Juvenile Lake Sturgeon Downstream Passage and Survival at Two Hydroelectric Dams

Jonathan Hegna1, Kim Scribner1, Edward Baker2
1Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan 48824
2Michigan Department of Natural Resources, Marquette, Michigan 49855

Introduction

Today lake sturgeon are estimated to be at only 1% of their historical abundance, and they are listed as threatened in almost all Great Lakes states (Tody1974; Peterson et al., 2007). Hydroelectric dams are thought to be one of the major factors preventing the restoration of lake sturgeon in the great lakes (Ferguson et al., 1997; Coscarelliet al., 2011). Dams are thought to limit access to important spawning habitat in many river basins (Coscarelliet al., 2011; Peterson et al., 2007). In addition, dams are thought to limit access to vital larval and juvenile rearing habitats (Coscarelliet al., 2011; Peterson et al., 2007). Moreover, dams fragment populations and lower genetic diversity and the long-term viability of populations (Ferguson et al., 1997; Jageret al., 2001). Finally, hydroelectric dams are known to entrain large numbers of fish and cause substantial mortality (Johnston et al., 1993; McDougall et al., 2013). Taken together, these negative factors caused by damsare thought to significantly affect lake sturgeon carrying capacities, recruitment, adaptability, and productivity (Ferguson et al., 1997; Coscarelliet al., 2011; Peterson et al., 2007; Jageret al., 2001).

Passing lake sturgeon up and downstream of hydroelectric dams is a major priority for management; however, there are substantial knowledge gaps about juvenile lake sturgeon passage behavior and survival. To date little information is available on mortality rates for larval or juvenile lake sturgeon passage through turbines or spillways, nor is there information on how multiple passage events influence survival. To this effect, we put together a research project designed to investigate the passage behavior and survival of juvenile lake sturgeon at two different hydroelectric dams (i.e., KleberDam and Tower Dam) in Northern Michigan. The data presented in this poster is from a pilot study that was done to inform the development of year round RFID and acoustic monitoring systems for a two year passage and survival study starting in 2015.

Juvenile Lake Sturgeon Downstream Passage and Survival at Two Hydroelectric Dams

Jonathan Hegna1, Kim Scribner1, Edward Baker2
1Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan 48824
2Michigan Department of Natural Resources, Marquette, Michigan 49855

Methodology

- Tower Dam and Kleber Dam were chosen for our evaluation of juvenile lake sturgeon passage behavior and survival in Northern Michigan (Figure 1).
- Radio frequency identification (RFID) technology was employed to setup multiple detection systems termed "PIT-tag Interrogation Systems" below both dams. We specifically used HDX long range readers manufactured by Oregon RFID.
- A PIT-tag interrogation system consists of an antenna, tuning equipment, antenna controller, and a data logger.
- For this 2014 pilot project a stream wide (75 ft) PIT-tag interrogation system was installed approximately 200 meters below both hydroelectric dams (Figure 2; Figure 3). Other PIT-tag interrogation systems were built, but none were sufficiently operational for the 2014 pilot project. Consequently, route specific survival information is not available.

Figure 1: Aerial map showing the location of Tower Dam, Kleber Dam, Black River, and Black Lake in Northern Michigan.

- Juvenile lake sturgeon for the project were produced at the Black River Sturgeon Facility through wild broodstock collection on the Black River.
- Once the juvenile lake sturgeon reached approximately 180 mm TL they were surgically implanted with a 23 mm HDX PIT-tag (weight: 0.6 g) through performing a laparotomy.
- 54 age-1 and 300 age-0 lake sturgeon were stocked upstream of each reservoir at the same time. All lake sturgeon were stocked on September 26th, 2014.

Figure 2: Aerial map showing the location of PIT-tag interrogation systems near Tower Dam. Green rectangles represent PIT-tag interrogations systems that were fully operational for this 2014 pilot study, while the red rectangles represent PIT-tag interrogation systems that will be fully operational in 2015.

Figure 3: Aerial map showing the location of PIT-tag interrogation systems near Kleber Dam. Green rectangles represent PIT-tag interrogations systems that were fully operational for this 2014 pilot study, while the red rectangles represent PIT-tag interrogation systems that will be fully operational in 2015.

