STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-80-R-7

Study No.: 230732 **Title:** Factors affecting lake sturgeon recruitment: a model system for species recovery in Michigan waters of the Great Lakes

Period Covered: October 1, 2005 to September 30, 2006

Study Objectives: The objectives of this study will be to:

1) develop models that relate the timing of spawning to environmental conditions,
2) build on demographic and genetic data collected in 2001 and 2002 to determine contributions from individual adults to annual recruitment, and to estimate adult spawning efficiency and effective population size,
3) estimate fertilization rate as a function of spawner number and sex ratio,
4) determine sources of egg predation and its magnitude prior to larval emergence,
5) determine factors that influence larval survival during downstream drift from spawning sites to rearing habitats,
6) develop a system for assessing juvenile survival and growth in river and lake systems that will be applied to potential restoration sites in Michigan,
7) test predications of timing, sources and magnitude of impediments to recruitment in other streams in Michigan using eggs and larvae of different sizes that are obtained from Black Lake, and
8) use data from Black Lake to parameterize models to predict the efficacy of alternative hatchery supplementation strategies in future restoration activities in Great Lakes tributaries.

Summary: Lake sturgeon *Acipenser fulvescens* were once abundant in the Great Lakes but current abundance is likely less than 1% of historic levels. Lake sturgeon rehabilitation is a high priority throughout the Great Lakes. However, little is known about fundamental aspects of the species' reproductive ecology and early life history. For example, information regarding inter-annual variation in natural recruitment and of natural environmental or biotic agents that are responsible for inter-annual variation is lacking. We lack quantitative estimates of egg or juvenile survival or of proportional contributions of adult spawners to recruitment. We know little of the importance of adult body size, age, and timing of spawning events to reproductive success. Understanding the importance of factors affecting lake sturgeon recruitment, survival, and philopatry will be critical to designs of restoration or reintroduction programs in Michigan drainages of the Great Lakes.

Most populations in the Great Lakes basin are too small or too broadly dispersed for research that seeks concurrently to estimate spawner contributions and progeny survival. Black Lake is ideal for this research and may serve as a model for lake sturgeon recruitment research in all Michigan waters of the Great Lakes. Using the Black Lake system as a "living laboratory," we seek to capitalize on extensive baseline information developed by collaborative Michigan State University, Central Michigan University, and MIDNR research to further characterize early life history characteristics and population recruitment in this system. Findings from the Black Lake system will be used to experimentally examine factors that may impede recruitment in other Great Lakes drainages that are candidate locations for repatriation or supplementation.

One potential explanation for the low abundance of lake sturgeon is that recruitment is too low to rebuild existing populations. For example, low rates of recruitment could be attributed to high rates of predation on eggs or low larval or juvenile survival. Therefore, we seek to determine the sources of egg predation and its magnitude prior to larval emergence and the factors that influence larval survival during downstream drift from spawning sites to rearing habitats. Low rates of recruitment could also be caused by low fertilization rates due to an Allee effect owing to low numbers of spawning adults. The species' mating system is characterized by aggregate spawning where males and females extrude gametes into the water column without nest construction or site preparation. In historical times when spawning aggregations were large, this strategy may have been adaptive, but because many Michigan streams support breeding populations that are characterized by low adult numbers, fertilization rates could be low. Estimates of fertilization rates and the effects of potential predators on lake sturgeon eggs and/or larva will be critical to restoration efforts.

Restoration of lake sturgeon may ultimately require translocations or hatchery supplementation, yet information about the efficacy of different supplementation programs is non-existent. The numbers of fish stocked, the number of adults contributing progeny, and the mating scheme currently used in stocking are all based on "best professional judgment" instead of quantitative data. We also know little of the effects of rearing environment and the degree of site fidelity or degree to which juvenile sturgeon imprint to streams. Therefore, we seek to empirically determine the effects of different gamete-takes, rearing conditions and stocking strategies commonly used by management agencies on juvenile lake sturgeon growth, survival, movements, and levels of genetic diversity. Results from parentage analysis will also provide much needed guidance for the hatchery production of lake sturgeon for stocking in waters targeted for rehabilitation. The availability of suitable habitats during larval drift and during early life are also critical but are not fully understood. Although spawning and adult habitat requirements are well known, very little is known about the habitat requirements of larval and juvenile lake sturgeon. Our results will facilitate efforts to locate, restore, and protect key juvenile habitats in several streams within the Cheboygan River watershed and potentially other tributaries of Lake Michigan.

Findings: Jobs 9 through 12 were scheduled for 2005-06, and progress is reported below.

