STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** T-10-T-5

Study No.: 237026 **Title:** Rehabilitation of Lake Sturgeon *Acipenser fulvescens* populations in Michigan

Period Covered: October 1, 2014 to September 30, 2015

Purpose and Objectives: The purpose of this study is to support Michigan Lake Sturgeon rehabilitation activities, as documented in the DNR Lake Sturgeon Recovery Plan (Hayes and Caroffino 2012), the state Wildlife Action Plan (Eagle et al. 2005), and in Great Lakes fish community objectives (see www.glfc.org). To address this purpose, the project has the following objectives: 1) to ensure ongoing, efficient production of Lake Sturgeon at important Michigan restoration sites; 2) to examine effects of fish culture practices on egg survival and larval Lake Sturgeon growth and survival; 3) to quantify environmental covariates (temperature and discharge) and their effects on larval Lake Sturgeon recruitment; 4) to quantify effects of stream habitat and the species composition and abundance of predators and alternative prey on Lake Sturgeon larval survival; and 5) to quantify stage-specific survival of natural and hatchery age-0 and older juvenile Lake Sturgeon.

Summary: Adult spawning assessments were successfully completed in the Black River, extending the multi-year spawner data set to 15 years. Stream flow and temperature data were recorded hourly. Newly-installed Passive Integrated Transponder (PIT) antennas at the river mouth and immediately below the spawning area allow collection of biological data on adult retention time in the river, repeat spawning (by males) and movements in the river. PIT tag data also allowed assessment of accuracy of visual surveys and numbers of physically handled adults as a surrogate of total spawner abundance. Surveys of larval Lake Sturgeon and co-distributed prey were conducted hourly each night in the Black River. Stream habitat and fish and invertebrate communities were enumerated in the stream also. Analyses are ongoing to develop biological and physical indicators of habitat suitability in terms of probabilities of larval Lake Sturgeon survival following emergence. Streamside rearing occurred on the Black, Kalamazoo, Cedar, and Whitefish rivers in support of ongoing rehabilitation (Kalamazoo River) and reintroduction (Black, Cedar, and Whitefish rivers) efforts.

Findings: Jobs 1–8 were active this year, and progress is reported below.

Job 1. Operate stream-side rearing facilities (SRF) for Lake Sturgeon on Michigan river systems.–

Black River SRF

The Black River Stream-side Lake Sturgeon Rearing Facility completed annual operations in early October 2014. All electronics and equipment were transferred to the Oden Fish Hatchery, Gaylord Operations Center, and Michigan State University. Analyses and reporting of data collected during the 2014 field season and planning for the 2015 field season continued until April 2015. Analyses were also ongoing associated with the Black Lake gill-net capture-mark-recapture work and associated with work to reconstruct pedigrees of larval Lake Sturgeon captured below Alverno Dam on the Lower Black River and from Indian River.

The facility was reopened April 6, 2015. During the course of the spawning season we collected eggs from 17 females and sperm from 47 males. We fertilized eggs from each female with milt from one to five males for a total of 47 crosses. We provided tribal biologists from the Little

Traverse Bay Band of Odawa Indians with both production and wild larvae for the purpose of stocking Burt Lake. Stocking occurred in Black, Mullett, and Burt lakes in the Cheboygan River drainage (Table 1) in support of the Cheboygan River management plan and State of Michigan Lake Sturgeon Recovery Plan. Fish stocked were of wild origin and represent three distinct drift peaks from the 2015 larval drift assessment. A total of 1,723 Lake Sturgeon larvae were captured during the larval drift period over a 6-week period of nightly effort.

Table 1.–Stocking of the Upper Black River (Black Lake), Mullett Lake and Sturgeon River (Burt Lake) occurred from mid-August to late September (see below).

Date	Stocking site	# Stocked	Mean length (mm)	Mean weight (g)	Tag type
8/22/2015	Upper Black River	240	197.7	31.4	PIT
8/22/2015	Mullett Lake	218	187.6	26.8	CWT
8/31/2015	Upper Black River	248	187.0	28.7	PIT
9/8/2015	Mullett Lake	282	180.4	23.9	CWT
9/8/2015	Sturgeon River	53	180.4	23.9	CWT
9/25/2015	Upper Black River	35	200.0	35.0	PIT

Kalamazoo River SRF

The Kalamazoo River SRF was operated from April 15, 2015 to July 29, 2015. Twelve Lake Sturgeon were stocked in the Kalamazoo River on July 28, 2015 and were produced from eggs collected on egg mats in the Kalamazoo River immediately downstream of the Allegan Dam.

