A Population Assessment of Lake Sturgeon in the Namakan River, Ontario 2006-08

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ABSTRACT

A population assessment of adult lake sturgeon was completed from October 2006 to October 2008 between Lady Rapids and Snake Falls on the Namakan River, located approximately 80 km southeast of Fort Frances, Ontario. Three hydroelectric generating facilities are proposed for development at Hay Rapids, High Falls and Myrtle Falls by Ojibway Power and Energy Group (OPEG). A total of 430 sturgeon were caught in large mesh gill nets, including 19 recaptures. External tags were applied to 397 fish with 89% of the catch exceeding 1,000 mm total length. Mean size of all fish sampled (n=407) was 1,211 mm (605-1,746 mm) total length, 11,858 g (1,100-36,350 g) round weight, and 442 mm (195-766 mm) girth. Mean age was 26.1 years (n=349) with fish ranging from 7 to 61 years and 39 age classes represented (34 with n>1). Annual mortality was low at an estimated 5.6%. In comparison to other populations in the Lake of the Woods/Rainy River drainage (DU6), Namakan River sturgeon are slower growing, with a lower maximum attainable length ($L\infty$) and mean condition factor. This comparison also indicates that most other population parameters were consistent with and reflect the attributes of recovering populations in Rainy River/Lake of the Woods, Rainy Lake and Seine River. It appears that the population has achieved short-term goals, including male fish to age 30, female fish to age 50 and at least 30 age classes present. Annual recruitment has also been observed over the 34 year period from 1963 to 1995. However, the number of age classes present (n>40) and the number of female fish over 2,030 mm (80 inches) and older than 70 years is still below long-term management goals.

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INTRODUCTION

A proposal to develop three hydro-electric generation sites at Hay Rapids, High Falls and Myrtle Falls on the Namakan River lead to the preparation of a Environmental Field Study Plan (OPEG, 2006) and commencement of an Environmental Screening process in 2006. An assessment of the lake sturgeon population(s) was identified as part of a larger fisheries data collection effort, including telemetry, tagging, genetics and habitat evaluation. The specific objective of this study was to evaluate the health and status of lake sturgeon *(Acipenser fulvescens)*, and contribute to the evaluation of potential impacts of hydro-electric development on the Namakan River. This population assessment should also provide valuable baseline data for the development of water management plans and long-term monitoring efforts, particularly if development proposals proceed.

Lake sturgeon are known to occur throughout the Namakan River system from Lac La Croix downstream to the Namakan Reservoir. Water control dams at Kettle Falls and Squirrel Falls regulate water levels on the Namakan Reservoir based on a "rule curve" established by the International Joint Commission (IJC) through the International Rainy Lake Board of Control (IRLBC). Recent changes to water regulation in 2000 lead to the development of a long-term monitoring strategy to evaluate aquatic ecosystem impacts; in which a lake sturgeon inventory and assessment program was included (IRLBC, 1999; Kallemeyn, 2000; Adams et al, 2006).

The Ontario-Minnesota Fisheries Committee established a Border Waters Lake Sturgeon Management Committee, which recommended that additional studies be completed on lake sturgeon populations where little or no information currently exists (OMNR and

MDNR, 1995). Previous population assessments have been completed for lake sturgeon in the border waters area including Lake of the Woods and Rainy River (Mosindy and Rusak, 1991; Stewig, 2005); Rainy Lake (Adams et al., 2006); and the Seine River (McLeod, 1999).

Little is known about the status, distribution and exploitation of lake sturgeon in the Namakan River, especially since development and road access to the system has been limited historically. The life history of the fish, the historic and intense exploitation, and the effects of dams and pollution on the ability of the species to reproduce have all contributed to low population levels of lake sturgeon elsewhere in Canada (Scott and Crossman, 1998). In the Great Lakes, the decline in lake sturgeon populations has been primarily attributed to three factors: physical impacts on spawning and nursery habitat, barriers to migration and over-fishing (Brousseau, 1987; Auer, 1999). Anthropogenic modifications of rivers and estuarine habitats have also reduced the growth and recruitment of other sturgeon species throughout their native range (Ziegeweid et al., 2008).

