A Management Plan for Lake Sturgeon in Yellow Lake

2019

by:

Yellow Lake Sturgeon Subcommittee
Introduction

Lake sturgeon *Acipenser fulvescens* are considered threatened throughout much of their historic range in North America (USFWS 2016). The waters of Wisconsin collectively possess one of the largest self-sustaining populations of lake sturgeon in the world (WDNR 2000). Lake sturgeon have a life strategy of slow growth and late maturation that makes them particularly sensitive to stressors such as environmental change, barriers to fish passage, inconsistent spring flow rates and over-exploitation. Female lake sturgeon become sexually mature at approximately 25 years and 55” (Becker 1983). Once reaching maturity, females will typically spawn every 4-6 years. Male lake sturgeon typically reaches sexual maturity at approximately 45” and spawn every other year (Becker 1983).

Yellow Lake supports a self-sustaining sturgeon population that supports both a tribal subsistence fishery and an angler sport fishery. Because of the importance of this lake sturgeon population in Yellow Lake, a management plan was initiated to protect the population. The main goal of this plan is to preserve the Yellow Lake sturgeon population. To achieve this, we will calculate an updated population estimate to be used to establish sustainable harvest quotas for the angling and tribal fisheries. We will identify data needs for the lake sturgeon fishery including: 1) updating angling effort data, 2) lake sturgeon recruitment and 3) population characteristics and lake sturgeon habitat.

Background

*Yellow Lake and watershed*

Yellow Lake is a large drainage lake located in west central Burnett County (Figure 1). The lake has a surface area of 2,287 acres with a maximum depth of 31 feet and mean depth of 19 feet with a diverse fish community (Roberts 2015). Water clarity is poor, with average summer secchi disk readings of approximately five feet (WDNR 2018). The shoreline is primarily privately owned and heavily developed. A water control structure (hydroelectric dam) on the Danbury Flowage maintains the lake level. This structure serves as a barrier to fish movement between the St. Croix River and Yellow Lake. Due to this barrier, lake sturgeon in Yellow Lake have been isolated from the St. Croix River sturgeon.
population since the 1930s (Johannes 1988). Aquatic invasive species present in Yellow Lake include common carp *Cyprinus carpio*, rusty crayfish *Orconectes rusticus*, Chinese mystery snail *Cipangopaludina chinensis*, purple loosestrife *Lythrum salicaria* and curly-leaf pond weed *Potamogeton crispus*.

The Yellow River is a tributary of the St. Croix River that flows through Yellow Lake and Little Yellow Lake. The Yellow River originates as Crystal Brook and Beaver Brook in Washburn County. Upstream of Yellow Lake, the watershed of Yellow River is 206.4 square miles. The portion of the Yellow River detailed in the plan includes the area immediately above Yellow Lake upstream to Conner’s Bridge, approximately 7.0 river miles (Figure 1). This area includes important spawning grounds for lake sturgeon from Yellow Lake.

![Figure 1. Map of study area, including Yellow Lake and Yellow River upstream to Conners Bridge, Burnett County, Wisconsin. Study area marked in yellow and bounded by blue dots. Yellow Lake directly adjacent to Hwy 35 and western blue dot on figure.](image-url)
Lake sturgeon fishery of Yellow Lake, past population estimates, and harvest history

Yellow Lake supports both a tribal and sport angling fishery. Harvest of lake sturgeon in Yellow Lake is managed by a quota system, with a maximum of 5% of the estimated adult population (>45 in) available for annual harvest. The quota is split evenly between the tribal and sport angling fishery with each receiving 2.5%.

Sport Fishery

Little information was known about the lake sturgeon population in Yellow Lake until anglers caught two record (hook and line) lake sturgeon from Yellow Lake in 1979 (Johannes 1988). One record currently stands as the Wisconsin state hook-and-line record measuring 79 inches and weighing 170 lbs 10 oz. Due to the publicity of these records, angler effort increased dramatically in the following years. In response to this increased effort, a study of lake sturgeon in Yellow Lake was initiated in 1980 to assess the population status (Johannes 1988). The study found that the lake sturgeon population was overexploited with most fish sampled being less than 20 years of age.

Hook and line regulations for most Wisconsin inland sturgeon angling waters, including Yellow Lake, have changed three times since 1980 (Table 1), becoming more restrictive each time. The state-wide minimum length limit for sport anglers is currently 60” (Table 1). Since 1983, a mandatory tagging and registration system has been in effect for all lake sturgeon harvested by sport anglers in Wisconsin. From 1983-2019, the number of lake sturgeon registered from Yellow Lake has ranged from 0-21 fish per year, with an average annual sport harvest of 7 fish (Figure 2). The average size at harvest has generally increased as the minimum length limit increased (Figure 3).