Cedar River and Whitefish River SRF's

The Cedar River and Whitefish River SRF's were both operated from early May through mid-September. Fish raised in the SRF's were produced from eggs and milt collected from spawning adults in the Peshtigo River, Wisconsin. Survival and growth of fish in the SRF's were better than has been realized in previous years, largely due to research conducted at the Black River facility that has resulted in improved operations, and there were a total of 2,247 fish stocked, 1,180 in the Whitefish River and 1067 in the Cedar River. Fish stocked in Whitefish River averaged 150 mm total length and 14 g. Fish stocked in the Cedar River averaged 156 mm total length and 16 g weight. All fish were tagged with PIT tags prior to stocking and given a ventral fin clip unique to the river.

Job 2. Evaluate stream-side rearing protocols.–We implemented hatchery protocols for egg, yolk sac fry and larval Lake Sturgeon that were developed during 2012 and 2013 at the Black River Stream-side Rearing Facility by John Bauman associated with a Great Lakes Fishery Trust Grant to co-PIs Scribner and Baker. Protocols covered egg fertilization, de-adhesion, and disinfection. Protocols for yolk sac fry covered use of cover to reduce stress. We reduced density in aquaria used for yolk sac fry as per John Bauman's thesis recommendations. We implemented protocols from the Bauman thesis for larvae including increasing feeding regimes and use of prophylactic peroxide disinfection treatments to decrease rates of ectoparasite infection. Protocols have been distributed to other stream-side hatcheries throughout the Great Lakes.

Larval survival exceeded stocking numbers desired. Thus, 250 larvae were released below Alverno Dam in the Lower Black River. A number of age-0, age-1 and age-2 fish were marked with PIT tags and released above Tower and Kleber impoundments in support of a research projects to monitor fish passage. Twenty six fish were retained and delivered to the Oden State Fish Hatchery for use in state-wide education programs (Sturgeon in the Classroom).

We continued an assessment program for egg and sperm quality. Eggs were collected from all females used in production crosses to determine lipid and hormone levels. Egg quality indices including egg diameter and developmental staging are ongoing and will provide an index of female provisioning and egg quality. Measures of sperm motility and concentration were also taken for the majority of males captured. We are working toward applications of the sperm quality assessments to increase fertilization rates.

Job 3. Evaluate environmental factors potentially influencing Lake Sturgeon spawning and early life stage survival.–We captured 248 adult Lake Sturgeon spawning in the Upper Black River over a 41 day period from 30 April through 10 June, 2015. All individuals were individually marked dorsally under the 4th dorsal scute with a full duplex PIT tag and ventrally at the base of the left pectoral fin with a half-duplex PIT tag. Spawning fish were also individually marked with floy tags to visually identify males and females with colors and body locations (right and left sides of the dorsal fin, respectively) signifying spawning time (early vs late in the spawning season) and sex. Of the 248 adults captured in the spawning area, 84 individuals were females, 163 individuals were males, and 1 was of unknown sex. Forty six individuals (18.6% of total captures) were never previously captured. Total lengths of newly captured individuals averaged 147.1 cm (range 118—188 cm).

We installed two additional passive PIT tag arrays in the upper Black River in mid-September we are now have 2 arrays at the mouth of the river and 2 arrays just downstream of the spawning area. Use of 2 arrays per site will allow determination of direct of movements (upstream vs downstream). We also deployed passive pressure and temperature recorders in multiple places in the Upper Black River to record environmental conditions. The passive PIT tag arrays also provided information pertaining to adult period of occupancy of river habitats and time at the spawning areas. Information was also obtained on repeat spawning to validate visual assessments.

Ongoing collections of environmental conditions, fish spawning behavior and genetic analyses to document proportional contributions of adults spawning at different times, using different behaviors, and under different environmental conditions will serve to develop a predictive model of environmental effects on annual year class recruitment.

Job 4. Quantify biotic and abiotic influences on larval and young-of-year Lake Sturgeon survival.–Work under this job was conducted in the Black River and in the Black River SRF.

