate change (timing, duration, bouts)

10

Eggs/Larvae/Age-0



Knowns

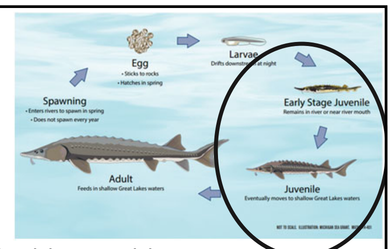
- Stay in substrate, drift "downstream"
- Small substrates

Unknowns

- Habitat selection – how far "downstream"?
- Outlet vs. river spawned progeny?
- Habitat connectivity needs?
- Food resources?
- Recruitment variability?
- Climate change effects on hatch success, nursery habitat availability?

11

Juvenile



Knowns

- Habitat use considered to be broad
- Highly influenced by flow and prey community
- Depth is highly variable
- Substrate consistent with prey availability

Unknowns

- Actual drivers are highly variable
- Habitat use is system dependent
- What habitats do juvenile sturgeon occupy through ontogeny?
- What are preferred juvenile feeding habitats?
- What is the impact of accumulating dressenid hash on feeding grounds?
- What are the effects of dredging on water quality (DO) and food availability for juvenile and subadult sturgeon?
- What are the effects of shipping on age-0 and juvenile retention in preferred habitats?
- Identify diet preference and characteristics of productive feeding grounds.

12

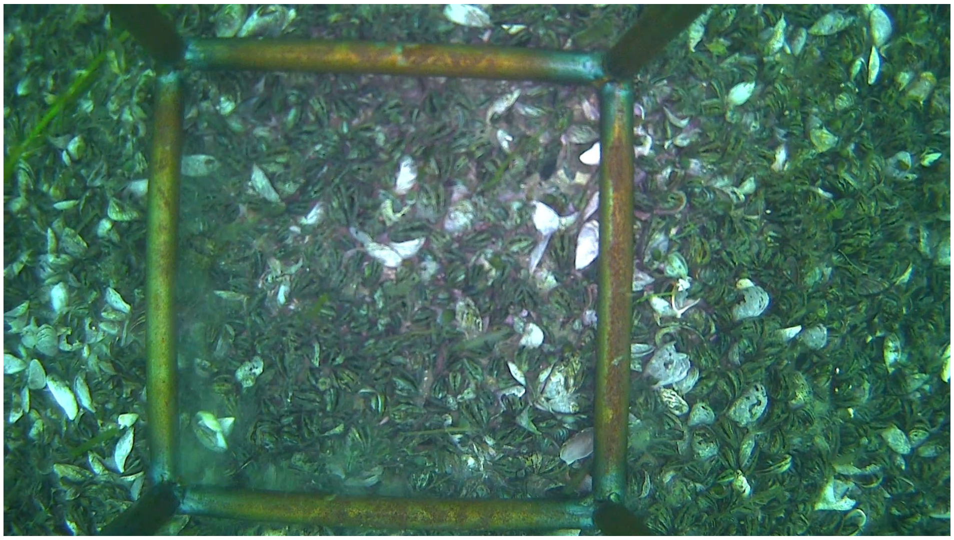
Emerging Concerns & Research Needs…

- SSA deemed the US side of the Great Lakes to generally have low population resiliency – where are habitat constraints?
- Climate change potential effects on habitat for all stages (e.g., temperature, vegetation, flow, habitat connectivity, food resources)
- Changing habitat conditions – e.g., mussel hash
- HABs – an emerging concern for adult sturgeon in North America
- Fine-scale resolution of habitat use (temporal and spatially)
  - Combined telemetry methods (VPS positioning) with environmental assessments and monitoring (temp, flow, vegetation, substrate, prey community)
  - Juvenile/Sub-adults, Adults (non-spawning periods)

13

Mussel hash, no secondary

14



Mussel reef; mussel hash

15

Emerging Concerns & Research Needs…

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- Climate change potential effects on habitat for all stages (e.g., temperature, vegetation, flow, habitat connectivity, food resources)
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  - Combined telemetry methods (VPS positioning) with environmental assessments and monitoring (temp, flow, vegetation, substrate, prey community)
  - Juvenile/Sub-adults, Adults (non-spawning periods)

16

Harmful algal blooms (HABs) are emerging as threats to sturgeon in other areas

What risks, if any, are posed to lake sturgeon in the Great Lakes basin by HABs?

Conservation

After 2022's Fatal Algal Bloom, Scientists Fear the Bay's Sturgeon Could Go Extinct

In an open letter, they're calling for California to consider making white sturgeon fishing catch-and-release for now.

by Guanani Gómez-Van Cortright

December 21, 2022

SHARE THIS:

New constraints on CA sturgeon fishing to save species

Written by Marc Albert and Greta Mart

Published: 13 October 2023

photo credit: Courtesy of CDFW
Now-retired CDFW environmental scientist Mike Harris holding a white sturgeon for a moment, before returning it to the waters of Suisun Bay.

Plummeting numbers of white sturgeon in California is prompting state environmental regulators to issue emergency regulations.

Those regulations close key spawning spots to sturgeon fishing. They also set a catch limit of one per year, change the size limit and ban boats from having more than two sturgeon aboard.

The California Fish and Game Commission passed the emergency measure this week, and the CDFW said the new regs go effect at the end of October or beginning of November, "following approval by the Office of Administrative Law."

Primarily a freshwater fish, sturgeon also dwell in estuaries, including San Francisco and San Pablo Bays, and occasionally visit near-shore ocean waters.

Sturgeon can live more than a century. Historic records show them growing larger than 25-feet in length, before intensive fishing consumed their abundance.

Most wild sturgeon today in California waters are less than 20 years old. That's actually a huge problem as the fish can't successfully reproduce until reaching at least 10 years of age, and only spawn every two to four years.

Recent red tides in San Francisco Bay also claimed large numbers of the fish.

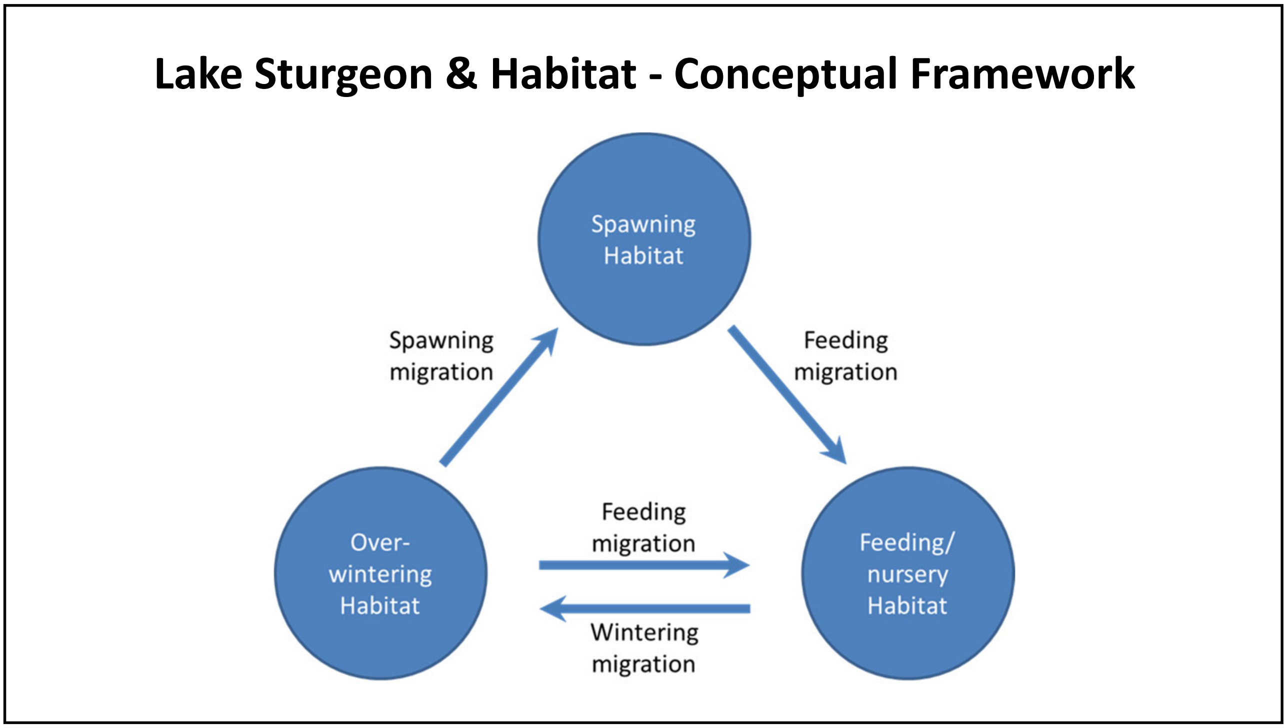
Over the past quarter century, the number of harvestable sturgeon in California has decreased by nearly 85 percent, according to CDFW.

17

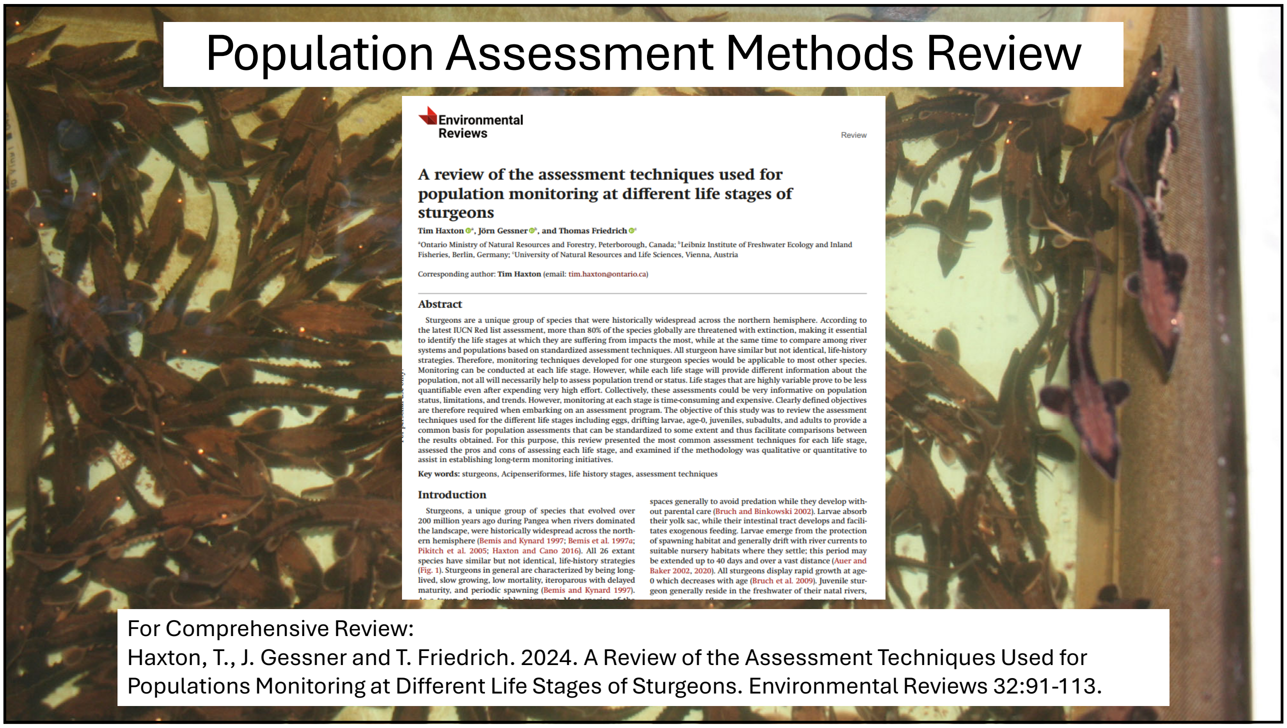
Emerging Concerns & Research Needs…

- SSA deemed the US side of the Great Lakes to generally have low population resiliency – where are habitat constraints?
- Climate change potential effects on habitat for all stages (e.g., temperature, vegetation, flow, habitat connectivity, food resources)
- Changing habitat conditions – e.g., mussel hash
- HABs – an emerging concern for adult sturgeon in North America
- Fine-scale resolution of habitat use (temporal and spatially)
    - Combined telemetry methods (VPS positioning) with environmental assessments and monitoring (temp, flow, vegetation, substrate, prey community)
    - Juvenile/Sub-adults, Adults (non-spawning periods)