The last creel survey in 2008 estimated anglers caught 430 fish and kept zero during the sturgeon fishing season. Examination of angler’s catch during the 2007 and 2008 sturgeon fishing season revealed that 93.9% of the fish caught were below the legal length limit of 60” and revealed no signs of over exploitation (Wendel and Damman 2011). Angling harvest has remained low since the 60-inch minimum
size limit was enacted in 2009. Recent sentiments from many anglers have been to make a portion/all of the lake sturgeon angling season catch and release to preserve and promote a trophy fishery in Yellow Lake. The current goal for the sport fishery is to maintain a “trophy fishery” in Yellow Lake (average size of all adults sampled range between 50 and 60 inches based on DNR sampling data from 2011 - 2019).

Table 1. Recent history of lake sturgeon angling regulations on Yellow Lake, Burnett County, WI.

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<td>1991 - 2008</td>
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*Tribal Fishery*

A total of 33 lake sturgeon were harvested by tribal spearers from 2006-2019 (Figure 3), ranging in length from 46” to 72.5” (average 59”). The sex ratio is difficult to determine in the tribal harvest data since most of the fish were recorded as unknown (creel clerks are instructed to record a fish as unknown if they are unable to observe gametes). The annual harvest from 2006-2019 ranged from 1 to 7 sturgeon and averaged 2.4 per year. The goal for the tribal fishery is to provide culturally appropriate sustainable harvest opportunities for lake sturgeon.
Figure 2. Annual harvest of lake sturgeon in Yellow Lake between 1983 – 2019.

Figure 3. Average size of lake sturgeon in Yellow Lake harvested from 1983 – 2019 by angling and tribal harvest. The open symbol represents one fish that season.
两大湖泊和安全捕捞配额

The first lake sturgeon population estimate for Yellow Lake was calculated from tagging efforts from 1979 through 1986. Wisconsin DNR crews utilized four gear types: fyke nets, gill nets, angling, and river electrofishing to tag sturgeon with metal monel tags on the front edge of the dorsal fin. Angler catch was used as the recapture sample and the marking sample included all fish marked by all methods prior to the recapture sample. Fish that were known to have been harvested were subtracted from the marking sample. Angling and river electrofishing (during spawning in the Yellow River) proved to be most effective collection methods and the data collected were used to generate multiple population estimates. Population estimates were calculated for 1984, 1985 and 1986 using the Bailey Modification of the Petersen Estimator (Johannes 1988). The average estimate between 1984, 1985, and 1986 was 290 fish or 0.13 fish/acre. The current safe harvest quota is 5% of the average population estimate from 1984, 1985 and 1986 (15 fish) and is split evenly between the state and tribal fisheries.

A second population estimate was attempted using data collected between 2005 – 2008. Sturgeon were marked with Carlin dangler tags and pit-tags primarily during spawning with electrofishing, block nets, and dip nets. Additional fish were marked using angling in 2007. As in the 1980s survey, the total number of fish tagged from 2005-2008 were used as the marked sample. No adjustments to marked fish at large were made for tag loss as that variable was not quantified. Lake sturgeon captured during the creel survey in 2008 were used as the recapture sample. The population estimate was calculated using the Chapman modification of the Petersen Estimator (Wendel and Damman 2011). Known mortalities and harvested fish were removed from the marked sample and added back to the population estimate. This method calculated a population estimate of 1,628 (95% C.I. 753-2,509, C.V.=0.28) or 0.7 fish/acre for fish greater than 45”.

The 2008 population estimate was rejected by the Technical Working Group (TWG) of the Ceded Territory for setting sturgeon harvest quotas based on recommendations of Wendel and Damman (2011). Wendel and Damman (2011) were concerned that recapture methods may have biased the estimate. They were also concerned about angling being biased toward specific segments of the population, lower catchability of mature fish than during spawning, and potential for tag loss. Using
fall angling as the recapture may bias the adult population estimate as immature sturgeon greater than 45” would not be vulnerable to spring sampling, but present in fall angling. Another concern was that new fish were not tagged in 2008, therefore there was potential for anglers to catch the same fish multiple times, also adding bias to the estimate. They went on to recommend that population estimates should be generated from spring sampling during the spawning run using a Jolly-Seber methodology (Wendel and Damman 2011). A third population estimate has been generated using methodology from Pledger et al. 2013 (Jolly-Seber type model). This estimate will be discussed in more detail later in this management plan but does follow recommendations of Wendel and Damman (2011) to use spring sampling during the spawning run for a more accurate adult population estimate.