Juvenile Lake Sturgeon Downstream Passage and Survival at Two Hydroelectric Dams

Jonathan Hegna1, Kim Scribner1, Edward Baker2
1Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan 48824
2Michigan Department of Natural Resources, Marquette, Michigan 49855

Results

- PIT-tag monitoring occurred from 26 September, 2014 to 31 December, 2014.
- 109 juvenile lake sturgeon passed through at least one hydroelectric dam.
- Approximately 95 lake sturgeon are thought to have survived their passage downstream through either Tower Dam or Kleber Dam.
- 35 age-0 and 19 age-1 lake sturgeon passed downstream through Tower Dam.
- 29 age-0 and 12 age-1 lake sturgeon that were originally stocked into Kleber Reservoir passed downstream through Kleber Dam.
- 10 age-0 and 14 age-1 lake sturgeon passed downstream through both hydroelectric dams.
- 7 age-1 lake sturgeon were found dead on the Tower Dam fish screens (2.5 cm spacing), while none were found dead on the fish screens (7.6 cm spacing) at Kleber Dam.
- 88% of passage events at Tower Dam took place at night.
- 94% of passage events at Kleber Dam took place at night.
- An unknown number of juvenile lake sturgeon may have taken up residency in Tower and Kleber Reservoirs for a period of time.
- An unknown number of juvenile lake sturgeon may have been killed directly during passage through the hydroelectric dams via the spillway or turbines.

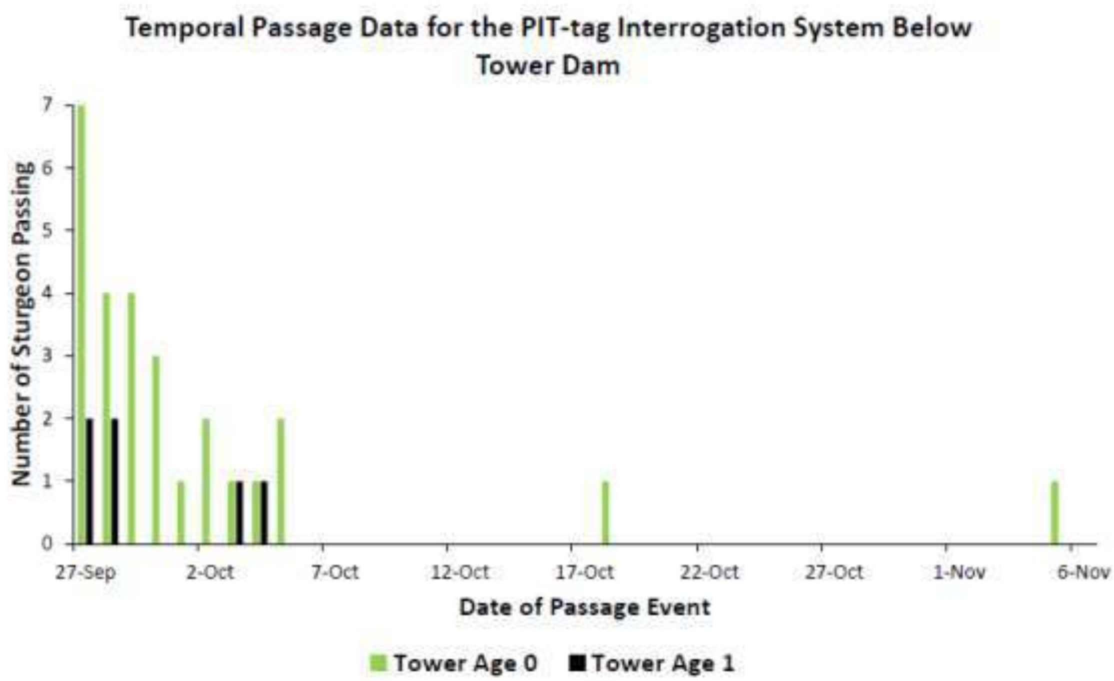


Figure 4: Temporal PIT-tag detection data from the PIT-tag interrogation system below Tower Dam. The age-0 and age-1 lake sturgeon were all stocked on September 26th, 2014 into Tower Reservoir. All lake sturgeon that reached this interrogation system are presumed to have survived passage through the hydroelectric dam. Route specific passage (i.e., spillway or turbines) was not determined. It should be noted that a number of lake sturgeon passed this PIT-tag interrogation site without being detected, but were later detected below Kleber Dam.