Natural recruitment of Lake Sturgeon to the larval stage is variable across years and very few larvae survive past the first year of life. Indeed, we have observed extremely high rates of mortality within a single night as a function of distance from the spawning areas. Figure 1 shows data for one night during 2006 as an example. We placed 5 D-frame larval drift nets in 3 locations and documented the number of Lake Sturgeon larvae captured in the drift as a function of distance downstream from the spawning areas. The 'upstream' nets were set immediately below the downstream most spawning area and are presumed to represent the numbers of larvae emerging prior to experiencing appreciable mortality. We also sampled 2 km and 4 km downstream from the "upstream" nets. The graph shows the chronology of when and how many larvae were captured by hour at each capture locale. These data were collected during each of 2 consecutive nights (second night not shown). We observed larvae caught during the first hour of collection (21:00-22:00) only at the upstream site. During subsequent hourly captures we began to see larvae captured downstream but in lower numbers at 2 km. Very few larvae were captured 4 km downstream during the entire evening. The chronology of when and how many Lake Sturgeon larvae were captured as a function of downstream distance was repeated during the second evening. The fact that no larvae are found downstream (i.e., at 2 and 4 km) as larval drift begins (e.g., at the 21:00 to 22:00 sampling period) each evening suggests that larvae are not 'short-stopping' prior to reaching the downstream nets. The tremendous declines in numbers from

upstream to 4 km downstream sampling locales suggests extremely high rates of mortality, likely due to predation. These preliminary data are the basis for our hypothesis that predation is a primary cause of low natural Lake Sturgeon recruitment in Black River.

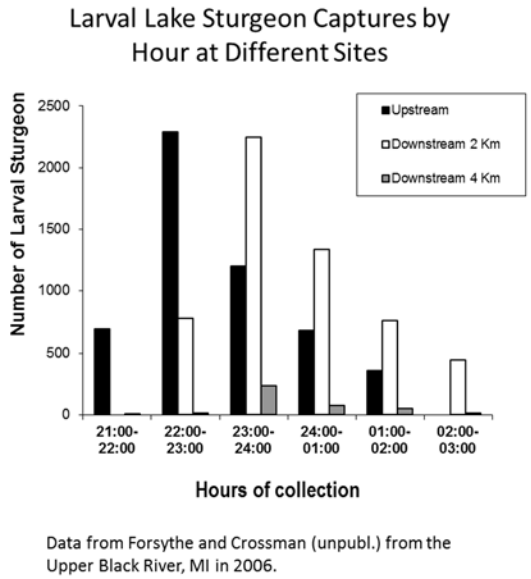

Figure 1.–Number of Lake Sturgeon larvae collected during six hourly collections at each of three river locations. Data from Forsythe and Crossman (unpublished) from the upper Black River, Michigan during one night in 2006.

The questions the current study is designed to address in the upper Black River include the following:

1. What are the physical stream features that are associated with when and how many larvae disperse?
2. Does the abundance and taxonomic diversity of co-distributed larval fish and macro-invertebrate prey that co-migrates with dispersing Lake Sturgeon larvae also vary in response to the same environmental queues?
3. What is the fish community in the stream? Does fish community composition and relative abundance vary spatially as a function of habitat (e.g., sand vs rock substrate), and temporally through the larval dispersal period?
4. What members of the stream fish community prey on larval Lake Sturgeon?
5. Does the abundance and taxonomic diversity of co-distributed larval fish and macro-invertebrate prey that co-migrate with dispersing Lake Sturgeon larvae affect levels of larval Lake Sturgeon mortality, and do larval Lake Sturgeon mortality rates vary as a function of stream fish community composition and habitat?

Methods and Results

Electrofishing and larval drift predator diet study

We established four 0.4 km transects in the upper Black River downstream of the spawning locations. Two transects were primarily composed of gravel substrate and two transects were primarily sand substrate (Figure 2). At the upstream and downstream end of each transect, we sampled dispersing larval Lake Sturgeon and co-drifting larvae of other fish species and macroinvertebrates. We counted the total number of larval sturgeon and collected a subsample of all