**PLAN GOALS**

The Yellow Lake Sturgeon Management Plan was initiated to protect the lake sturgeon population in Yellow Lake and Yellow River and to evaluate the status of the adult population for setting the harvest quota for the combined lake sturgeon fishery. The main goal of this plan is to preserve the lake sturgeon population in Yellow Lake. To achieve the goal we will 1) update the population estimate from 1986 to adjust the safe harvest quotas for the tribal and sport fisheries. Also, we will identify data needs for the management of the lake sturgeon fishery including: 2) updating angling effort, 3) lake sturgeon recruitment, and 4) population characteristics and lake sturgeon habitat. The following sections address our sampling methods and goals for parts 1-4.

**Field Sampling and Aging**

Between 2011-2019, lake sturgeon were captured in the Yellow River by pulsed DC daytime electrofishing and dips nets. Sampling coincided with spring lake sturgeon spawning runs. Each sturgeon captured was measured to the nearest 0.1” TL and sexed. All sturgeon were double tagged with an individually numbered Carlin disc dangler tag at the base of the dorsal fin and were tagged with a passive integrated transponder (PIT) tag that was injected near the base of the left pectoral fin.
Individual tagging allowed for development of capture histories and for determining breeding return times for use in estimating the population abundance. Typically, long-lived fish species such as lake sturgeon do not breed every year and are not accessible during non-breeding periods to sampling gears.

Lake sturgeon were aged by removing a section of pectoral fin ray similar to methods described by Rossiter et al. (1995). Fin rays were allowed to dry before a thin cross section was cut using a Buehler low speed Isomet saw (Buehler LTD). A compound microscope at 4-10X magnification was used to estimate age.

Catch curve analysis was used to determine lake sturgeon mortality. The descending limb of a catch curve regression was used to estimate total annual mortality (Ricker 1975). The mortality estimates are conservative because typically aging from fin rays underestimates the age of older fish resulting in an overestimated of annual mortality (Bruch et al. 2009). As aging materials were not taken for all fish, an age-length key was used to assign a sample age distribution. Use of this method assumed that recruitment and survival did not vary at age over time. Lake sturgeon age classes 17-42 provided the strongest predictive power ($r^2$) and were included in the catch curve regression.

Mean length at age was used to assess growth using the following von Bertalanffy equation:

$$l_t = L_\infty(1-e^{-K(t+t_0)})$$

Where $l_t$ is length at time $t$, $L_\infty$ is asymptotic length, $K$ is a growth parameter, $t$ is age in years, and $t_0$ is the age at which $l_t$ is zero (Van den Avyle and Hayward 1999). Assuming dimorphic separation of length at age (Bruch 2008), growth equations were calculated separately for male and female lake sturgeon.

1. **Population Estimate**

Since 2011, data has been collected on 132 individual females, 266 individual males, and 84 individual unknowns. Seventy-eight of the unknowns were greater than 45” in length. Female lake sturgeon in Yellow Lake breed once every 4 years on average and male lake sturgeon spawn once every 2 to 3 years on average. Breeding time Jolly-Seber (JS) return models were used to estimate the Yellow
Lake lake sturgeon population abundance following methods developed by Pledger et al. (2013) and were calculated using R (R Core Team 2018). Population estimates were calculated for both sexes because of the differences in breeding return times for males and females (Pledger et al. 2013). No estimate was calculated for the dataset containing the unknown sex fish because they had no recapture events associated with them and no breeding return time was determined for those fish. The final estimate is the sum of the two estimates for the males and females. Catch histories of fish that were known to have died or been harvested during the sampling period were removed from the model estimates. Based on spring sampling data collected from 2011 – 2019, there are approximately 861 adult lake sturgeon (640 – 1196; 95% CI) in Yellow Lake (Appendix Table 1). Based on recommendations of the Yellow Lake Sturgeon subcommittee of Technical Working Group (TWG), the 78 unknown sexed fish were excluded from the final estimate because of the possibility that they may have been immature females. The adult density suggests the current population is roughly 0.4 fish/acre for Yellow Lake.

