STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-80-R-5

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, 2003 to September 30, 2004

Study Objectives: The objectives of this study are to (1) develop models that relate 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 sturgeons 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 and/or low larvae 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 attributed to 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 in absence of nest construction or site preparation. In historical times when spawning aggregations were large, this strategy may have been adaptive, but since many Michigan streams support breeding populations that are characterized by low adult numbers, fertilization rates could be low. Estimates of fertilization rates and the impact 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 1 through 8, 10, 11, and 12 were scheduled for 2003-04, and progress is reported below.

Job 1. Title: <u>Construct and test egg catchment devises for use in egg fertilization and predation studies. Place devices in locations downstream from spawning sites. Estimate rates of egg fertilization for each spawning segment of the adult population each year. Estimate rates of egg predation by invertebrates and fishes. Record hatching times and correlate to stream environmental parameters.</u> – Egg catchment and egg predation devices were constructed and used in both egg fertilization and predation pilot studies. These devices were used to estimate rates of egg fertilization for each spawning segment of the adult population and to estimate rates of egg predation by invertebrates and fishes. *Rates of Egg Fertilization:* We were successful in collecting approximately 1,000 eggs directly from the water column using collection devices that were deployed for five consecutive days during peak spawn. Eggs were collected on circular porous filters that were attached to metal poles and positioned in several locations and at multiple depths downstream from each spawning group. Filters were removed from the stream after 12 hours, taken back the field station, and then placed in heath trays until fertilization success could be determined. Fertilization rates appear to be high based on samples taken during this pilot study. However, high incidence of fungus on eggs confounded interpretation. In the coming year we will use formalin baths and filtered water to minimize egg death due to confounding factors. We will conduct more extensive sampling during the next spawning season using additional filters in order to provide more conclusive results. *Rates of Egg Predation:* Prior to spawning, experimental devices were fabricated which would allow us to provide estimates of egg predation before larval hatching and to make inferences about which stream predators are consuming eggs at the highest rate based on exclusion (i.e., fish vs. invertebrates). We used wire mesh of different sizes that were differentially accessible to predators of different size. Devices were deployed at

several locations near the spawning sites on the Upper Black River and monitored over a 10-day period. Preliminary results indicate that there is a substantial loss of eggs over time and that lake sturgeon eggs are prone to fungus buildup even in stream conditions. However, assessing the source of predation was difficult as many of these devices were disturbed during flood conditions. Egg predation devices will be deployed again next field season at several different locations on the Upper Black River and after each spawning run. Approximate hatching times will be back-calculated from the larval drift data collected during Job.4 and correlated to environmental variables.

Job 2. Title: Work with Basin Teams to identify release streams and release and rearing site characteristics for larval sturgeon. Review species composition data for each putative release site. – We worked with Basin Teams, local biologists and Sturgeon For Tomorrow in order to identify release streams and release and rearing site characteristics for larval sturgeon. After consultation with these groups, it was determined that any release stream or putative release site should be kept within the Cheboygan River Watershed. Species composition data for each putative release site within this watershed are currently under review.

Job 3. Title: Monitor and tag adult lake sturgeon entering Black River and record stream environmental data. Determine retention time in streams of males and females. – Large D-frame dip/landing nets were used to capture adult lake sturgeon at several spawning sites located on the Upper Black River. Despite the harsh river conditions, we were successful at capturing a total of 101 individuals (75 males, 25 females and 1 undetermined). Almost half (48) of these fish were recaptures from previous field seasons. The following biological information was collected from each individual captured: weight, total length, fork length, girth and sex/stage. We also recorded the PIT tag number from individuals that had been captured and marked during previous field seasons. A PIT tag was injected underneath the fourth dorsal scute of fish that were captured at the spawning site for the first time. Fin clips were taken from the tip of dorsal fin for genetic analysis regardless of capture status (see Job 10). The first adult sturgeon was captured on 05/01/04 and the last was captured on 05/29/04. At least two different spawning runs were observed in 2004. The exact number of runs remains unclear due to several flood events and treacherous water conditions that precluded us from sampling. Estimates of spawning site retention time for several males and females can be derived based on tagging data. Total stream retention time remains unclear, however, because of flood conditions that prevented us from establishing a secured fish weir and a video camera designed to restrict and monitor the movement of adults at the mouth of the river. We will attempt to estimate stream retention time of both males and females using a fish weir during future field seasons. We recorded stream environmental data during the entire field season. Three temperature loggers were deployed at several locations along the Upper Black River (Kleber Dam, larval drift site and at the mouth of the river) several weeks before the adult lake sturgeon migrated upstream to spawn. Loggers were programmed to record the water temperature every hour during the entire field season. Stream depth and discharge were also evaluated each night using a stadia rod to determine stream depth and a flow-meter (March and McBirney Model 2000) to calculate the stream velocity. Our discharge measurements will be coordinated with measurements of discharge taken by operators working at Kleber Dam during each year of this study.