Jonathan Hegna1, Kim Scribner1, Edward Baker2

1Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan 48824

2Michigan Department of Natural Resources, Marquette, Michigan 49855

Results (continued)

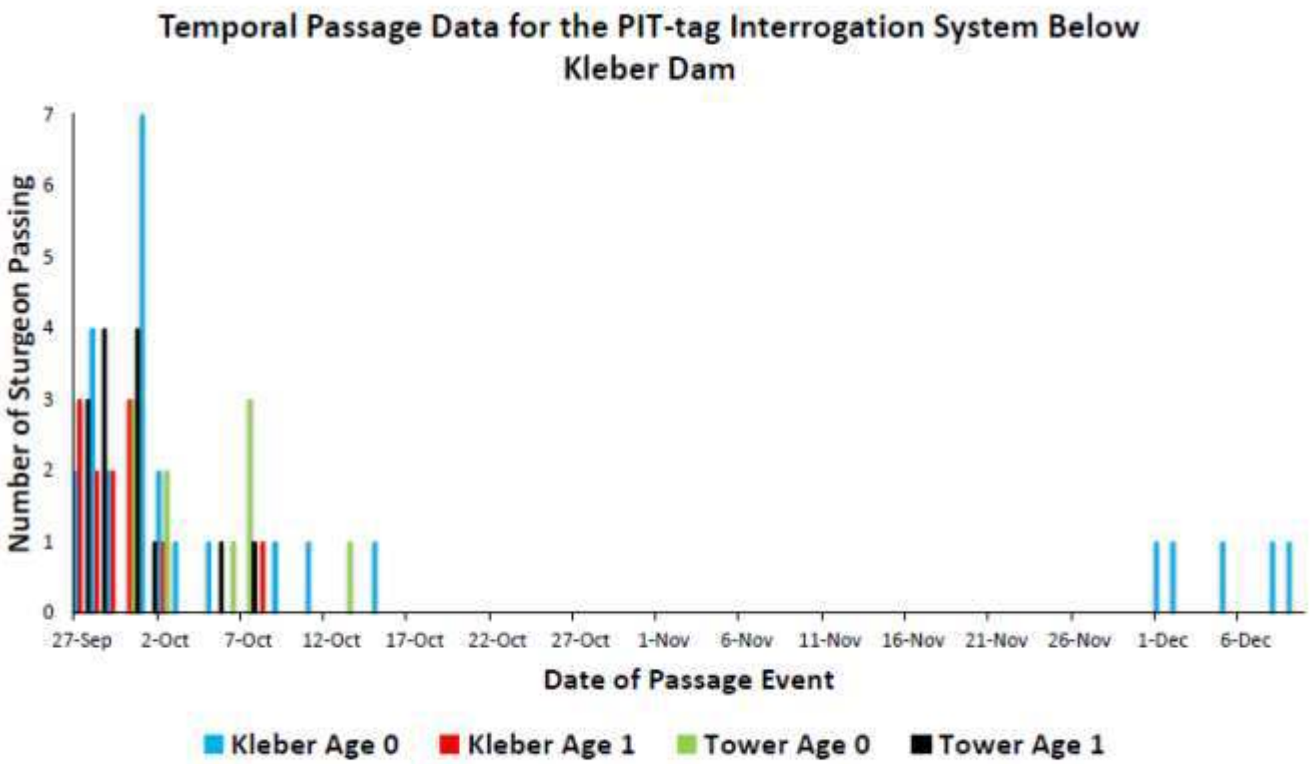


Figure 5: Temporal PIT-tag detection data from the PIT-tag Interrogation system below Kleber Dam. The age-0 and age-1 lake sturgeon were all stocked on September 26th, 2014 into either Tower Reservoir or Kleber Reservoir. All lake sturgeon that reached this interrogation system are presumed to have survived passage through the hydroelectric dam. Route specific passage (i.e., spillway or turbines) was not determined.