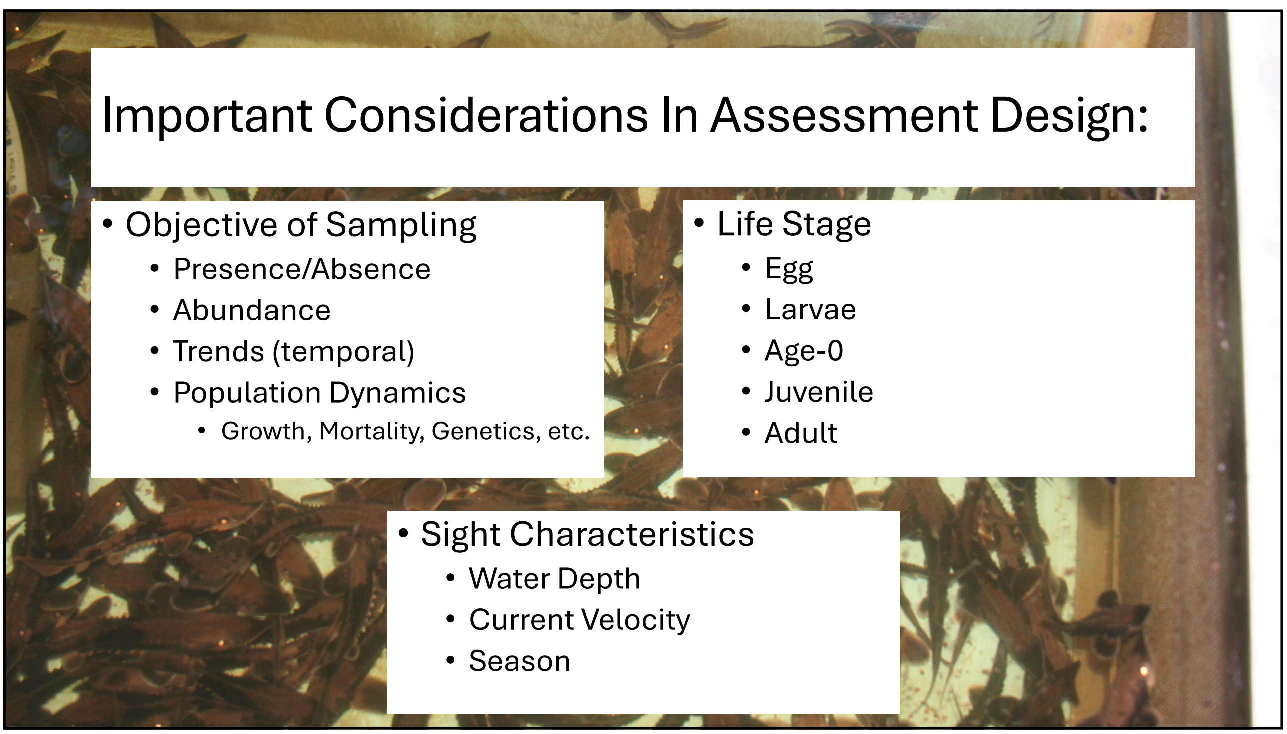
18


Lake Sturgeon & Habitat - Conceptual Framework
Spawning Habitat
Spawning migration
Feeding migration
Over-wintering Habitat
Feeding migration
Wintering migration
Feeding/ nursery Habitat

19


Population Assessment Methods Review
Environmental Reviews
Review
A review of the assessment techniques used for population monitoring at different life stages of sturgeons
Tim Haxton[a], Jörn Gessner[b], and Thomas Friedrich[c]
[a]Ontario Ministry of Natural Resources and Forestry, Peterborough, Canada; [b]Leibniz Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany; [c]University of Natural Resources and Life Sciences, Vienna, Austria
Corresponding author: Tim Haxton (email: tim.haxton@ontario.ca)
Abstract
Sturgeons are a unique group of species that were historically widespread across the northern hemisphere. According to the latest IUCN Red list assessment, more than 80% of the species globally are threatened with extinction, making it essential to identify the life stages at which they are suffering from impacts the most, while at the same time to compare among river systems and populations based on standardized assessment techniques. All sturgeon have similar but not identical, life-history strategies. Therefore, monitoring techniques developed for one sturgeon species would be applicable to most other species. Monitoring can be conducted at each life stage. However, while each life stage will provide different information about the population, not all will necessarily help to assess population trend or status. Life stages that are highly variable prove to be less quantifiable even after expending very high effort. Collectively, these assessments could be very informative on population status, limitations, and trends. However, monitoring at each stage is time-consuming and expensive. Clearly defined objectives are therefore required when embarking on an assessment program. The objective of this study was to review the assessment techniques used for the different life stages including eggs, drifting larvae, age-0, juveniles, subadults, and adults to provide a common basis for population assessments that can be standardized to some extent and thus facilitate comparisons between the results obtained. For this purpose, this review presented the most common assessment techniques for each life stage, assessed the pros and cons of assessing each life stage, and examined if the methodology was qualitative or quantitative to assist in establishing long-term monitoring initiatives.
Key words: sturgeons, Acipenseriformes, life history stages, assessment techniques
Introduction
Sturgeons, a unique group of species that evolved over 200 million years ago during Pangea when rivers dominated the landscape, were historically widespread across the northern hemisphere (Bemis and Kynard 1997; Bemis et al. 1997a; Pikitch et al. 2005; Haxton and Cano 2016). All 26 extant species have similar but not identical, life-history strategies (Fig. 1). Sturgeons in general are characterized by being long-lived, slow growing, low mortality, iteroparous with delayed maturity, and periodic spawning (Bemis and Kynard 1997).
spaces generally to avoid predation while they develop without parental care (Bruch and Binkowski 2002). Larvae absorb their yolk sac, while their intestinal tract develops and facilitates exogenous feeding. Larvae emerge from the protection of spawning habitat and generally drift with river currents to suitable nursery habitats where they settle; this period may be extended up to 40 days and over a vast distance (Auer and Baker 2002, 2020). All sturgeons display rapid growth at age-0 which decreases with age (Bruch et al. 2009). Juvenile sturgeon generally reside in the freshwater of their natal rivers,
For Comprehensive Review:
Haxton, T., J. Gessner and T. Friedrich. 2024. A Review of the Assessment Techniques Used for Populations Monitoring at Different Life Stages of Sturgeons. Environmental Reviews 32:91-113.

1


Important Considerations In Assessment Design:
• Objective of Sampling
• Presence/Absence
• Abundance
• Trends (temporal)
• Population Dynamics
• Growth, Mortality, Genetics, etc.
• Life Stage
• Egg
• Larvae
• Age-0
• Juvenile
• Adult
• Sight Characteristics
• Water Depth
• Current Velocity
• Season

2

Eggs

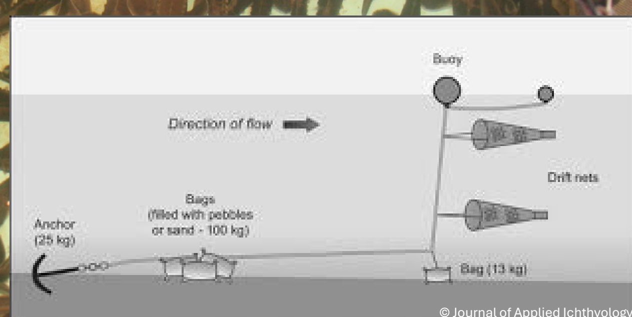
- Egg mats
- Drift nets
- Kick Sampling

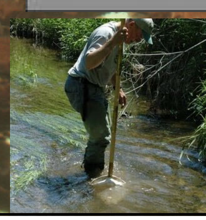
- Presence/Absence
- Spawning Activity
- Habitat Use