other species in the drift. We also collected a subsample of the larval sturgeon from each site and photographed them to calculate length to document evidence of size-selective mortality. We estimated larval sturgeon abundance at each of the drift sites and subtracted the estimate of the downstream site from the upstream site to determine an estimate of larval loss that occurred over the transect (adjusted based on discharge and gear efficiency at each site). The day after we sampled the drift in a transect, we sampled the same entire 0.4 km reach of river using a barge electrofishing boat and recorded the community species composition and abundance (CPUE) of fish and aquatic amphibians. Feces and gastric lavage samples were collected from some fish in the field while others were sacrificed and dissected to extract contents of the entire digestive tract (up to 20 samples of the same species per transect). Diet samples were preserved in ethanol or frozen for later analysis to determine the presence of all prey items present in the drift (especially larval sturgeon). We used the electrofishing CPUE estimates of fish relative abundance and the relative abundance of each macro-invertebrate species based on a benthic macroinvertebrate survey (220 ¼ m^2 plots over the same 2 km of stream) conducted in 2014. Data for this field season have not been analyzed. As an example of the type of data to be collected by transect (upstream and downstream location), Figure 3 characterizes the numbers of Lake Sturgeon larvae and other samples from over the course of a previous field season. Data analyzed to date for this season show a difference in fish communities in gravel and sand transects and for some fish species, we noted a temporal (May vs June) change in relative abundance coincident with 'early' and 'late' periods of the larval dispersal period. A similar experimental design will be used in 2016 to increase the number of replicates in each substrate type. Further, relatively few larval sturgeon were captured in 2015. Thus, a second year, hopefully characterized by higher larval sturgeon abundance, can be compared to this year when relatively few larvae sturgeon were captured.

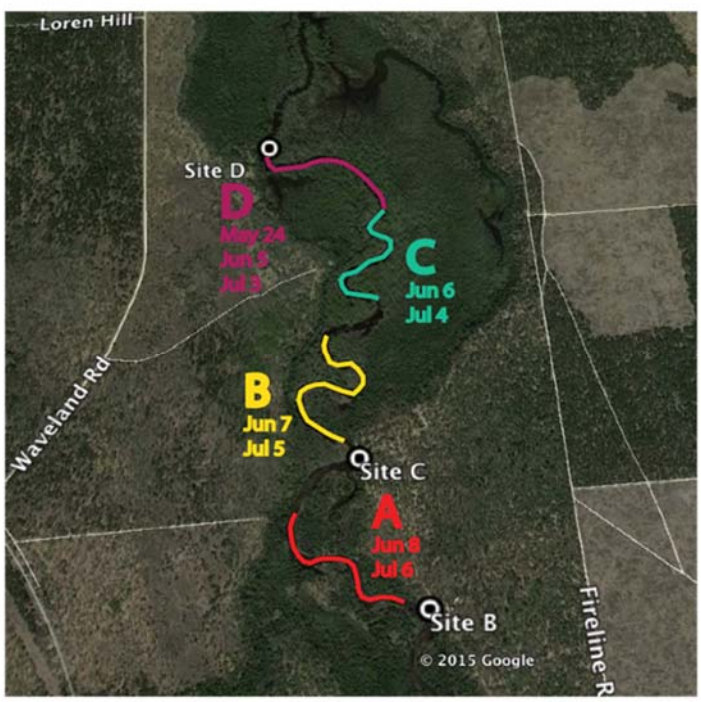

Figure 2.–Map showing the experimental transects for the predation study on Sturgeon larvae in the drift. Transects A and B have primarily gravel substrates and are immediately downstream of the major Sturgeon spawning sites (Site B and Site C) while Transects C and D have primarily sand substrate and are further downstream from the spawning sites.

