Lake Sturgeon Rehabilitation in the Kalamazoo River

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INTRODUCTION

Information regarding lake sturgeon in southern Michigan systems is primarily limited to recent population assessments (2002-2010), historical accounts of migration, early commercial fishing data, and angler catches (Baker 1980; Organ et al. 1978; Wesley 2005). Some data is available based on excavations at archaeological sites and reports from early European settlers. Analyses of animal remains from prehistoric archaeological sites in southwestern Michigan have revealed the significance of a late spring and early summer fishery that focused on lake sturgeon (Martin and Brashler 2002). Middle Woodland (ca. 250 BC-AD 500) mound groups in the river basins of the St. Joseph, Grand, Kalamazoo, and Muskegon provided the first indication that lake sturgeon were intensively exploited and that it was far more important than any other fish taxa until the 1850's. Lake sturgeon remains are virtually ubiquitous at many archaeological sites in the valleys of the Grand, Kalamazooo, and St. Joseph Rivers where they migrated upstream to rapids for spawning (Brashler et al. 1998, Martin and Brashler 2002). The distinctiveness of this lake sturgeon population in southwest Michigan suggests a more important reliance upon lake sturgeon by early residents that contrasts to sites in the Saginaw Valley where lake sturgeon was only one of several fish species that were sought (Bigony 1970; Martin and Richmond 1993).

A summary of Fisheries' Division, Southern Lake Michigan Management Units planned activities to benefit lake sturgeon in the Kalamazoo River over the next several years is below:

Objective: Lake Sturgeon Rehabilitation
a) Stock fall fingerling Lake Sturgeon produced from a stream side rearing facility in the Kalamazoo River.
b) Improve the reproductive success of adult lake sturgeon through the construction of spawning habitat.
c) Increase survival of larval and young-of-the-year lake sturgeon and protect this remnant population from recruitment failures as a result of anthropogenic sources.

Objective: Sturgeon Population and Life History Information Needs
a) Continue lake sturgeon population assessments
b) Conduct early life history research and assessments of anthropogenic sources of mortality.
c) Evaluate contemporary and archaeological genetic structure of the Kalamazoo River population and nearby populations that may be used as donor stocks.

Objective: Habitat Protection and Enhancement
a) Identify and develop critical spawning habitats and habitat requirements for various life stages in targeted rehabilitation areas where needed.
b) Protect existing lake sturgeon habitat from anthropogenic sources of habitat loss.
c) Monitor the status of habitats to the contribution of annual production of stocked and wild lake sturgeon.
d) Work with Consumers Energy to provide a stable flow during adult lake sturgeon spawning, egg deposition, and outmigration of larval fish from mid-April to the end of May.

Objective: Sturgeon Stocking Assessment

a) Evaluate the feasibility and success of collecting lake sturgeon gametes versus larval dispersion techniques.

b) Monitor the downstream dispersal and survival of juvenile lake sturgeon released from the Stream- side Rearing Facility.

c) Periodically determine the degree of genetic diversity maintained between parents and stocked offspring to insure a genetically conservative stocking strategy.

Kalamazoo River Population Status

Lake sturgeon bone fragments found with Potawatomi artifacts in 1250 AD in the lower reaches of the Kalamazoo River indicate that lake sturgeon were a valuable resource and very abundant during seasonal migration (Barr 1979, Walz 1991). Contemporary assessment efforts conducted with gill-net surveys and angler accounts on the Kalamazoo River have indicated the presence of mature adult lake sturgeon in this system. Based on angler reports and contemporary assessment efforts (2002-2010), there is a limited number (<44 individuals per year) of mature adult lake sturgeon that utilize the lower Kalamazoo River on an annual basis for spawning. The success of spawning and reproduction remains unclear with intermittent numbers of larval fish captured during years with higher spawning fish abundance and minimal adjustment to flow and debris management at the Calkins Dam. Analysis of age structures collected from mature lake sturgeon from 2002-2010 indicates that mostly older females (>30 years old) and males (22-40 years old) are present and that recruitment has not recently been successful. Future viability of the Kalamazoo River population is uncertain. Recent surveys have documented age-0 fish located in the lower river and Kalamazoo Lake, indicating that natural reproduction is episodic.