3

Larvae

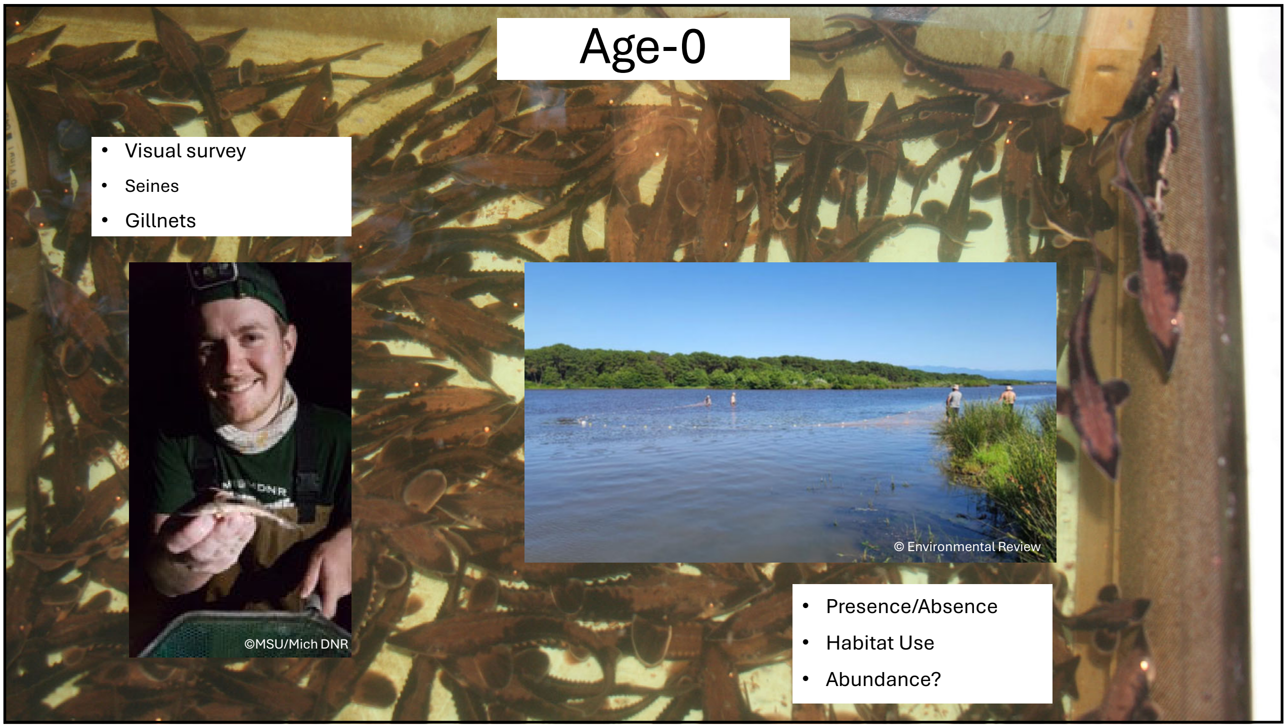
- Drift sampling
- Kick sampling





- Presence/Absence
- Reproductive success

4



5

6

Population Assessment Methods Review

Adults

- Dip Nets
- Gillnets
- Bottom Trawls
- Trammel Nets
- Set Lines
- Electrofishing
- Commercial Fisheries

- Presence/Absence
- Habitat Use
- Abundance (mark-recapture)
- Population Trends

7

"Remote" Sensing

J. Appl. Ichthyol. 23 (2007), 113–121

ISSN 0175–8659

Received: May 18, 2006
Accepted: July 22, 2006
doi:10.1111/j.1439-0426.2006.00833.x

Assessment of lake sturgeon spawning stocks using fixed-location, split-beam sonar technology

By N. A. Auer[1] and E. A. Baker[2]

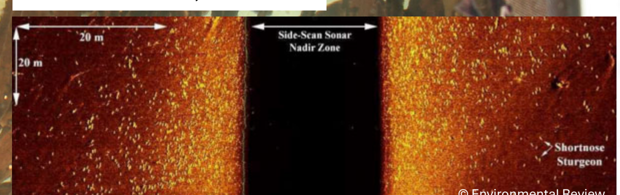
[1]*Michigan Technological University, Houghton;* [2]*Michigan Department of Natural Resources, Marquette Fisheries Station, Marquette, MI, USA*

Summary

Fixed-location, split-beam sonar technology was used successfully to identify adult lake sturgeon *Acipenser fulvescens* as they moved upstream and downstream for spawning in the Sturgeon River, Michigan, May–June 2004. A Hydroacoustic Technology Inc. Model 241 Split-Beam Echo Sounder operating at 200 kHz and a single 4 × 10° elliptical-beam transducer with a near field range of 1.7 m set perpendicular to the river flow was used. Data collected from migrating lake sturgeon included direction of movement, swimming speed, range from transducer, time and date of passage, and target strength. The spawning population of lake sturgeon was estimated to be at 350–400 fish, with almost equal numbers of fish seen moving upstream as downstream. Most fish were recorded moving within the mid-section of the river, 1.5–1.65 m deep, and swimming speeds upstream were slower than those for downstream moving fish. These results show that spilt-beam sonar can be applied to lake sturgeon assessments, without the stress of actually handling these large, pre-spawning fish.

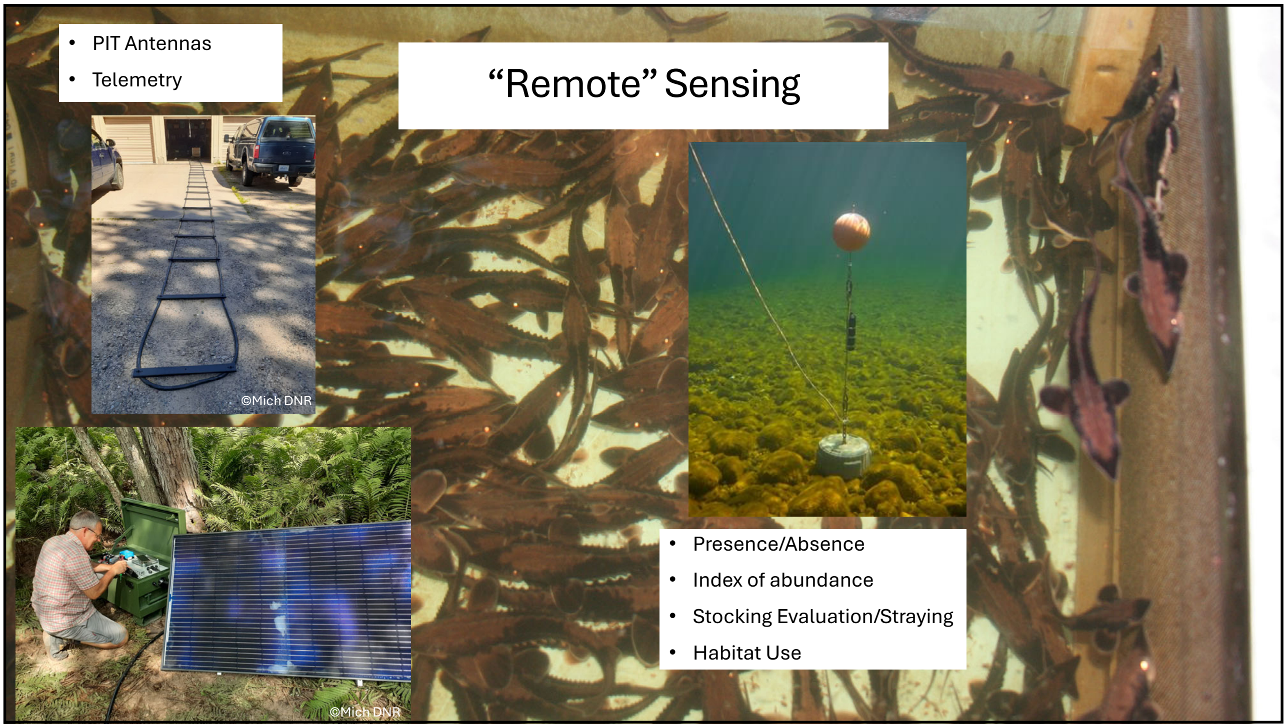
unobtrusive and does not result in fish mortality, an important consideration when dealing with threatened or endangered species. Fixed-location, split-beam hydroacoustic equipment can be deployed in a river and allowed to passively sample fish as they move up- or downstream. Data collected with such gear include fish counts, direction of

- Side-Scan sonar, DIDSON

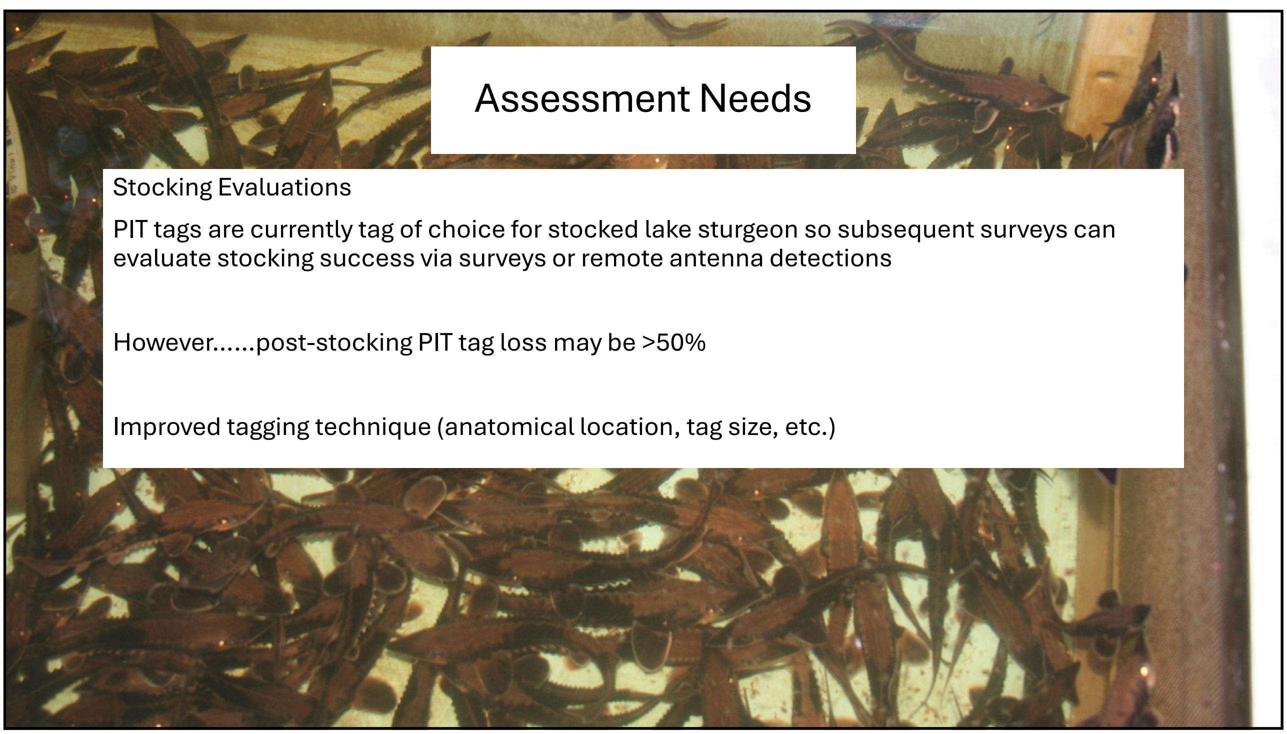


- Presence/Absence
- Index of abundance

8


• PIT Antennas
• Telemetry
"Remote" Sensing
©Mich DNR
©Mich DNR
• Presence/Absence
• Index of abundance
• Stocking Evaluation/Straying
• Habitat Use

9


Assessment Needs
Stocking Evaluations
PIT tags are currently tag of choice for stocked lake sturgeon so subsequent surveys can evaluate stocking success via surveys or remote antenna detections
However……post-stocking PIT tag loss may be >50%
Improved tagging technique (anatomical location, tag size, etc.)