Job 4. Title: Estimate lake sturgeon larval abundance from drift sampling. Estimate the relative abundance of other larvae species in the drift. – D-frame drift nets (76 cm across the base, 54cm high with a knotless 1600 μM mesh nylon bag 317.5 cm long with a detachable collection cup on cod-end) were used during the 2004 field season to sample out-migrating larval sturgeon. Drift nets were deployed at the same location on the Upper Black River (D3) throughout the entire larval sampling season because of high water and flood conditions. Within this location, four drift nets were deployed approximately two meters apart in a straight line along

a transect across the stream channel. Sampling was conducted during a 5-hour time period, beginning at dusk and ending in the early morning. Majority of the larval fish were captured during several "peak" hours (between 11:00 pm and 1:00 am) within a particular sampling evening. Even though a few larval sturgeon were observed every evening over the entire sampling period, majority of the fish this spring were captured during several consecutive evenings of "peak" drift activity occurring in mid-June. In total, 437 lake sturgeon larvae were collected from this one sampling site. All larvae were transported to Wolf Lake Fish Hatchery for rearing. The composition and abundance of other fish and invertebrate species in drift was also noted. More accurate estimates of the relative abundance of other larval species in drift will be obtained during future field seasons.

Job 5. Title: Estimate rates of larval lake sturgeon mortality using either repeated drift net sampling or acoustic sonar. – Due to dangerous water conditions throughout the entire field season, only one site on the Upper Black River could be accessed on a continual basis for the purpose of larval sampling. Therefore, estimates of larval lake sturgeon mortality using either repeated drift net sampling or acoustic sonar equipment could not be obtained. We will attempt to estimate rates of larval lake sturgeon mortality using repeated drift net sampling next year at sites that have already been identified.

Job 6. Title: Estimate magnitude of predation on larval lake sturgeon and other larval species by fish predators down-stream of the spawning sites. – Estimating the magnitude of predation on larval lake sturgeon and other larval species by fish predators down stream from the spawning sites can accomplished in one of two ways: 1) passively sampling the stream community or 2) electroshocking. During this past field season, we attempted to passively the sample the stream for potential fish predators using fyke nets placed downstream from the larval drift site (D3). Two fyke nets were deployed for three evenings in conjunction with larval sampling and during peak larval drift. The stomach contents of all potential predators were examined at the end of each evening. Several species of larval fish were observed in the stomachs of predators but we failed to find a single larval lake sturgeon. This result was most likely due to small sample sizes (<5); probably based on the relative inefficiency of our sampling gear or how and where it was deployed. Since it seems nearly impossible to obtain the sample sizes we need to determine predation rates by passively sampling the stream, electroshocking seems to be the best option and will be pursued during next field season. This portion or our research plan has already been communicated with local MDNR biologists.

Job 7. Title: Rear lake sturgeon larvae to different sizes for release into experimental restoration sites identified under Job 2. – Larvae were transported to indoor flow-through tanks at a mobile hatchery located at our field station. The flow-through tanks in the mobile hatchery were filled with filtered water taken directly from Rainy Creek, a small tributary of Black Lake. After several days, the larvae were transported to Wolf Lake fish hatchery where they are currently being maintained by hatchery personnel. Even though large sample sizes were not obtained (see Job 8), we were able to refine our ability to rear larval lake sturgeon to different sizes for release into experimental restoration sites next field season.

Job 8. Title: Estimate rates of lake sturgeon larval mortality in stocked sites using either repeated drift net sampling or acoustic sonar. – We were unable to estimate the rates of lake sturgeon larval mortality in stocked sites using either repeated drift net sampling or acoustic sonar largely because of a small sample size (approximately 30 individuals). Several factors prevented us from obtaining the sample size necessary to complete this job. First, harsh environmental conditions and flood stages prevented us sampling during the first half of the larval drift period. Second, recruitment was at an extremely low level compared to previous sampling years; recruitment was potentially limited because of lower spawner number and increased mortality

during the egg and larval stage as a result of harsh river conditions. Third, the larval lake sturgeon we did capture and transport to Wolf Lake Fish Hatchery experienced a much higher mortality rate as compared to previous years. The combination of each of these factors prevented us from obtaining the sample size necessary to estimate rates of lake sturgeon mortality in stocked locations. In order to ensure that these problems do not continue, additional drift nets will be deployed at each sampling site so that a larger proportion of the larvae in drift are sampled, offspring will be reared from eggs taken during artificial crosses and collected on filter pads, and an intern will be hired specifically for rearing and husbandry of lake sturgeon transported to Wolf Lake. Lake sturgeon larvae will be reared to different sizes, released into experimental sites, and then estimates of larval mortality will be obtained during this next field season.

Job. 10. Title: Conduct genetic analyses of lake sturgeon larvae and adults to determine parentage and estimate the proportional contribution of different adults to total larval recruitment. Estimates will be made by year and cumulatively across all years of this study and previously to obtain a complete picture of total lake sturgeon reproductive contribution for the entire Black Lake population. – Fin clips were taken from every adult collected during this past spawning season (Job 3). All fin clips were dried and stored individually at ambient temperatures. Tissue samples were also taken from out-migrating lake sturgeon larvae that were collected using 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 will eventually be 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 continue into this next year.

Job 11. Title: Supervise graduate research assistants, non-DNR funded assistants, and technical staff. – I currently supervise 2 graduate students that are directly associated with this project.

Job 12. Title: Prepare annual report and as appropriate communicate program results in the form of peer-review publications, reports, popular articles, and presentations. – 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. I represented the State of Michigan at the 2004 Great Lakes Lake Sturgeon Coordination Meeting and at several other meetings concerning lake sturgeon. I and my graduate students have made presentations at a several professional meetings including the American Fishery Society meeting in Madison, WI. 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 Management Unit in order to coordinate future research efforts. The objectives and results of our research have been communicated to the general public through local and state-wide press releases. Publications will be submitted to peer-reviewed journals in the upcoming years.

Prepared by: Kim T. Scribner
Date: September 30, 2004