**Population Estimate Management Goal**

The Wisconsin DNR will continue to sample the Yellow River during the lake sturgeon spawning run to annually calculate a population estimate. This will ensure that the most accurate and current population estimate is used for setting harvest quotas. The estimate will be reviewed at the annual August TWG meeting and as needed by the Yellow Lake sturgeon subcommittee. At the December TWG meeting, the quota for the upcoming fishing season will be set by consensus. Factors that could be considered in setting the quota include: the most recent population estimate, the long-term trend in adult abundance, indices of natural reproduction, recruitment and juvenile abundance, harvest history, and age structure in the population.

2. **Angling Effort**

Lake Sturgeon angling harvest requires mandatory tagging and registration for all inland populations open to harvest in Wisconsin. However, there hasn’t been a recent creel survey (2008) for
Yellow Lake investigating overall angling pressure for lake sturgeon. The creel survey in 2008 suggests a higher angler effort on Yellow Lake for lake sturgeon than previous creel surveys conducted during the 1980’s (Table 2, Wendel and Damman 2011). An updated creel survey for Yellow Lake is currently being planned. This creel survey coupled with an estimate of lake sturgeon hooking mortality (this research is currently being performed by WDNR Office of Applied Science) would help our understanding of potential hooking mortality that may occur.

Table 2. Summary of lake sturgeon creel statistics for Yellow Lake, Burnett County, Wisconsin (Wendel and Damman 2011).

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<td>150</td>
<td>158</td>
<td>174</td>
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<td>430</td>
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**Angling Effort Goal**

We propose to update angling effort information using a creel survey during the 2021 September angling season. Data will be used to improve knowledge of the sport fishery and potential for hooking mortality in Yellow Lake.

**3. Juvenile Lake Sturgeon**

Very little is known about the juvenile lake sturgeon population in the Yellow Lake system. Overall, the juvenile lake sturgeon data that have been collected has come from immature fish captured during hook-line sampling. These fish have ranged from 20.0 to 54.2” in length and range in age from 2 to 17 years. However, exploring other sampling methods such as drift nets for larvae in the river (Caroffino et al. 2010), small mesh gill nets for juveniles (Schloesser, J and H. Quinlan. 2010) or other
methods may provide a better and more consistent method for estimating juvenile sturgeon recruitment in Yellow Lake. These methods would ensure less potential for bias with unknown adults being a part of the juvenile sample (i.e., adult non-spawning males or females, which are assumed to be juvenile because of sample timing).

**Juvenile Lake Sturgeon Goal**

Establish a method to consistently collect juvenile lake sturgeon and quantify recruitment for the lake sturgeon population in Yellow Lake. This method should be designed to monitor trends over time for lake sturgeon recruitment.

**4. Population characteristics and lake sturgeon habitat**

**Mortality**

Total instantaneous mortality \((Z)\) for age classes 17 – 42 was 0.065 (\(r^2 = 0.50\); Figure 4). Total annual mortality \((A)\) was calculated to be 6.3\% \(\text{with annual survival being} \ 93.7\%\). This estimate of mortality is slightly higher than the estimate for Yellow Lake in 2008 (3\%). However, this estimate is lower than majority of other lake sturgeon populations in the Upper Midwest (range 5\% - 20\% see Table 6 in Wendel and Damman (2011)).
Figure 4. - Catch curve for lake sturgeon sampled from Yellow Lake, Burnett County, Wisconsin.

**Length Frequency, Age, and Growth**

The average length for lake sturgeon collected between 2011-2019 was 63.4” for females, 51.2” for males and 55.7” for unknowns (Figure 5). Age was determined for 318 lake sturgeon from 2011 to 2019 (a portion of the 2019 sample still needs age analysis). These fish ranged in age from 9 to 60 years old with a mean age of 25. The von Bertalanffy growth function (K) was 0.11 for female sturgeon and 0.17 from male sturgeon. This K function is much higher than what was observed in 2008 (females = .011; males = .028). The L∞ or estimated maximum size was 69 inches for females and 56 inches for males. These estimates are smaller than the L∞ estimates from 2008 study where females was estimated at 105.8” and males estimated at 63.5” (Wendel and Damman 2011). However, the current growth analysis utilized a bigger sample size and was composed of only adult fish.
Figure 5. – Relative frequency of lake sturgeon sampled in the Yellow River, Wisconsin from 2011 – 2019.