10

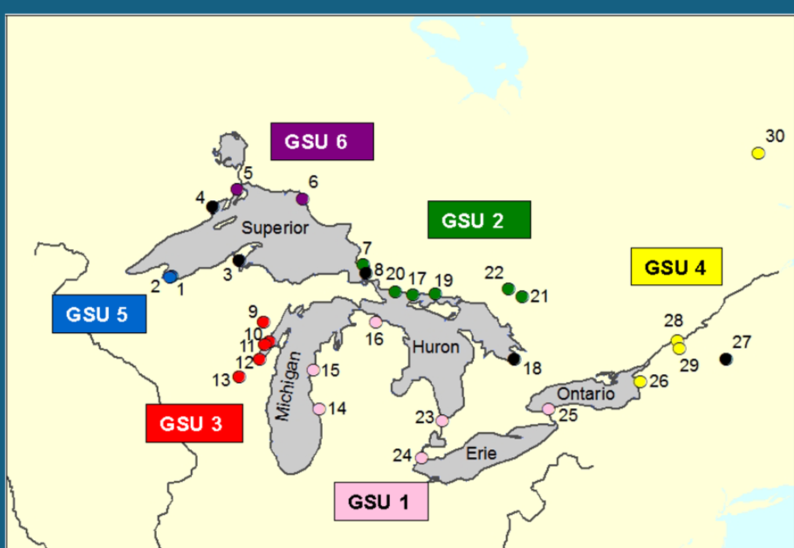

Assessment Needs
Population Parameters
-Abundance
-Survival, recruitment, age/growth, longevity
Aspects of early life history remain a bit of a mystery
J. Appl. Ichthyol. 18 (2002), 519–528
Received: July 8, 2001
Accepted: July 12, 2002
NRC Research Press
REVIEW
Review of a species in peril: what we do not know about lake sturgeon may kill them
Michael S. Pollock, Meghan Carr, Natasha M. Kreitals, and Iain D. Phillips
history: Enigmas, myths, and insights
Revised: 27 June 2018
Accepted: 20 August 2018
WILEY
restimating recovery of sturgeon populations using
pture surveys?
Mike J. Friday
Abstract

11

Status of Lake Sturgeon Genetics

Amy Welsh
West Virginia University

1



Where have we been?

Microsatellites

Welsh et al. (2010) Genetic guidelines for the stocking of lake sturgeon in the Great Lakes basin

2

Assignment Testing

Evaluation of St. Louis River stocking program

- Tracked stocked individuals in Lake Superior
- Identified Sturgeon R. as most successful source stock

Welsh et al. (2019)

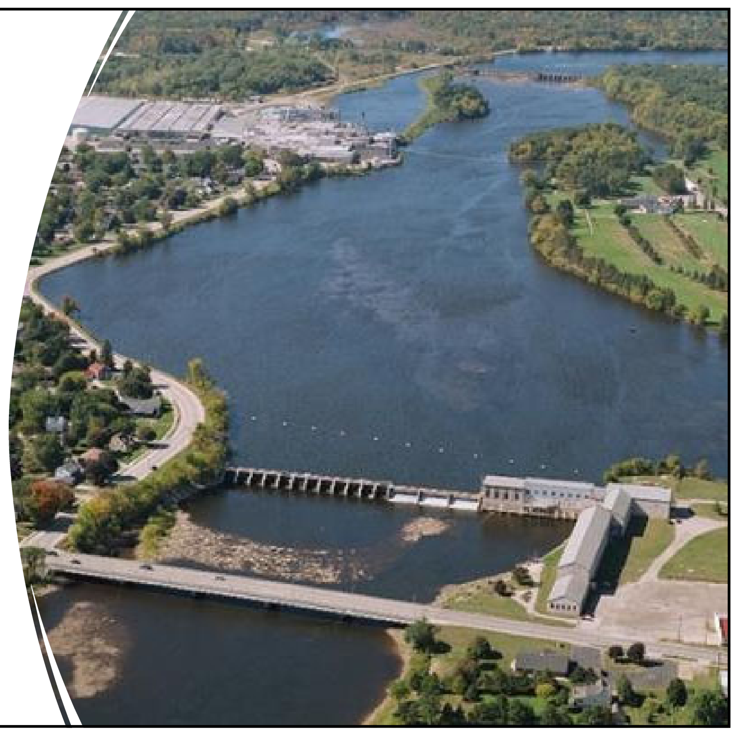
3

Parentage Analysis

Fish passage monitoring

- Fish passed over the Menominee R. dam successfully reproduced, boosting genetic diversity

Forsythe et al. (in review)

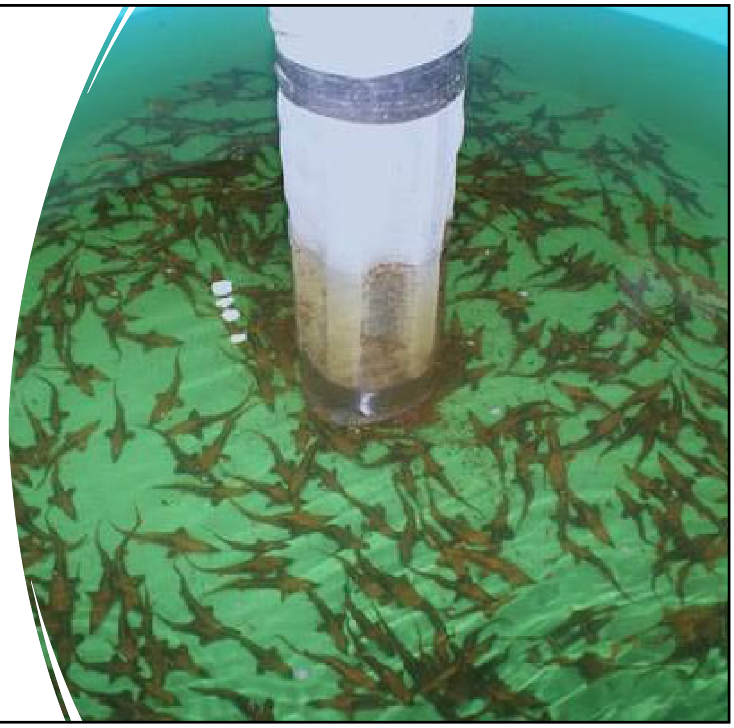


4

Parentage Analysis

Evaluation of stocking success

- Hatchery-reared sturgeon had unequal paternal representation compared to wild-produced sturgeon



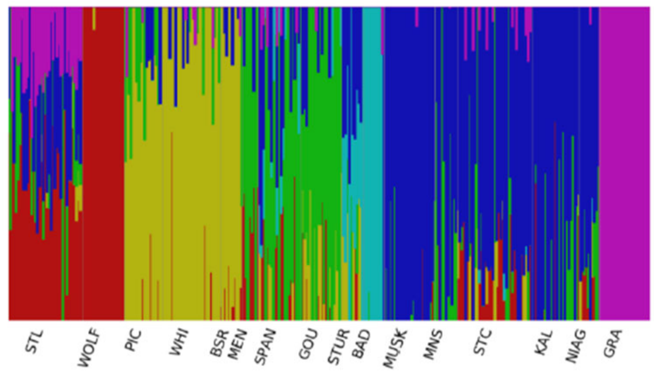
Akers et al. (2023)

5

6

SNP Development

- 116,601 SNPs
- 831 potentially adaptive



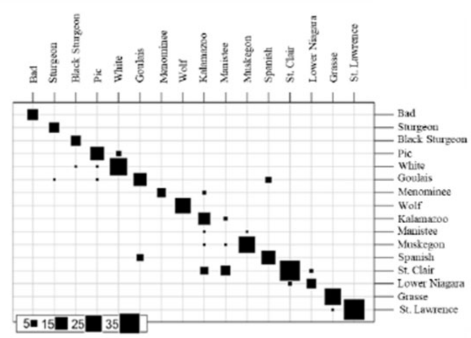
Welsh et al. (2020) GLFT Final Report

7

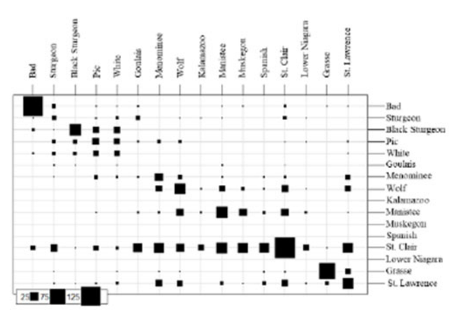
SNP Development

- Greater assignment power than microsatellites

SNPs



Microsatellites



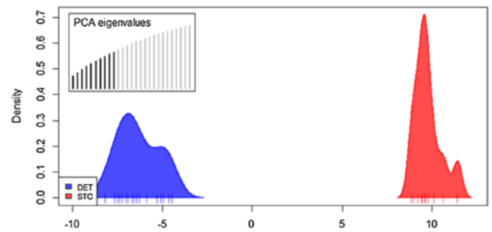
Welsh et al. (2020) GLFT Final Report

8

SNP Panel

- 258 SNPs with highest resolution

Improved Population Delineation



Whitaker et al. (2020)

9

SNP Panel

- 258 SNPs with highest resolution

Greater Assignment Power

More individuals can be assigned with greater confidence

Lake Superior

- Microsatellites: 61.43% of individuals assigned
- SNP panel: 94.29% of individuals assigned