Table 1: Descriptive passage information for age-0 and age-1 lake sturgeon stocked into tower and kleber reservoirs between September and December of 2014.

Stocking Location and Age Group	Total Number Stocked	Total Number Passing Tower Dam	Total Number Passing Kleber Dam	Total Number Dying on Tower Dam Fish Screen	Total Number Dying on Kleber Dam Fish Screen
Tower Age-0	300	35	10	0	0
Tower Age-1	54	19	14	7	0
Kleber Age-0	300	NA	29	NA	0
Kleber Age-1	54	NA	12	NA	0

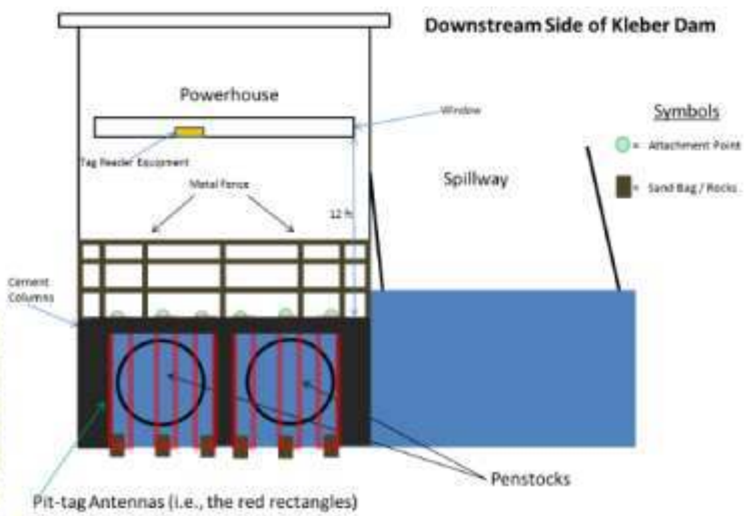
Juvenile Lake Sturgeon Downstream Passage and Survival at Two Hydroelectric Dams

Jonathan Hegna[1], Kim Scribner[1], Edward Baker[2]
[1]Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan 48824
[2]Michigan Department of Natural Resources, Marquette, Michigan 49855

Current Research

Starting in 2015 we will be implementing a two year passage and survival study that will examine age-0, age-1, and age-2 lake sturgeon. We will finish installing RFID PIT-tag interrogation systems at the powerhouses and spillways of both dams to provide route specific survival information (Figure 2; Figure 3). We will also be installing two PIT-tag interrogation antennas at the mouth of the Black River where it enters into Black Lake (Figure 1). This will allow us to look at natural and delayed mortality due to passage through a hydroelectric dam. In addition, it will allow us to examine in-stream residency time for juvenile lake sturgeon.

We will also be using acoustic telemetry to examine fine scale passage behavior. We will use the Juvenile Salmonid Acoustic Telemetry System (JSATS) that was developed by the Pacific Northwest National Laboratory and the United States Army Corps of Engineers for research on salmon smolts in the Columbia River. The JSATS system uses a 416.7 KHz BPSK coded digital sound signal, and JSATS transmitters are able to transmit their signal in 744 microseconds. This largely eliminates problems with multi-path and signal collisions. Hydrophone arrays will be deployed in front of both Tower Dam and Kleber Dam to allow for fine scale 2D acoustic positioning. This will allow passage route (i.e., spillway or turbines), forebay residency time, number of passage attempts, impingement mortality, and fine scale passage behavior to be determined. We are currently planning on tagging and monitoring 100 age-0, 100 age-1, and 100 age-2 juvenile lake sturgeon over two years with JSATS acoustic transmitters. We will use 0.6 g transmitters for age-1 and age-2 lake sturgeon and 0.32 g transmitters for age-0 lake sturgeon.