**Lake Sturgeon Diseases**

In 2019, Yellow Lake sturgeon tested positive for Acipenserid Herpesvirus 1. One fish was identified with the virus and verified by laboratory testing. There have been multiple unverified observations in the past in the Yellow River. It is unknown what effects (if any), this virus may have on the lake sturgeon populations in Wisconsin. Currently, this virus has only been verified in Yellow Lake, The Lake Winnebago System, the Chippewa River, the Menominee River, and the St Louis River in Wisconsin (WDNR Fish Health personal communication 2019). Acipenserid Herpesvirus 1 has been known to cause increased mortality in juvenile white sturgeon (Hedrick et al. 1991). The Wisconsin DNR will continue to evaluate the distribution of the virus within Wisconsin waters and potential impacts of the virus on lake sturgeon populations.

**Lake Sturgeon Genetics**

In 2018, the Yellow Lake sturgeon population genetics were analyzed by UW-Stevens Point using tissue samples from 50 lake sturgeon collected in the Yellow River during their spawning migration. This analysis found that Lake Sturgeon from the St. Croix River basin are unique genetically.
relative to other lake sturgeon populations in Wisconsin (Wes Larson UW-Steven Point personal communication 2018). This analysis also found a lower amount of genetic diversity in the Yellow Lake system relative to other populations in the state. UW-Stevens Point recommended adhering to genetic units when developing stocking protocols (Wes Larson UW-Steven Point personal communication 2018). This analysis further supports the importance of the Yellow Lake sturgeon population as a brood source for other lake sturgeon populations in recovery in the St. Croix river basin.

**Habitat**

While Wisconsin DNR has sampled in the study area (Figure 1) since the 1980s. There has never been a formal habitat survey to document what type of rocky habitats the lake sturgeon utilizes while spawning. It is also unknown if a portion of the lake sturgeon population spawns farther upstream than the Connor’s Bridge section of the Yellow River.

**Population Characteristics and Lake Sturgeon Habitat Goal**

The Wisconsin DNR would continue to update mortality, age, and growth parameter estimates as data are collected annually to gain a better understanding of the population. We also plan to document adults with apparent Acipenserid Herpesvirus 1 in yearly sample, especially spring to better understand presence within the adult population. Document the current suitable spawning habitat in the Yellow River system upstream of Yellow Lake, based on areas of known spawning activity. If present, explore additional areas upstream of Connor’s bridge for lake sturgeon spawning activity.

**Harvest Quota Recommendation**

The Yellow Lake Sturgeon subcommittee of the TWG recommends setting the sturgeon harvest quota utilizing 5% of the lower 95% confidence interval of the 2019 adult population estimate. Under this process the sturgeon harvest quota for 2020 would be 32 sturgeon for Yellow Lake. The harvest quota would be split between sport and tribal fisheries at 16 fish per group. This is a more conservative
approach to setting harvest quotas then the previous approach using 5% of the adult population. The Yellow Lake Sturgeon subcommittee of TWG supports using a conservative approach to set the sturgeon harvest quota because of the unique value of the population and uncertainties about upcoming recruitment of juvenile sturgeon, hooking mortality, spawning habitat, population trajectory, effects of Acipenserid Herpesvirus 1 virus on the population, and the importance of maintaining Yellow Lake as a potential brood source for other recovering populations in the St. Croix river basin (Namekagon River, Upper St. Croix River, and other tributaries).

Literature Cited


Fisheries Research Board of Canada 191. 382p.


Wisconsin Department of Natural Resources. Spooner, WI.


WDNR 2000. Wisconsin’s lake sturgeon management plan. Wisconsin Department of Natural Resources, Bureau of Fisheries Management and Habitat Protection.

Initial run of Jolly-Seber Return Models by Pledger et al 2013

Lake Sturgeon capture histories from 2011-2019

*BIC has a stronger penalty against too many parameters.

Model was run separately by sexes

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<td>709</td>
<td>520</td>
<td>967</td>
<td>8</td>
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</tr>
</tbody>
</table>

The first three letters specify constant C or time-varying t assumptions for the entry parameters β, the survival probabilities Φ and capture probabilities p respectively. τ = time between spawning events and was set at four years for females and at three years for males. Models excluded unknown fish above 45". Model runs with unknowns created problems because of no recaps/ fish returning.

<table>
<thead>
<tr>
<th>Total N</th>
<th>Lower 95</th>
<th>Upper 95</th>
<th>5% of N</th>
<th>5% of Lower</th>
</tr>
</thead>
<tbody>
<tr>
<td>861</td>
<td>640</td>
<td>1196</td>
<td>43.05</td>
<td>32</td>
</tr>
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