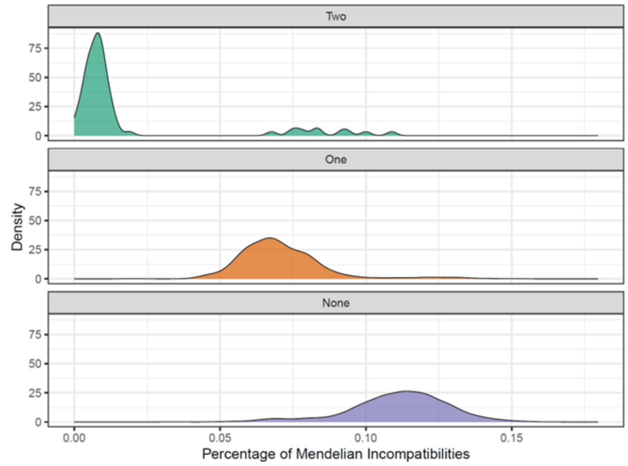
Schumacher et al. *in progress*

10

SNP Panel

- 258 SNPs with highest resolution

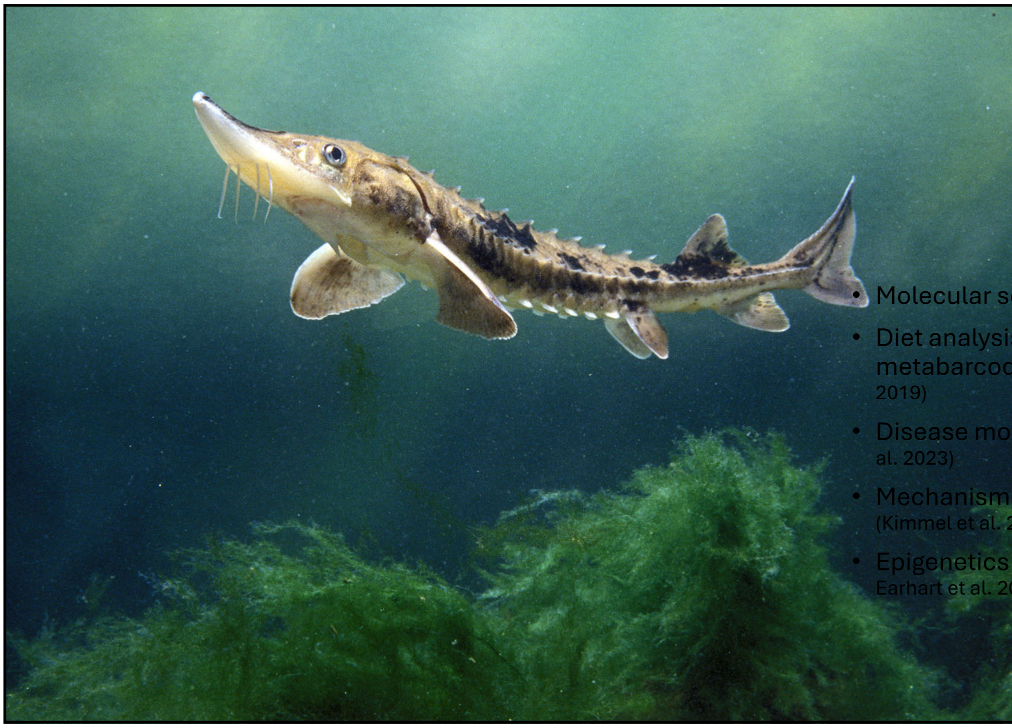
Improved Parentage Testing



Larson et al. (2022) GLFWRA Final Report

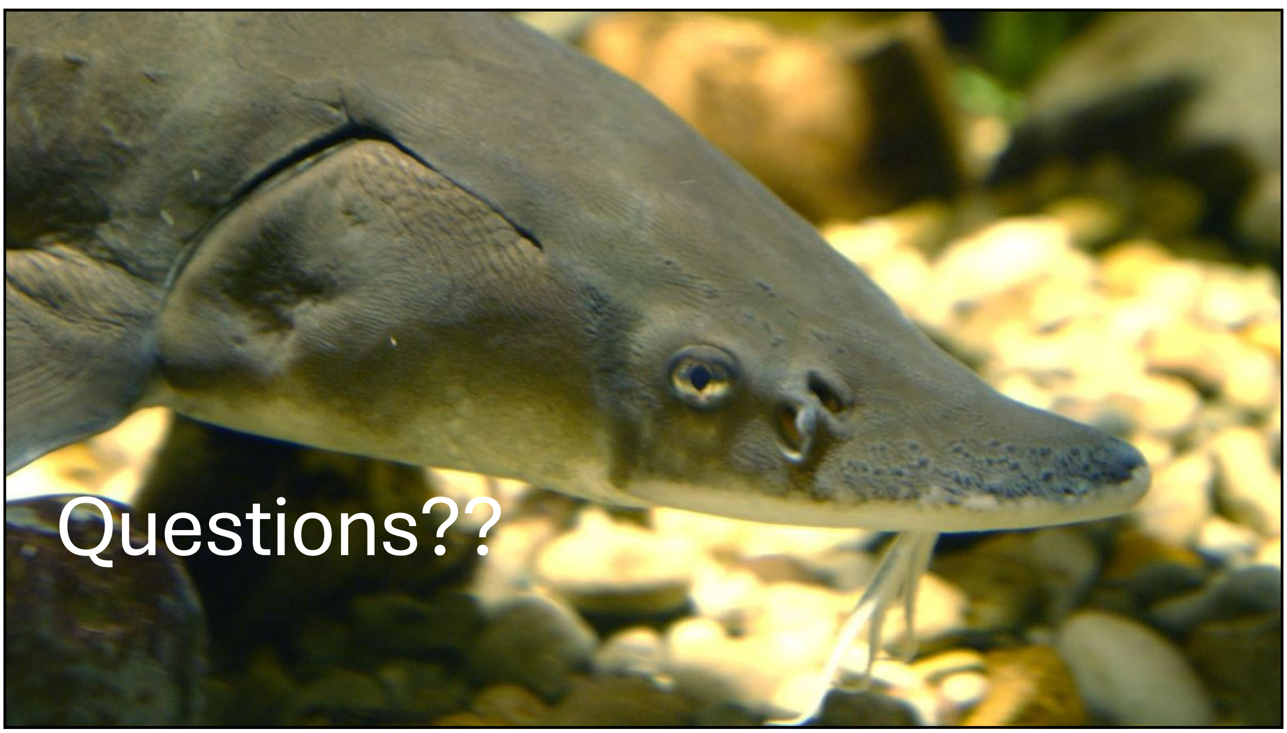
11

12



- Molecular sexing
- Diet analysis through metabarcoding (Waraniak et al. 2019)
- Disease monitoring (Johnston et al. 2023)
- Mechanisms of imprinting (Kimmel et al. 2023)
- Epigenetics (Whitaker et al. 2018, Earhart et al. 2023)

13



14


Great Lakes
Fishery Trust
Lake Sturgeon Workshop
Tribal Cultural Importance of Nmé
and Propagation
Archie Martell - Little River Band of Ottawa Indians

1


Nmé
(Lake Sturgeon)
Stewardship Plan
for the
Big Manistee
River and
1836 Reservation
Little River Band
of Ottawa Indians

2

Little River Band of Ottawa Indians
375 River Street
Manistee MI 49660

Resolution # 03-0910-282

Resolution of support and commitment to the long-term management and assessment of the Maánmég (Lake Sturgeon) in the rivers within the 1836 Reservation, the 1855 Reservation, and in other waters encompassing the 1836 Ceded Territories.

WHEREAS, the Tribal Council is authorized under the Tribal Constitution, Article IV, Section 7(a), "to promote, protect and provide for the public health, peace, morals, education and general welfare of the Little River Band and its members;" and

WHEREAS, the maánmég once were known as the King Fish among the Anishinaabek; and the Anishinaabek who represented the clan of this sacred and magnificent species were the teachers of the community, who also were responsible to speak in council for the other fish clans;

WHEREAS the maánmég, as a sacred clan animal, share a significant and central role in the cultural continuity and identity of the of the Anishinaabek of the Little River Band, and

WHEREAS, the population of maánmég have been severely diminished from the rivers and waters of the 1855 Reservation, the 1855 Reservation, and the 1836 Ceded Territory due to unbridled private and commercial over-harvesting; and

WHEREAS, the Little River Band has committed, through prior Tribal Council action, to the goals of "protecting species of cultural importance" and to "providing for the rehabilitation of Native aquatic speciesˮ found within the 1836/1855 Reservation boundaries and the 1836 Ceded Territories;

3

Goals Toward Stewardship

- Restore the harmony and connectivity between nmé and the Anishinaabek and bring them both back to the river
- Restore the nmé and reclaim the environment on which it depends for future generations of nmé and Anishinaabek in perpetuity
- Emphasize strategies that promote natural reproduction and a healthy watershed
- Protect Tribal sovereignty and Treaty rights

4

7 Generation Target

Return the population to pre-1836 levels and/or to the contemporary carrying capacity of the Big Manistee River. The adult population would be comprised of females age 20-70, and males age 12-55.

"Bringing back the sturgeon is bringing back our cultural heritage." -Patrick Wilson

5

"The grandfather fish (sturgeon), and its relatives the undermouth fish (sucker), they would sacrifice themselves during the sucker moon so the people would have food until the other crops were available." – Jay Sam

"This is a rare fish, rare clan. Decline of the sturgeon has corresponded with decline in sturgeon clan families. Only a few sturgeon clan families are around here." - Kenny Pheasant

6

Streamside Rearing

7

Why Streamside Rearing?

- **Increase likelihood of imprinting and fidelity to target waters**
- **Minimize genetic risks to other populations from potential straying**
- **Supplementing recruitment of wild populations**
- **Reintroducing fish to extirpated systems**

8

9

10

Tribal Cultural Importance of Nmé and Propagation

11

12

Tribal Cultural Importance of Nmé and Propagation

Michigan State University

Black River Streamside Rearing Facility

Doug Larson
Department of Fisheries and Wildlife
Michigan State University

1

Streamside Rearing

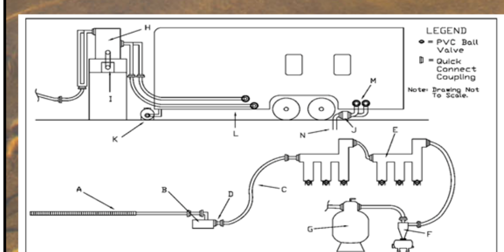


Figure 1 from Holtgren et al. 2007

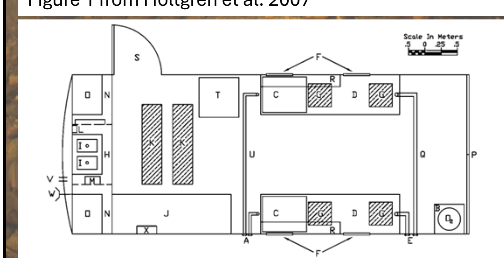
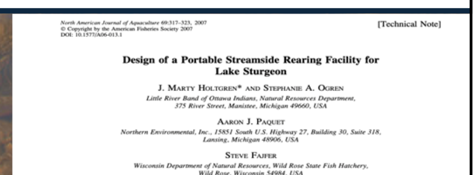


Figure 3 from Holtgren et al. 2007



North American Journal of Aquaculture 69:317–323, 2007
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DOI: 10.1577/A06-013.1

[Technical Note]

Design of a Portable Streamside Rearing Facility for Lake Sturgeon

J. Marty Holtgren* and Stephanie A. Ogren
Little River Band of Ottawa Indians, Natural Resources Department, 375 River Street, Manistee, Michigan 49660, USA

Aaron J. Paquet
Northern Environmental, Inc., 15851 South U.S. Highway 27, Building 30, Suite 318, Lansing, Michigan 48906, USA

Steve Fajfer
Wisconsin Department of Natural Resources, Wild Rose State Fish Hatchery, Wild Rose, Wisconsin 54984, USA

- Pros
  - Cost effective
  - Flexible
  - Imprinting / spawning site fidelity
  - Wild-captured broodstock
- Cons
  - Limited monitoring – remote locations
  - Surface water

Holtgren, J. M., & Ogren, S. A. 2007. Design of a Portable Streamside Rearing Facility for Lake Sturgeon. North American Journal of Aquaculture, 69: 317-323.