Hydro-acoustics and side scan sonar surveys have been conducted to map potential juvenile lake sturgeon habitat to assist with habitat protection and possible survey locations where fish may occupy certain habitat types. Gravel and cobble substrates comprise only an estimated 6.0 % of the substrate in the lower Kalamazoo River below Allegan Dam, which may not be enough to support large numbers of lake sturgeon spawners and could be a limiting factor in their spawning success. Michigan Department of Natural Resources and Consumers Energy Corp. have designed plans for spawning habitat creation at three locations downstream from Calkins Dam. These structures will be completed by 2014 and should provide additional restoration of habitat for lake sturgeon. The lower portion of the river and Kalamazoo Lake provide to some degree the amount of suitable conditions necessary for juvenile lake sturgeon. In addition this lower section has access to Lake Michigan for additional juvenile habitat. The section of the river above Calkins Dam has been fragmented and disconnected from lake sturgeon use by numerous dams (Allegan City Dam, Trowbridge Dam, Otsego Dam, Otsego City Dam, and Plainwell Dam) restricting sturgeon migration and access to spawning habitat. The upper river section with the largest area of cobble habitat is between the Otsego City and Plainwell Dams. Regardless of the amount of suitable spawning habitats in the upper river, the lack of nursery habitats upstream from Calkins Dam and the character of lake sturgeon larval drift (Smith and King 2005) would result in larval sturgeon to flow down to the Lower River and Kalamazoo Lake in order to grow and feed successfully. Currently, there is no mechanism to allow safe passage for adult lake sturgeon upstream to spawn or larval stages to drift downstream past the multiple dams that exist. Juvenile lake sturgeon habitat in Kalamazoo Lake has been threatened by dredging and shoreline development and remains an Area of Concern for PCB contamination.

The Michigan Department of Natural Resources (DNR) has developed a Lake Sturgeon Management Plan for the entire state (Carrafino and Hayes, 2012). As part of this plan, certain Lake Michigan tributaries have been identified in the priority list of Michigan Lake Sturgeon Rehabilitation waters. These waters include the Kalamazoo, Grand, and Muskegon Rivers along eastern Lake Michigan. The main goals of the rehabilitation of Lake Sturgeon in the Kalamazoo River are to increase genetic diversity of the adult stock and to add multiple year classes to the spawning stock since the age structure of mature females is comprised of only seven year classes. The other goal is to identify critical habitat and enhance this habitat. Population goals are to achieve 20 female family groups crossed with 3 to 5 males over the first 15 years. A population should be comprised of 26 year classes by 2035 with representatives from the restoration efforts. After preliminary goals are met then objectives for achieving population sizes of at least 750 mature adults can be considered as recommended by Welsh et al (2010) and consideration would then be given to managing the species as a sport fish by delisting their status and sustaining a harvest based on regenerative capacities.

PROCEDURES

"For many populations, the most appropriate source for supplementation may be its own stock, if that stock has maintained an appropriate level of genetic diversity. If the donor stock cannot be from the source population then the donor population should be from a metapopulation with similar genetic characteristics (i.e., allele frequencies), ecological and environmental attributes (Welsh et al 2010)." It is our intent to adhere to these guidelines to the extent possible; however if these efforts prove to be unsuccessful during certain later years it may be prudent to use gamete collections from nearby populations within the Muskegon River that has been shown to have similar genetic characteristics to the Kalamazoo and Grand Rivers along eastern Lake Michigan.

Michigan DNR has requested fall fingerling Lake Sturgeon be stocked into the Kalamazoo River for the next 20 to 25 years. This will involve using a minimum of 20 female family groups over this duration. In addition, other stocking strategies may be necessary, including evaluating the success of egg deposition recovery and larval dispersion.