Job 9. Title: <u>Determine movements of lake sturgeon using telemetry.</u>–Forty juvenile lake sturgeon, 20 reared at our stream side facility and 20 reared in the traditional hatchery setting, were surgically implanted with small coded ultrasonic tags; 1.7 ± 0.01 cm in length and 0.7 ± 0.001 cm in diameter with a mass of 1.95 ± 0.01 g in water (Vemco, model V7, Nova Scotia, Canada). Fish averaged 31.23 ± 0.25cm in total length and 106.41 ± 2.01g in weight prior to surgery. All surgeries were conducted between 8-12 December 2005. Sonic transmitters were set at an operating frequency of 69 kHz and programmed to emit a coded pulse randomly between 40s and 120s. The weight of the tag did not exceed 2% of the fish weight, which fell well within the generally accepted 2% rule. Lake sturgeons were reared in the two separate environments until September 2005 when all individuals from the streamside facility were transported to Michigan State University. The protocol was to accomplish two goals (1) overcome logistical constraints keeping our stream side facility operating and (2) to increase growth to a level (approximately 25 cm total length) that would support the insertion of the ultrasonic transmitters. When this size was attained juvenile lake sturgeon were transported to holding tanks at Michigan State University. Fish were anesthetized using tricaine methane sulfonate (MS222; 125 mg/l) in an aerated container prior to surgery. For the duration of the surgery sedation was maintained with a maintenance dose of MS222 (50 mg/l) recirculating through a portable surgical table. This involved anchoring the transmitter to the wall of the peritoneal cavity, which provides significantly higher retention rates than allowing the transmitter to be placed freely within the

cavity. Incisions were closed using 3-0 gauge non-absorbable monofilament nylon sutures (Ethicon) in an interrupted pattern. Ovadine antiseptic was applied to the wound to promote rapid healing. Following surgery fish were monitored for a 3-day period prior to their release into Black Lake. Movement and activity levels of sonically tagged fish were monitored from a boat using a Vemco receiver (model VR100) equipped with both omni-directional (VH65) and directional (V10) hydrophones. The directional hydrophone has a horizontal beam width of 22 degrees and a vertical beam width of 150 degrees for transmitters operating at 69KHz. Tracking was done manually with transmitters having a potential detection range of 1km. Hydrophones were deployed every 500m on calm days and every 250m or less during days with moderate waves. Each time the hydrophones were deployed the boat motor was be shut off to reduce background interference on the receiver. Algae, thermoclines, water turbulence, and other 2-stroke boat motors are known to affect signal strength of the sonic pulse. Fish were tracked monthly through the winter months and bi-weekly through the spring, summer, and fall months. Winter tracking entailed drilling holes through the ice and deploying the hydrophones a meter under the ice to eliminate broken sonic signals caused by ice interference. We also attempted to monitor continuously for 24 hours to identify diurnal activity patterns. Fish localizations were triangulated with a minimum of three geographic points. Recorded positions of detected fish were made using a handheld WAAS enabled GPS receiver and an integrated depth sounder/GPS receiver that is also WAAS enabled. Bearings were taken using a magnetic compass adjusted to obtain true magnetic north. Automated hydrophone receivers (Model VR2) were also placed within Black Lake to monitor approximate fish locations. Surface and bottom water quality parameters (temperature, and dissolved oxygen) as well as substrate size and type (using a ponar sample) were recorded at all fish detection locations through out the study. Positioning data will eventually be managed and analyzed using geographic information system (GIS) software (ESRI, ArcMap v. 8.3, Arcview v. 3.3, and Arcview spatial analyst v. 2.0a). GIS software will allow us to overlay data onto maps and to improve the interpretation of the results. Habitat maps, including depth, temperature, and substrate size and type, will be created using the ordinal krigging method in the GIS software using a cell size of 10m. Animal Movement Analysis extension will be used to analyze movement data recorded for the juvenile lake sturgeon. Total and daily linear distance traveled will be calculated by summing all straight-line distances between consecutive estimated locations. Area occupied (Total km^2 and Daily km^2) will be calculated using minimum convex polygon (MCP). Calculating MCP is one of the most basic home range analysis methods and allows for easy comparison with other studies. Only estimated fish locations from hydrophone collections will be used when calculating MCP. Calculated detection polygons extending outside of the extent of the Black Lake system will be edited to only include the system.

Preliminary results.–Tracking efforts have been made lake wide by running transects and checking every 300m along these lines. We have found 16 fish to date, 7 reared at our streamside hatchery and 9 from Wolf Lake Hatchery (Table 1; Figure 1). Preliminary tracking suggests that 2 of these fish may be dead or that the transmitters were expelled. They are the only two fish that we have found during consecutive tracking excursions in the same location. Their location is close to the release location and our automated receiver at that location has recorded the same two individuals since soon after release. We are continually tracking and will complete a survey of both the Upper and Lower Black Rivers. As we locate more fish, we will be able to position our receivers in more effective locations.