2

Black River Streamside Rearing Facility

Brood Sources

Contents lists available at ScienceDirect
Aquaculture
journal homepage: www.elsevier.com/locate/aqua-online

Gamete and larval collection methods and hatchery rearing environments affect levels of genetic diversity in early life stages of lake sturgeon (*Acipenser fulvescens*)

James A. Crossman [a,*], Kim T. Scribner [b], Duong Thuy Yen [a], Christin A. Davis [a], Patrick S. Forsythe [b], Edward A. Baker [c]

[a] Department of Fisheries and Wildlife, Michigan State University, 13 Natural Resources Building, East Lansing, Michigan 48824-1222, USA
[b] Department of Zoology, Michigan State University, 13 Natural Resources Building, East Lansing, Michigan 48824-1222, USA
[c] Michigan Department of Natural Resources, 484 Cherry Creek Road, Marquette, Michigan 49855, USA

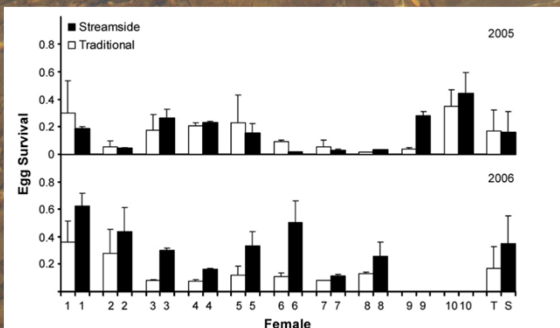


Figure 3 from Crossman et al. 2011

		Streamside hatchery			Traditional hatchery		
		Collection method			Collection method		
Year	Genetic variable	DGT	NPE	DL	DGT	NPE	DL
2005	Mean r_{xy} (variance)	0.067[a] (0.051)	–	0.068[a] (0.034)	0.071[b] (0.060)	–	0.039[a] (0.037)
2006	Mean r_{xy} (variance)	0.082[c] (0.051)	0.065[b] (0.066)	0.008[a] (0.056)	0.079[b] (0.057)	0.052[b] (0.027)	0.011[a] (0.028)
2007	Mean r_{xy} (variance)	0.032[b] (0.043)	0.027[ab] (0.030)	0.015[a] (0.027)	–	–	–
2005	Coancestry	0.029	–	0.008	0.033	–	0.009
2006	Coancestry	0.03	0.003	0.005	0.043	0.019	0.004
2007	Coancestry	0.019	0.012	0.005	–	–	–
2005	N_b (95% CI)	11.0 (8.6–13.5)	–	28.2 (22.9–34.5)	11.8 (9.6–14.2)	–	41.3 (33.3–51.5)
2006	N_b (95% CI)	12.9 (10.7–15.3)	88.0 (39–1985)	146.8 (103–224)	7.2 (5.6–8.8)	43.0 (17.9–inf)	103.3 (67.4–186.7)
2007	N_b (95% CI)	16.3 (13.4–19.4)	31.2 (17.8–73.4)	126 (105–150)	–	–	–
2005	N_{bv}	29.4	–	101.5	26.7	–	120.3
2006	N_{bv}	26.2	95.9	176.7	15.0	35.8	247.9
2007	N_{bv}	38.6	45.7	181.3	–	–	–

Table 2 from Crossman et al. 2011

3

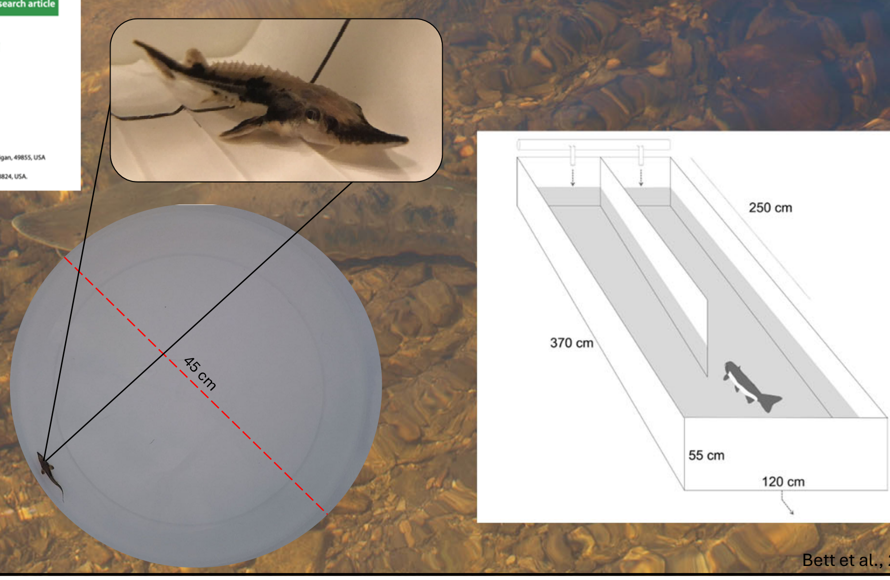
Streamside Rearing

Conservation Physiology
Volume 11 • 2023
10.1093/conphys/coad045
Research article

Behavioral evidence of olfactory imprinting during embryonic and larval stages in lake sturgeon

Jacob G. Kimmel[1], Tyler J. Buchinger[1], Douglas L. Larson[1], Edward A. Baker[2], Troy G. Zorn[2], Kim T. Scribner[1,3] and Weiming Li[1,*]

[1] Department of Fisheries and Wildlife, Michigan State University, 480 Wilson Road, East Lansing MI 48824, USA
[2] Michigan Department of Natural Resources, Marquette Fisheries Research Station, 484 Cherry Creek Road, Marquette, Michigan, 49855, USA
[3] Department of Integrative Biology, Michigan State University, 288 Farm Lane, East Lansing MI 48824, USA
*Corresponding author: Department of Fisheries and Wildlife, Michigan State University, 480 Wilson Road, East Lansing MI 48824, USA. Email: Liweim@msu.edu

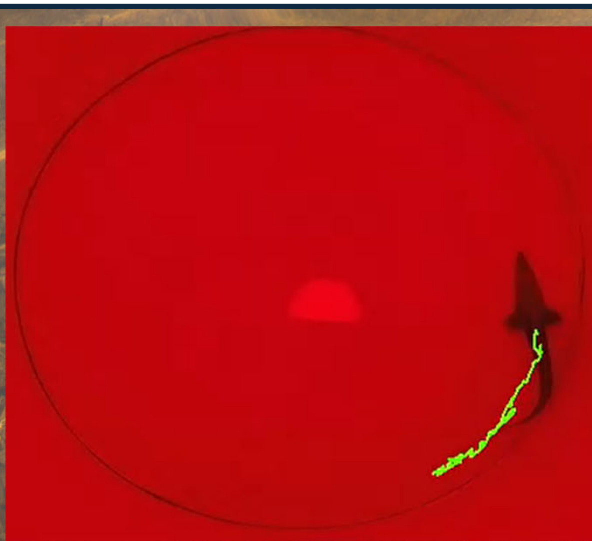


Bett et al., 2016

4

Black River Streamside Rearing Facility

Imprinting / Natal Memory

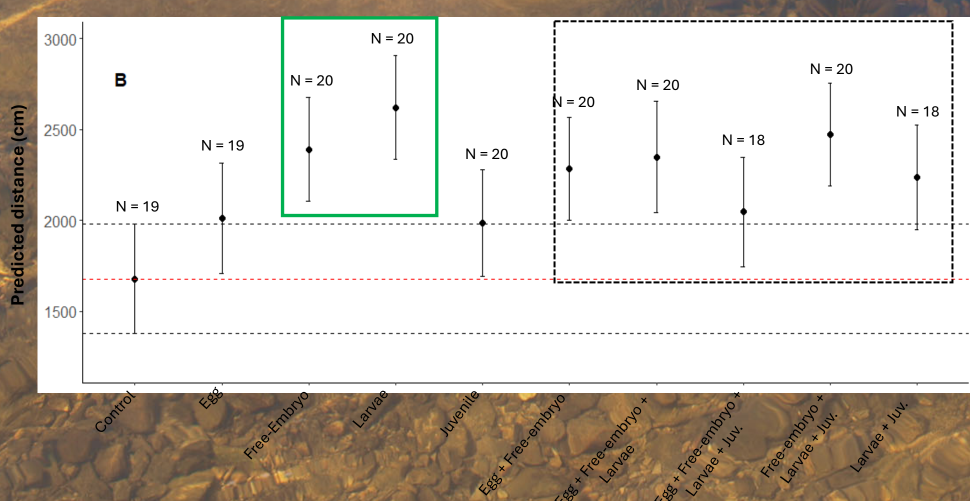


	Avg. acceleration	Avg. deacceleration	Time active (%)	Time active (s)	Time inactive (s)	Time inactive (%)	Distance Traveled
Avg. velocity	0.98	-0.98	0.36	0.35	-0.34	-0.36	0.89
Avg. acceleration		-1.00	0.27	0.26	-0.27	-0.27	0.84
Avg. deacceleration			-0.27	-0.26	0.27	0.27	-0.84
Time active (%)				0.99	-0.97	-1.00	0.66
Time active (s)					-0.93	-0.99	0.66
Time inactive (s)						0.97	-0.63
Time inactive (%)							-0.66

5

Imprinting / Natal Memory

Behavior results: predicted responses



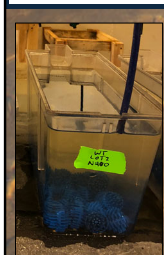
6

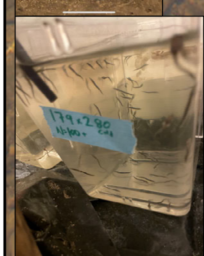
Imprinting / Natal Memory

Ok, so what?

7

Hatchery Rearing





- Density
  - [1]Free embryo/juvenile: <9,688 individuals / m^2 is optimal 150 individuals at emergence (5.85 g / m^2)
    - 25 individuals at larval feeding (12.5 g / m^2)
    - 3L aquaria
  - [2]Juvenile:150 – 450 individuals / m^2
    - 1.35 – 3.75 kg/m^2
- Feeding
  - [3]Sturgeon feed most efficiently when fed episodically (3x per day)
  - [3,4]Survival highest when fed live feeds.
  - [3]Feeding Prescription
    - Week 1/2 - 28% BW (Brine Shrimp)
    - Week 3 – 13% BW (Brine / BW intro)
    - Week 4 - 11% BW (50:50 BS:BW)
    - Week 5+ - 5-7% BW (BW)

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TECHNICAL NOTE

Effects of Rearing Density on Total Length and Survival of Lake Sturgeon Free Embryos

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COMMUNICATION

Effects of Family, Feeding Frequency, and Alternate Food Type on Body Size and Survival of Hatchery-Produced and Wild-Caught Lake Sturgeon Larvae

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TECHNICAL NOTE

Effects of Alternative Food Types on Body Size and Survival of Hatchery-Reared Lake Sturgeon Larvae

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Black River Streamside Rearing Facility

Hatchery Rearing – Sex Bias

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/ijglr

ELSEVIER IAGLR

Multi-year evidence of unbiased sex ratios in hatchery and wild-reared age-0 lake sturgeon (*Acipenser fulvescens*)

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- AllWSex2 acipenserid sexing marker
- Surviving stocked hatchery fish and hatchery mortalities.
- No evidence of sex selection during streamside rearing.