METHODS

<u>Direct gamete takes</u>: Gamete collection and mating techniques maximize representation of a large number of adults to the restored population and minimize reproductive differences among adult males and females. For smaller remnant populations where low population size (<50 fish in annual spawning run) is a problem, alternative donor sources within the metapopulation may be used if available (Welsh et al 2010). Mature adult lake sturgeon possibly will be captured on the spawning grounds using boom-electrofishing gear or large-mesh gill nets. Eggs can be removed by hand stripping females captured in the act of spawning. Sperm can be collected by inserting a tube into the urogenital opening and

aspirating to withdraw the sperm. This method minimizes the possibility of urine contamination within the samples. Urine can cause activation of sperm and reduced storage time. Lake sturgeon duration of sperm motility after activation in de-ionized water was 285 sec until sperm cells ceased all forward movement (Wayman 2003). Sperm can be collected from males using a 30-mL syringe, then immediately placing on ice until enough eggs have been obtained. Water is added to activate the gametes. After 5 min, the water is poured off and a Fuller's earth solution is added and mixed to reduce egg adhesiveness. The use of Fuller's Earth can be used to reduce the eggs adhesive properties because it adsorbs to the exterior surface preventing clumping of large egg masses. After 30 min, the eggs are rinsed and transferred to the streamside rearing facility where they are placed in McDonald type jars for incubation at ambient river water temperature or less than 16 degrees Celsius.

Spawning ratios can be maintained at three to five males for every female, or as observed in the annual spawning event. If a female has to be used more than once due to low abundance, she would be mated with a different male from another breeding period(s). Gametes will be kept separate by family (male-female pair) so that the number of progeny from each family can be equalized during the rearing process. An estimate of the number of eggs needed from each female can be determined a-priori based on expected survival rates during incubation and rearing so that sufficient progeny are available to meet stocking targets without encumbering the facility with unusable excess. Annual stocking targets are not described here because the goal is to achieve representative year classes and family groups and not a targeted population size as is the difference in goals between reintroduction and restoring a remnant population.

Mature lake sturgeons have been captured from the river using electrofishing techniques from 2003 until 2010. Lake sturgeon injuries (e.g. ruptured notochord) have been reported from historic sampling efforts using electrofishing gear that incorporated high outputs and alternating current settings. Therefore, gear settings and electrofishing techniques need to be followed to insure no mortalities occur as a result of this sampling technique. Adult lake sturgeon have been captured in the Kalamazoo River with a 21-foot modified Michigan DNR boat with Smith-Root electrofishing gear. The electrofishing gear was set to deliver pulsed direct current (less than 30% duty cycle) on low range (250 volts and 15 pps) at less than 3 amps. A single pass was made in a downstream direction along each streambank and at five linear transects across the middle of the channel. Fish captured are either held in an onboard recovery tank or taken to a holding net located outside of the electric field until sampling is completed. Demographic information is collected on each fish, a PIT tag is either recorded for previously captured fish or added to each new captured individual, external features are noted, gender is determined by physically emitting gametes from each fish, and then the fish is released to the river after recovery. A dorsal fin ray is collected for all new captured fish to determine ages of the spawning population.

In recent years, reproductive asynchrony has been observed between captured males and females. The ability to capture and retain gravid females has limited the collection of eggs through direct and traditional methods. Some future alternatives may include induced spawning techniques or refrigerated storage of sperm. White sturgeon sperm (Conte et al., 1988) and Atlantic sturgeon sperm (DiLauro et al., 1994) have been stored undiluted for as long as 14-17 d. Wayman (2003) evaluated the use of extenders for refrigerated storage of sperm in pallid, shovelnose, and shortnose sturgeon. The author found that Sturgeon sperm stored undiluted retained equal or greater motility than sperm stored in any of the extender and osmolality combinations. The inclusion of potassium in extenders for refrigerated storage of sturgeon sperm could maintain sperm in a quiescent state and enable longer storage times for samples that are contaminated with urine (Wayman 2003).

Dispersing larvae: Collection of dispersing larvae downstream from the adult spawning areas can be used as the primary means to restore the Kalamazoo River population. Larval sampling occurs on an annual basis and can be conducted for a five hour period from dusk and ending in the early morning (Smith and King 2005). The target sampling period is 9:00 PM - 1:00 AM (2100-0100 hrs). This option would produce inconsistent numbers annually because of the intermittent and episodic larval dispersion observed over the past seven years.