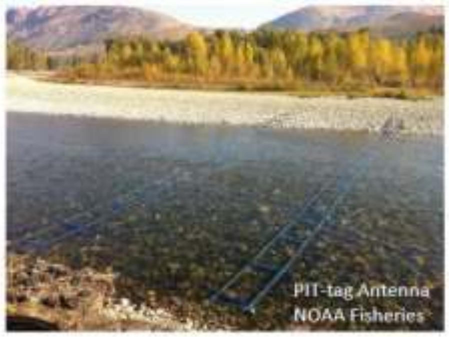


Juvenile Lake Sturgeon Downstream Passage and Survival at Two Hydroelectric Dams

Jonathan Hegna1, Kim Scribner1, Edward Baker2
1Department of Fisheries and Wildlife, Michigan State University, East Lansing, Michigan 48824
2Michigan Department of Natural Resources, Marquette, Michigan 49855

Discussion

The results generated from the 2014 pilot study and the two year passage study starting in 2015 will have multiple important outcomes for management. Firstly, the research on juvenile lake sturgeon passage mortality rates will directly inform managers about the potential recruitment benefits of passing adult lake sturgeon above dams without juvenile bypass systems. The research will also inform managers about the propensity for juveniles to migrate downstream through reservoir habitat. In addition, the research will instruct managers on how to develop operational windows and best practices to improve juvenile lake sturgeon survival at hydroelectric dams. The results will further inform managers and other stakeholders on how to best develop a juvenile lake sturgeon bypass system. Furthermore, the research will inform managers about the most effective fish screen spacing and dam layout characteristics that can maximize survival. Managers will also benefit from the project's analysis of mortality rates associated with Kaplan turbines and type-Z vertical shaft turbines. Finally, this research can directly instruct managers about how to design and implement technology that can assess the passage behavior and survival of lake sturgeon at hydroelectric dams for future studies.



References

Coscarelli, M. A., Forsythe, P. S., Holey, M. E., & Elliott, R. F. 2011. Enhancing Lake Sturgeon Passage at Hydroelectric Facilities in the Great Lakes. Great Lakes Fishery Trust, Workshop Report; Ferguson, M. M., & Duckworth, G. A. 1997. The status and distribution of lake sturgeon, Acipenser fulvescens, in the Canadian provinces of Manitoba, Ontario and Quebec: a genetic perspective. Environmental Biology of Fishes, 48, 299-309. Jager, H. I., Chandler, J. A., Lepla, K. B., & Van Winkle, W. 2001. A theoretical study of river fragmentation by dams and its effects on white sturgeon populations. Environmental Biology of Fishes, 60:4, 347-361; Johnston, S.V., B.H. Ransom, and J.R. Bohr. 1993. Comparison of Hydroacoustic and Net Catch Estimates of Fish Entrainment at Tower and Kleber Dams, Black River, Michigan. ASCE Waterpower, 1993: 308-317; McDougall, C.A., P. J. Blanchfield, S. J. Peake& W. G. Anderson. 2013. Movement Patterns and Size-Class Influence Entrainment Susceptibility of Lake Sturgeon in a Small Hydroelectric Reservoir, Transactions of the American Fisheries Society, 142:6, 1508-1521, DOI:10.1080/00028487.2013.815659; Peterson, D. L., Vecsei, P., & Jennings, C. A. 2007. Ecology and biology of the lake sturgeon: a synthesis of current knowledge of a threatened North American Acipenseridae. Reviews in Fish Biology and Fisheries, 17:1, 59-76; Skalski, J.R., Dilip Mathur& Paul G. Heisey. 2002. Effects of Turbine Operating Efficiency on Smolt Passage Survival. North American Journal of Fisheries Management, 22:4, 1193-1200.; Tody, W. H. 1974. Whitefish, sturgeon, and the early Michigan commercial fishery. Pages 45-60 in Michigan fisheries centennial report 1873-1973. Mich. Dep. Nat. Res., Lansing, Michigan.

Acknowledgements

We would like to thank the Great Lakes Fishery Trust Fund for providing vital funding that made this research project possible. We would also like to thank Nathan Barton for his important role in organizing the installation of the PIT-tag interrogation systems used in this research project. Furthermore, we would like to thank Jared Millitelo and Lindsey Adams for their vital assistance in installing the RFID antennas.