		2016			2017			2018		
		Alive	Dead	Proportion	Alive	Dead	Proportion	Alive	Dead	Proportion
Hatchery-reared larvae	Male	25	20	54.9 %	103	101	53.4 %	252	225	50.5 %
	Female	16	21	45.1 %	88	90	46.6 %	220	247	49.5 %
	Total	41	41	–	191	191	–	472	472	–
Wild-captured age-0	Male	–	–	–	3	–	27.3 %	16	–	40.0 %
	Female	–	–	–	8	–	72.7 %	24	–	60.0 %
	Total	–	–	–	11	–	–	40	–	–
Total drift larvae collected	4,053		19,135		48,048					

9

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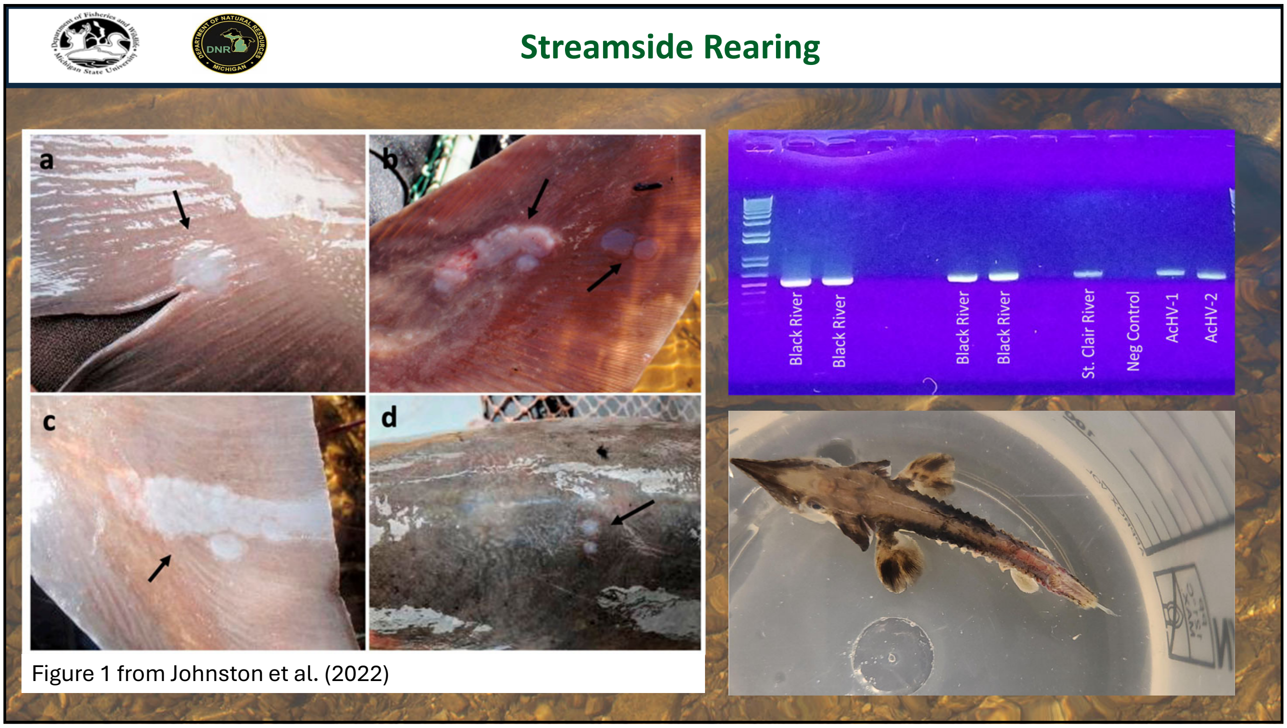

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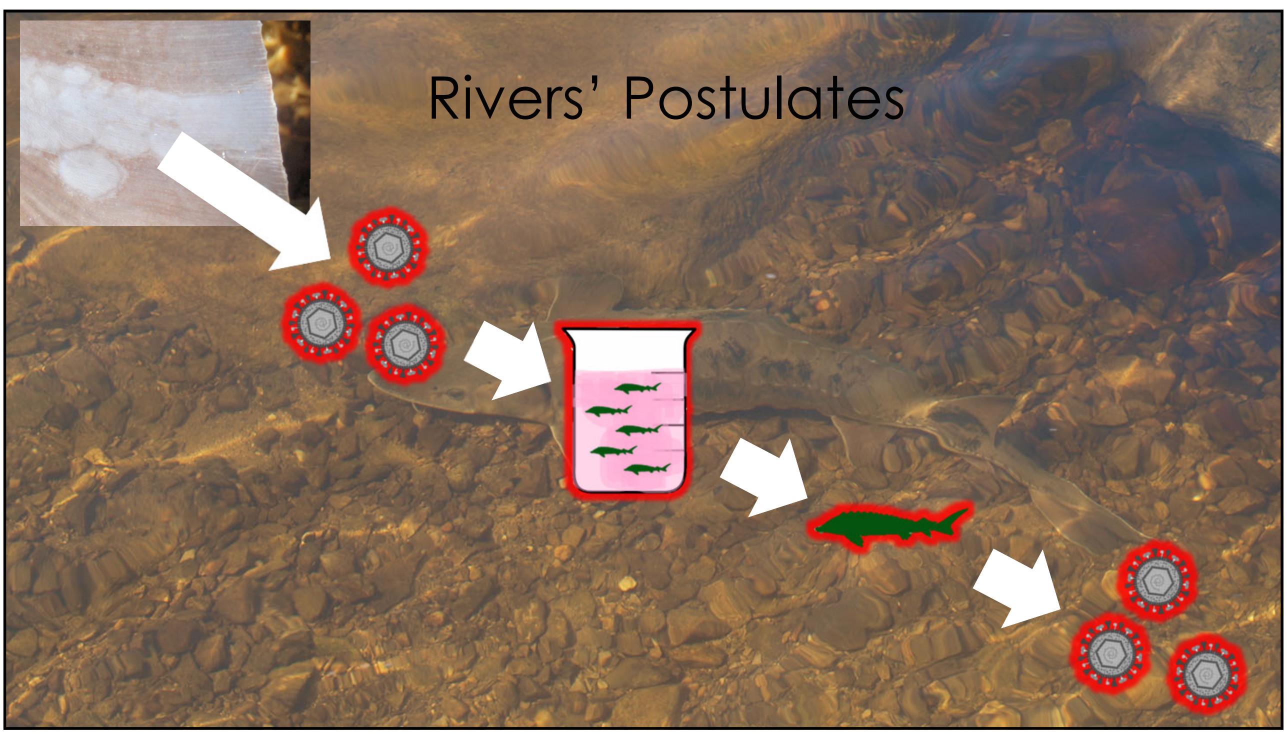

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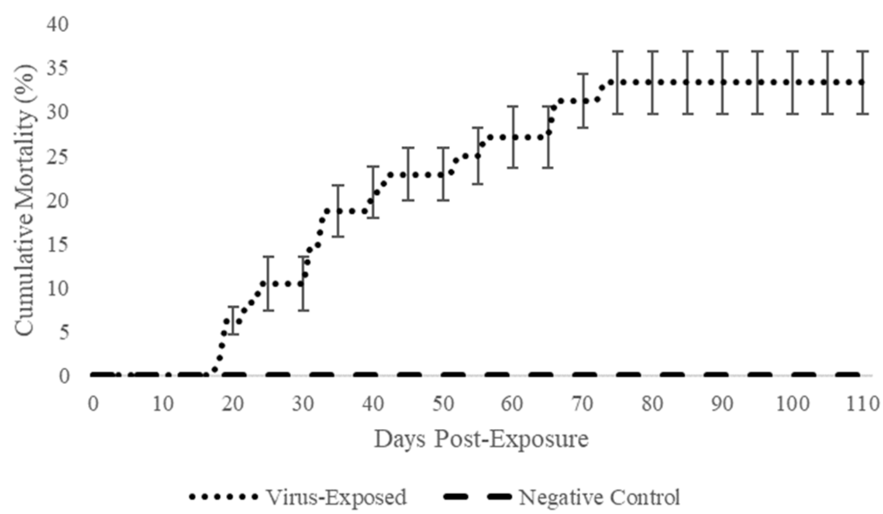
Black River Streamside Rearing Facility

Disinfectants in Aquaculture



Johnston et al 2022

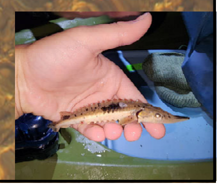
13

Disinfectants in Aquaculture

14

Summary

- Live capture ideal for genetic health.
- Sturgeon exhibit natal memory.
- Rearing methodology is well described.
- No evidence of sex bias in hatcheries.
- Fish health remains an area of concern.



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Going Forward

- Sturgeon rearing – where should we invest our resources?
  - Fish Health
  - Aquatic Animal Drugs
  - Long-term estimates of tag loss

16

Artificial Propagation

Propagation Technology and Methods have now been well established

Cost-effective Artificial Propagation Techniques and Associated Strategies

Artificial propagation for population recovery was identified as the area with greatest research advancements since 2000 (3.42) and least need for remaining atop the priority list (3.08, indicating only moderate agreement on average). Importantly, these results varied by organization type, with some respondents suggesting research in this area remains insufficient and needs to remain a priority. Lack of knowledge in this area was ranked fifth overall in terms of threat to populations, and fourth regarding the immediacy of that threat. The biggest identified knowledge gaps in this area center around assessing the impacts of these techniques on sustainable populations. In particular, there is an identified need to compare fish emerging from streamside and traditional hatcheries, as well as comparing those groups to wild individuals. Comparison needs include survival, behavior, and imprinting. Additional knowledge gaps included how to address staffing and infrastructure/equipment needs, cost reduction, and specific propagation techniques.