To assess larval lake sturgeon drift in the Kalamazoo River, we used similar D-frame drift nets as Smith and King (2005), consisting of a stainless steel frame (76 cm across the base, 54 cm high) with a knotless 1600 micro-m mesh nylon bag 317.5 cm long and detachable cod-end. The D-frame nets are deployed using a triple-point bridle attached to the net. A mechanical flow meter is attached in the center of the frame mouth to estimate volume of water sampled. Gear was assembled onboard a DNR boat (equipped with a jet motor) by attaching a spherical buoy (0.3 m diameter) to a 20 kg trapnet anchor using enough braided nylon rope (6.4 mm diameter) to compensate for both depth and drag by the current. This constituted the upstream anchor and the buoy aided in retrieving the anchor from the river bottom when sampling was completed. The D-frame net was attached to the upstream anchor using 3 to 5 m of braided nylon rope (9.5 mm diameter) tied to the trapnet anchor and then to the lead of the three point bridle attached to the D-frame net. A second 0.3 m diameter buoy was attached to the top of the D-frame net and was used to lift the net during tending. In recent years only a single buoy was used to reduce the navigation hazards by anglers. Deployment of the gear began by locating the upstream end of the desired sampling site and marking this with a GPS device. The trapnet anchor was then lowered into the river using the anchor line while paying out the line until the anchor reached the river bottom. The vessel then backed downstream while the crew dispensed the rope until the net was reached. Once all of the line was deployed, the net was lowered into the water using the buoy line attached to the top of the D-frame. Retrieval of gear during tending involved several steps; lifting the net by the downstream buoy line, tying the line to the vessel to hold the boat in place, and processing the sample by washing the contents of the net into the cod bucket and then dispensing the contents into a 5 gallon collection bucket. The net was then redeployed by untying the lead from the vessel and lowering the net back to the bottom to be fished for the desired sampling duration. We fished up to eight nets at one hour intervals over the course of a night, taking about 5 minutes each to retrieve, wash down the sample, and re-deploy. Presumably there will be as many as 12 to 16 nets deployed during the rehabilitation effort and therefore sampling durations may be prolonged to 1.5 hours.

Naturally produced eggs: Collection of naturally produced eggs downstream from the adult spawning areas has not been shown to be an efficient or viable collection strategy in the Kalamazoo River because of hydropower and debris management operational activities. Egg deposition in the Kalamazoo River has been determined previously with the use of furnace-filter egg mats placed on the river bottom following procedures described by Nichols et al. (2003) and Manny et al. (2010). Each egg mat consisted of a rectangle (38 x 50 x 2.5 cm) of furnace filter material wrapped around a concrete cinder block and secured with two bungee cords. Ten egg mats linked together, end to end, with 3 m lengths of 0.95 cm diameter braided nylon line formed a gang of egg mats. Each gang was anchored on the shoal with a small (3.6 kg) trapnet anchor on the upstream end and another anchor on the downstream end which was connected to a 0.3 m diameter orange surface buoy. Both anchors were separated from the egg mats using a 3 m length of 0.95 cm diameter nylon braided line. Deployment of the egg mat gang consisted of navigating slowly upstream to the spawning location, then reversing course backing the vessel with the current. As the vessel backed downstream, the lead anchor was deployed (at the waypoint location) and the egg mats were pulled off the vessel as it pulled away from the anchor. Finally the rear anchor would be deployed, and the line/buoy was allowed to pay out leaving the buoy floating on the river surface. Retrieval of the egg mat gang occurred in reverse of the deployment, hooking the buoy/line floating on the surface, then navigating upstream as the gear was pulled onboard. Our study typically left the egg mat gang in place (with the buoy floating on the river surface) on the river for 8 - 10 weeks, returning every other day to retrieve the egg mats and inspect for eggs before redeploying for another couple days. Once the mats were onboard, eggs were enumerated and removed from the egg mats, and the gear re-deployed by beginning at the upstream anchor and backing downstream while dropping the gear as described above.

In recent years, egg collectors modeled after the mats used in sturgeon research from other systems proved difficult to retrieve from the riverbed and did not collect large numbers of viable eggs. Tubular egg collectors designed to remain suspended off the bottom were successfully used in previous years during periods after the peak Kalamazoo River discharge. Specialized floating egg mats have periodically been used to capture fertilized eggs produced from a few remnant mature adults. Eggs were found on tubes retrieved from the middle of the channel and none have been present on tubes placed along the channel margins. Although eggs were spatially distributed in a clumped manner at sample sites, the mean number of eggs per tube was low, indicating a relatively small spatial area that spawning takes place in the deepest sections of the channel. Alternatively an egg sampler constructed out of angle iron that is lighter in weight and has a larger surface area may be used to collect eggs deposited on the river bottom.