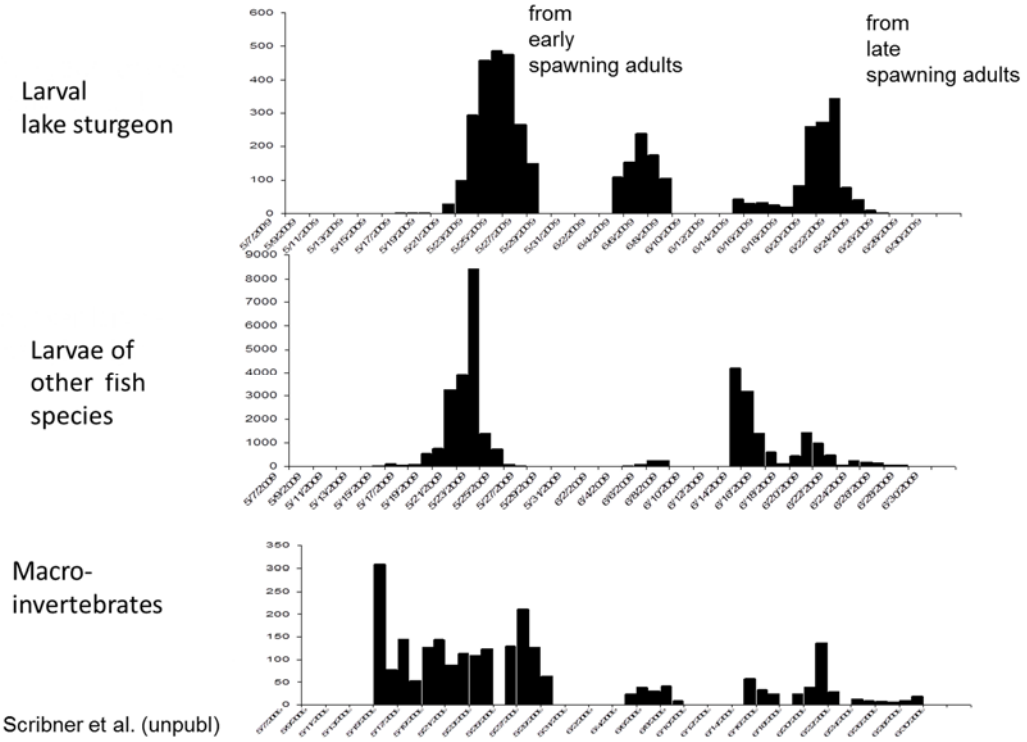

Figure 3.–Numbers of Lake Sturgeon larvae and co-distributed prey (other larval fish and macroinvertebrates) captured by night.

Artificial Stream Predation Experiment

We established two flowing streams using raceways that were 24-ft long and 2-ft wide, with water depth of 1 ft. The tanks were supplied with water on a flow through system that could simulate a stream environment (Figure 4). Wire mesh created exclusion areas at both ends of the tanks, allowing for larval fish to be introduced and collected without predator interference. The tanks were surrounded with canvas with viewing ports so we could observe the experiments without disturbing the fish. Predators were obtained from Black River and the nearby reservoirs with a barge electroshocker and were kept in the hatchery for at least 24 hrs before being moved to the artificial streams. Predators were allowed to acclimate for 10-18 hrs in the artificial stream at slow flow (0.05m/s) and 1 hr at high flow (0.15m/s) before the introduction of larval prey. Prey consisted of larval sturgeon and larval suckers, which were photographed for length before and after the experimental trial to determine size selectivity of predators. Prey was introduced continuously and randomly over the course of 30 min and survivors were collected, counted, and photographed. A total of 14 potential predator species were assessed for consumption of larval fish, average number consumed per individual and whether there was preference for a certain prey item using Chesson's selectivity index. The majority of predators surveyed consumed both Lake Sturgeon and suckers. We documented preferences for Lake Sturgeon for several fish predators and evidence of size-selective predation on Lake Sturgeon by one predator species.

Figure 4.–Photo showing the experimental flowing streams used in predation trials to determine levels of predation by different resident fish species present in the upper Black River. Samples of Lake Sturgeon larvae and larval Suckers were placed simultaneously into the raceway with the potential predators over an hour period and numbers of Lake Sturgeon and Suckers surviving were recorded.

Job 5. Quantify levels of survival of Lake Sturgeon cohorts stocked from SRF.–

Estimates of genetic diversity of stocked cohorts–Standard measures of genetic diversity including number of alleles per locus and heterozygosity were comparable across year cohorts after stocking. Analyses for cohorts stocked into Burt, Mullet, and Black Lakes are being synthesized into a publication.

Estimates of first year survival following release–We have summarized all cohort-specific stocking data including data pertaining to significant relationships of size at release on first year survival into a publication.

Job 6. Quantify recruitment of juvenile Lake Sturgeon into the adult reproductive population and provide population estimates for use in setting harvest limits.–In the return-time capture-mark-recapture model we developed (Pledger et al. 2013), we estimated a beta parameter which is the pseudo-recruitment parameter. The beta parameter is defined as the proportion of the population first breeding in the study. The beta value was 0.05 for both females and males in 2015. The relatively high values are likely due to the stocking history in Black Lake. This proportion of presumed primiparous males and females is consistent with the size distributions of 'new' (untagged) individuals. Using the spawning adult captures for 2015, the population estimate for Black Lake was 1,090 fish, 500 females and 590 males, which represents a 6% increase from the 2014 estimate.

Job 7. Convene regular meetings of the Fisheries Division Lake Sturgeon working group.–The Department of Natural Resources Lake Sturgeon Committee met on two occasions (January by conference call and July) in 2015. Meetings were held in March with DNR hatchery, research,

and management staff and Michigan State University personnel to discuss operational plans for the 2015 field season at the Black River Lake Sturgeon SRF.

Job 8. Write annual report.–The materials presented herein constitute the annual report for the reporting period.

Literature Cited

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