1

Selection of Broodstock Source

Natural Spawning

- Temperature and flow dependent
- Collecting gametes from actively spawning fish
- Sometimes Remote Locations
- Partnerships

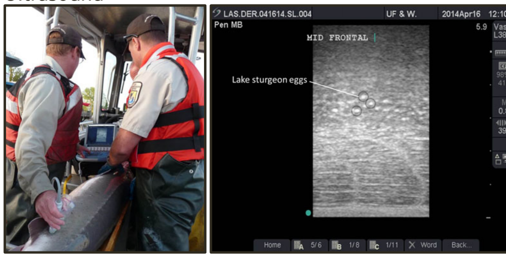
Broodstock Collection and Induction

- Site selection (partnerships)
- Electrofishing, gill nets, set lines
- Infrastructure: tanks, pumps, alarms
- Monitoring Adults in holding tanks
- Induction

2

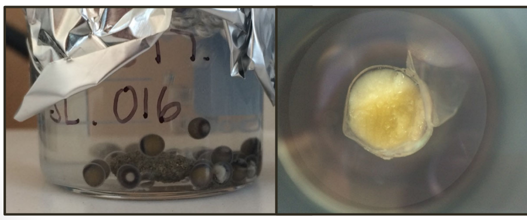
Sex Determination and Maturity

Ultrasound

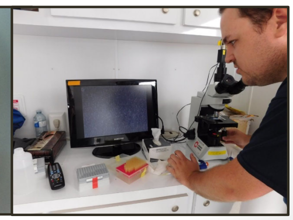


Egg Extraction

Progesterone assay and Polarization Index



Sperm Motility



3

Hormone Injection

- Aquatic Animal Drug Approval Partnership Program(AADAP) and (INAD) program
- Common Carp Pituitary (CCP)
- Luteinizing Hormone-Releasing Hormone (LHRHa)
- Note: Challenges: CCP out of stock in 2024

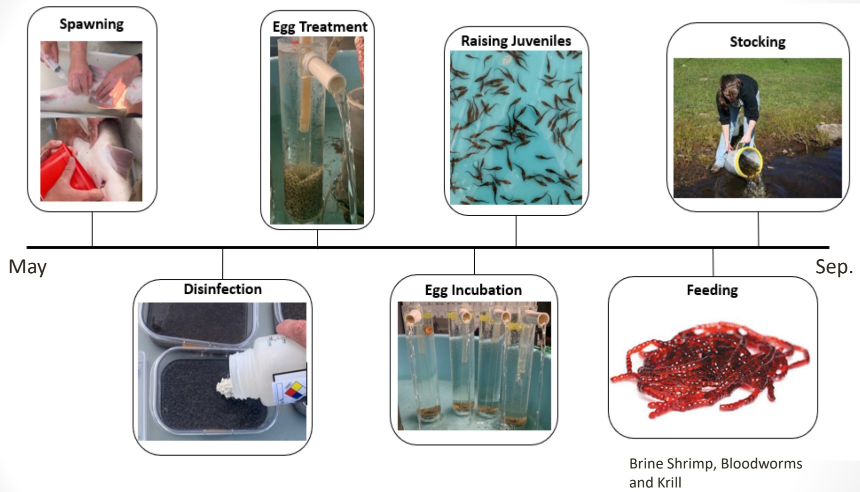
Induction Sequence

1. Midnight (hour 0), female 10%, male not handled
2. Noon (hour 12), female 90%, male 100%
3. morning (hour 32), female should show signs of maturation (eggs dropped), males ready for sperm harvest

Gamete Collection and Fertilization

4

Lake Sturgeon Propagation



5

Genetic Considerations

Hatchery Considerations:

- Shift to stocking less fish from a given year class with increased number of female and male contribution
- Maximize the number of parents used for each generation
- Equalize family contributions
- Question: How do hatcheries and streamside trailers need to adapt infrastructure and operations to successfully meet stocking objectives?

	Number of parents	Female 3	4	5	6	7	8	9	10	11	12
Male	4		8.0								
	5		8.9	10.0							
	6	8.0	9.6	10.9	12.0						
	7	8.4	10.2	11.7	12.9	14.0					
	8	8.7	10.7	12.3	13.7	14.9	16.0				
	9	9.0	11.1	12.9	14.4	15.7	16.9	18.0			
	10	9.2	11.4	13.3	15.0	16.5	17.8	19.0	20.0		
	11	9.4	11.7	13.8	15.5	17.1	18.5	19.8	20.6	22.0	
	12	9.5	12.0	14.1	16.0	17.7	19.1	20.6	21.8	23.0	24.0
	13	9.8	12.2	14.4	16.4	18.2	19.8	21.3	22.6	23.8	25.0
	14	9.9	12.4	14.7	16.8	18.7	20.4	21.9	23.3	24.6	25.8
	15	10.0	12.6	15.0	17.1	19.1	20.9	22.5	24.0	25.4	26.7
	16	10.1	12.8	15.2	17.5	19.5	21.3	23.0	24.6	26.1	27.4
	17	10.2	13.0	15.5	17.7	19.8	21.8	23.5	25.2	26.7	28.1
	18	10.3	13.1	15.7	18.0	20.2	22.2	24.0	25.7	27.3	28.8
	19	10.4	13.2	15.8	18.2	20.5	22.5	24.4	26.2	27.9	29.4
	20	10.4	13.3	16.0	18.5	20.7	22.9	24.8	26.7	28.4	30.0

$N_e \geq 20$

Welsh et al. 2010

6

Staffing, Infrastructure, Equipment

Maximize the number of parents used for each generation

- Hatching and rearing space constraints in Traditional and Streamside facilities
  - For Example: Traditional Hatcheries rearing 6 strains of lake sturgeon may need up to 60 larval tanks for initial rearing if 10 females were collected from each strain.
- Cost Associated with expanding infrastructure
- Increased Staffing levels (Operation Budgets $)

Equalizing family Contributions:

Question? Should family groups remain separate until stocking? or Identify appropriate time to equalize family units for grow out prior to stocking.

7

Rearing Density

- Higher the Density = Slower growth
- Density = fish health
- Goal: Bigger fish = Increased Survival post Stocking

"Surplus Fish"

- Management Decisions Regarding "Surplus Fish"?
- Cull? When to Cull?
- Stock fish early?
  - Un-tagged/marked
  - Fish health certificates
  - If decision is made to stock, how many?

8

Increased Interest in stocking new tributaries

- How many tributaries can/should be stocked with fish from a single year class?

Can we meet the demand for egg requests?

Example: WI DNR Wisconsin River Egg requests

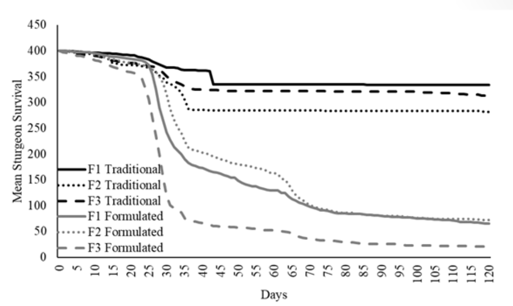
- Wild Rose State Fish Hatchery
- Minnesota Department of Natural Resources
- South Dakota Game Fish and Parks
- Lost Valley Fish Hatchery-MO DOC
- Neosho National Fish Hatchery
- Genoa National Fish Hatchery
- Illinois Jake Wolf Memorial Fish Hatchery
- Iowa Department of Natural Resources

9

Cost: Cost-effective alternatives

Feeding

- Picky eaters'
- Traditional diets mimic wild diets (Aloisi et al. 2006)
  - Effective but expensive
  - **Contaminants**
- Formulated diets as cheaper alternatives



Question? Could we reach target stocking numbers if bloodworms were not available? Further research to evaluate contaminants/heavy metals in bloodworms and long-term effects or since bloodworms are fed generally a short period of time are we not concerned? Or investigation into an alternative live feed transition (Brine Shrimp - ? - Krill)

10

Tagging and Marking

- Provide insight on appropriate PIT tag size (8mm and 12mm) for different size class and recommended post-tag holding time.

Objectives

- Determine if PIT tag size influences retention, growth, & survival of three size classes of age-0 Lake Sturgeon:
  - Small (75-125 mm), mid (126-175 mm), & large (176->200 mm)
- Provide insight on the appropriate tag size for different size classes & a recommended post-tag holding threshold

Results – Tag Retention

- VetBond© did not increase tag retention
- Although tag loss was greatest within two weeks after tagging, with 76% of tag loss occurring during this time, fish continued to lose tags up to 63 days post-tagging

Retention Rate		
Size Class	**8-mm**	**12-mm**
Small	95%	68%
Mid	100%	85%
Large	100%	100%

- Are retention rates similar at traditional hatcheries compared to streamside facilities?
- How long should fish be held post tagging to ensure tag retention?

11

Survival of Stocked fish

- Survival increases with stocking size (Baker and Scribner 2017)
- Hatchery fish released at 18cm
  - 80% survival

Question?

- How does survival rate differ based on stocking location?
- Are survival rates the same between hatchery and streamside reared fish?

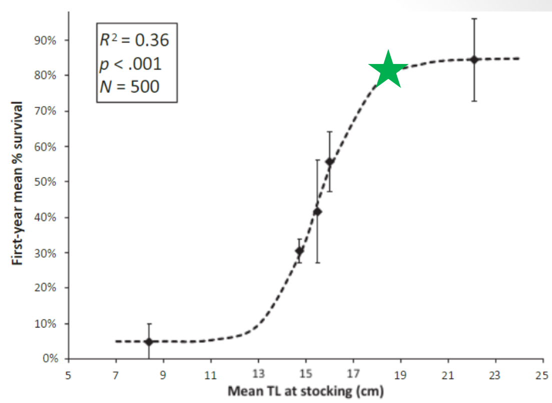
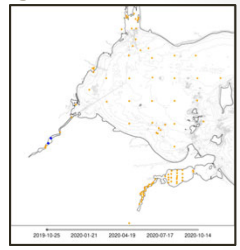


FIGURE 4 Estimated first-year mean % survival for age-0 lake sturgeon, *Acipenser fulvescens*, stocked in Black Lake, Michigan (USA) as a function of average fish size (TL, cm) at stocking (does not include estimate for 2007 year class). Error bars = 95% confidence intervals of the mean % survival

Management decisions on stocking rates rely heavily on estimated survival rates

12

Comparing Fish from Streamside and Hatchery



Red = Genoa
Blue = Toledo Zoo

Annually stock 3,000 fingerlings into Maumee River (1,500 streamside; 1,500 Genoa National Fish Hatchery) – **EVALUATE IMPRINTING**

Do lake sturgeon cultured in a streamside rearing facility exhibit higher stocking site fidelity rates (i.e., a surrogate measure for natal imprinting) than lake sturgeon reared at another locale (i.e., Genoa National Fish Hatchery)?

- Adult returns

13

MEMBERS ONLY SPORTS NORTHLAND OUTDOORS

Spawning spectacle in Otter Tail River is big news in efforts to restore lake sturgeon to Red River Basin

Sturgeon – dozens upon dozens of them – congregated in an obvious act of spawning, the first verified sighting in more than 100 years of lake sturgeon actively spawning in the Red River Basin.

Lake sturgeon by the dozens congregated to spawn Thursday, May 19, 2022, in the Upper Otter Tail River. The effort marked the first verified spawning of lake sturgeon in the Red River Basin since efforts to re-establish the species began in the late 1990s and marks a huge step in the ongoing recovery program. Contributed / Nick Kludt, Minnesota DNR

- We now have reproductive age fish from hatchery stocking
- Next steps to verify natural reproduction
- Additionally, in 2024 Evidence of lake sturgeon spawning in the Missouri River's Osage River
- Research opportunities

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