Design of the tubular egg collectors includes a rectangular piece of furnace filter material wrapped around a 15.24 cm diameter by 45.7 cm Polyvinyl chloride (PVC) tubing and secured with two bungee cords. A sponge float (12.7 cm D x 28 cm L) was placed inside of each PVC tube to suspend the egg mat just above the stream bottom. Three to five such egg mats linked together with a similar assemblage as the traditional egg mats was used. Although lake sturgeon eggs are adhesive, these properties can be chemically separated through the use of sodium sulfite to remove the eggs from the furnace filter material. Eggs can be collected from the furnace filter material and incubated within the rearing environment but protecting the eggs from fungal infection by the use of UV light treatment to the extent possible. Numbers and techniques would follow gamete collections as indicated above. The benefit of this strategy would be that rearing of naturally spawned eggs would maximize genetic diversity and would also employ mechanisms to maintain the spatial and/or temporal diversity similar to larval dispersal techniques.

Specific allocations and stocking numbers are not given because the number of dispersing larvae and naturally produced eggs available for stocking fingerlings is highly variable and seldom known ahead of time. In summary, restoration of the Kalamazoo River lake sturgeon population should occur through the use of various methods to achieve the overall goal of restoring this population through sound biological principles. Because of the low adult population size it is practical to use all three proposed methods and manage for similar sized family groups that are stocked annually.

REARING TECHNIQUES

For stocking into open systems, streamside rearing has been identified as a method expected to maximize the likelihood of imprinting and thus minimize the risk of straying of stocked fish. This technique can add logistics and expense above what is typical for other alternative techniques or what can be expected for each population. Acquiring a state operated stream side rearing facility would benefit management of this population. Directly stocking eggs or very early stage larvae could also reduce the risk of straying if they are acquired post development of site-specific olfactory structures. Partnership with USFWS, Gun Lake Tribe, Grand Valley State University, Allegan County, and Sturgeon for Tomorrow will be important to accomplish this financial commitment.

RELEASE TECHNIQUES AND EVALUATION

Lake sturgeon will be released at the earliest life stage possible (e.g. 17 weeks) based on growth rates measured from ongoing juvenile research in the Kalamazoo and Grand Rivers that have verified out-migration of this life stage to Lake Michigan at sizes ranging from 180 to 240 mm. All propagated fish will be PIT tagged prior to release to determine the origin of individuals from the various stocking events. Stocking strategies from the Milwaukee River have shown that these fish may wonder to other areas of SE Lake Michigan, therefore tagging of released fish will be important to verify origin of individuals. Tissue samples will be collected from all fish to be stocked in order to characterize the genetic lineage of the stocked fish. All fish will be released near verified juvenile habitats located upstream of the Morrison Bayou and Indian Cut.

Based on information from ultrasonic tagged fish, Michigan DNR will be able to assess the preferred habitat of stocked versus wild lake sturgeon. Ongoing surveys have already detailed areas of use by juvenile lake sturgeon in the river and along the south-eastern basin of Lake Michigan. These sites will continue to be monitored along with the long-term assessment that has occurred since 2003. Detailed GIS enabled assessment surveys will quantify the habitat including instantaneous water characteristics (air and water temperature, conductivity, turbidity, total dissolved solids, dissolved oxygen, pH, flow, continuous logged water temperature and water clarity), basin characteristics (stream widths, channel condition, sinuosity, gradient) and in-stream and riparian habitat characteristics have been measured using Biosonics and Sidescan Sonar technology. Fisheries' Division will use a variety of gears to capture lake sturgeon including river electrofishing, small mesh gillnetting, and trawls during different times of the year to quantify survival of differently stocked lake sturgeon (e.g. 17 and 20 weeks of age). Recaptures of tagged fish from the Milwaukee River and juvenile fish from the Grand, Muskegon, and Manistee Rivers have been collected at these long-term assessment sites along the south-eastern basin of Lake Michigan, and will likely be important areas to monitor for released fish from the Kalamazoo River. Submersible ultrasonic receivers (SUR's) will be placed at 1.25 mile intervals from the rearing facility downstream to the mouth at Lake Michigan to evaluate the downstream dispersal and survival of stocked juvenile lake sturgeon.

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