Job 10. Title: <u>Conduct genetic analyses.</u>–Fin clips were taken from every adult collected during the 2006 spawning season. All fin clips were dried and individually stored at ambient temperatures. Tissue samples were also taken from out-migrating lake sturgeon larvae that were collected by drift nets deployed downstream from the spawning sites (Job 4). DNA has been extracted, quantified, and diluted from the tissue collected from each adult using a QIAGEN DNeasy Kit (Qiagen Inc., Valencia, CA). Several microsatellite loci have been amplified using PCR protocols

developed for use with fluorescent-labeled primers. PCR products for each locus have been run onto 6% denaturing polyacrylamide gels and scanned using either an FM BIO II (Hitachi, Inc.) or LICOR IR2 scanner, both located in the Scribner lab. Genotypes have been assigned based on molecular size standards and by running individuals of known genotype on each gel as standards. DNA will be extracted from all larvae during this upcoming year, parents will be assigned to each individual, and the proportional contribution of different adults to the total larval recruitment will be determined. Sampling and genotyping efforts will also continue into 2007.

Job 11. Title: Supervise staff.–I currently supervise two graduate students and one full time employee that are directly associated with this project. In addition, three full time temporary seasonal workers participated in the research this field season.

Job 12. Title: Write annual performance report.–Besides this annual report, the results of our research have been communicated to MDNR biologists, natural resource managers and concerned members of non-profit organizations such as Sturgeon for Tomorrow throughout the entire year. My graduate students and I have represented the State of Michigan by making presentations at the 2005 AFS conference in Alaska, 2006 AFS conference in Lake Placid, 2005 Fisheries and Wildlife Graduate Research Symposia, 2005 Midwest Fish and Wildlife Conference and at several other meetings concerning lake sturgeon. We have also presented the results and future directions of our research to Sturgeon for Tomorrow members at several annual banquets and board meetings. Finally, we have also made presentations to the Lake Huron and Lake Michigan Basin Teams, Wolf Lake State Fish Hatchery and MDNR Gaylord Fisheries Division in order to coordinate future research efforts. The objectives and results of our research have been communicated to the general public through local and statewide press releases. Publications will be submitted to peer-reviewed journals in the upcoming years.

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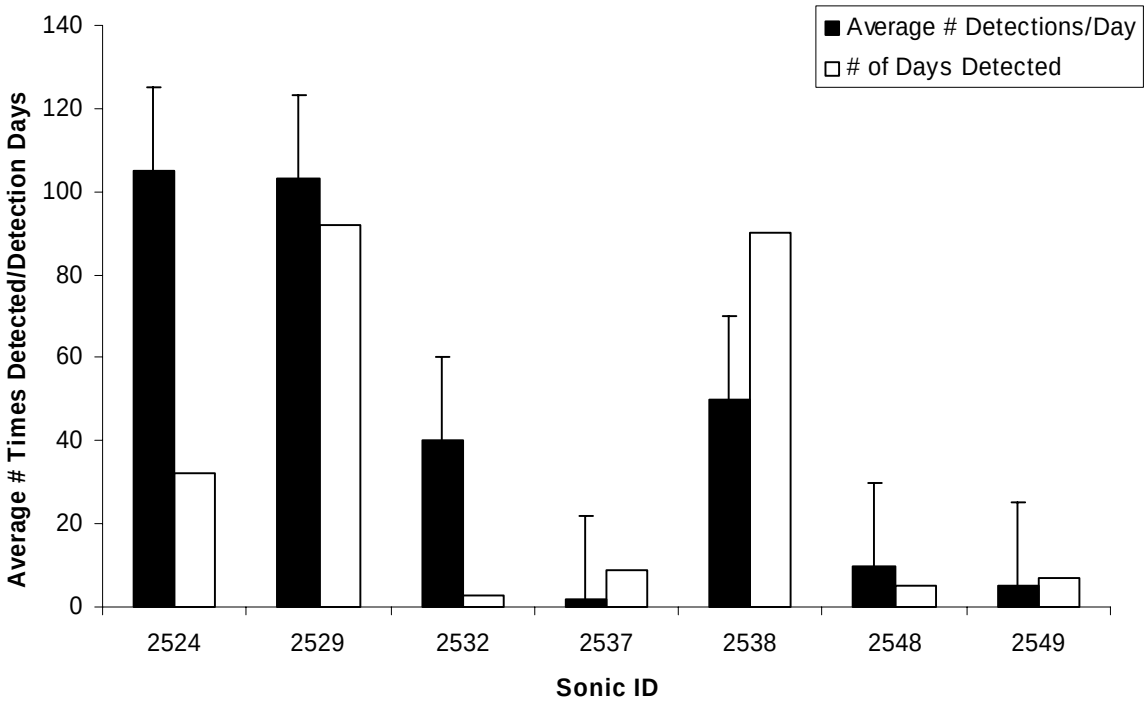

Figure 1.–This figure depicts the total number of days each fish was detected by our automated receiver and the average number of times detected during any given day.

Table 1.–Automated receiver detection results from the period of December 15 2005 until May 2 2006.

Sonic ID	1st Date Detected	Last Date Detected	# of Days Detected	Largest # of Consecutive Days Detected
2524	02-19-06	04-17-06	34	32
2529	12-28-05	05-02-06	91	91
2532	12-30-05	01-01-06	3	3
2537	12-22-05	03-09-06	9	2
2538	12-24-05	05-02-06	90	90
2548	04-05-06	04-14-06	4	2
2549	01-09-06	03-03-06	7	5