Lake sturgeon are currently designated as a species of “Special Concern” in Ontario and regulated under the Endangered Species Act (S.O. 2007). A similar designation exists in Minnesota, but the legal context is different. In Canada, the species is under review by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) for possible designation under the Species At Risk Act (S.C. 2002). From an international perspective, lake sturgeon are also regulated through the Convention on International Trade in Endangered Species of Fauna and Flora (CITES – Appendix II). Conservation status is listed as “Vulnerable” by the American Fisheries Society (AFS, 2008), while global status is “G3-Vulnerable” and provincial status is “S3-Vulnerable” (NatureServe, 2008).

Although there is no history of commercial fishing on the Namakan River, low to moderate levels of non-resident angling and First Nation subsistence fishing are known to occur. Commercial fishing licenses for lake sturgeon previously existed downstream in Namakan Reservoir from 1916 to 2001; and upstream on Lac La Croix from 1959 to 1966. Although annual commercial harvest records are available since 1924, there is no information on harvests levels prior to this period. Historical accounts indicate that a commercial pound-net fishery for lake sturgeon and whitefish existed on both Namakan Reservoir and Lac La Croix in the 1890’s (Pearson, 1963). Creel surveys have not been completed to evaluate angling effort and harvest, but little or no sturgeon angling has been observed in the Namakan River. Exploitation is likely incidental and similar to Namakan Reservoir where the majority of angler effort is generated by non-residents (99%) and directed at walleye (85 %) (Elder, 2001).

From 1994-1999, non-resident anglers were restricted to catch and release angling only for all fish species, unless staying overnight at an Ontario tourist establishment, houseboat, recreational fishing site, parcel of land or provincial park as described in the regulations. Pending a NAFTA trade challenge by the U.S., more general regulations were put in place across the border waters area in 2000 to limit harvest by all non-resident anglers. Effective July 1, 2008, the catch and possession limit for recreational angling of lake sturgeon was changed from one to zero for all anglers. Prior to this change, the daily catch and possession limit included a minimum size limit, whereby only fish greater than 190 cm (74.8”) total length could be retained. Prior to January 1, 2008, there was no size restriction on the Namakan River. The open season for angling of lake sturgeon was June 30 to May 15 each year until 2008, when it was changed to July 1 to April 30.

STUDY AREA

The Namakan River is located immediately downstream of Lac La Croix and upstream of Namakan Lake (Figure 1), approximately 80 km southeast of Fort Frances, Ontario. This 1,252 ha and 30 km long, mesotrophic river is found in the southern range of the boreal forest in North America, and is typical of Canadian Shield lakes and rivers with soft water and little submerged aquatic vegetation. The Namakan River drains close to 8,860 km^2 in Ontario with an elevation drop of 20 m from Lac La Croix to Namakan Lake. It provides approximately 75% of the inflow to Namakan Reservoir; and contributes the largest single source of inflow with a mean discharge of 109 m^3/sec (Kallemeyn et al., 2003). Table 1 provides of summary of known physical and chemical characteristics of the river, and reflects current knowledge of the three lakes situated along the river system, including Little Eva (281 ha), Bill (134 ha) and Three Mile Lake (399 ha).

Water levels and flows in the Namakan River are not regulated. An Environment Canada (HYDAT) water level gauge at the outlet of Lac la Croix provides relevant information on inflows to the Namakan River since 1921 (LWCB, 2008). A maximum flow of 771 m^3/sec was recorded in June, 1950 while a minimum flow of 15 m^3/sec was recorded in January, 1977 and February, 1924. Annual flow metrics derived from a recent 20 year period (1980-1999) suggests a mean and median flow of 118 and 87

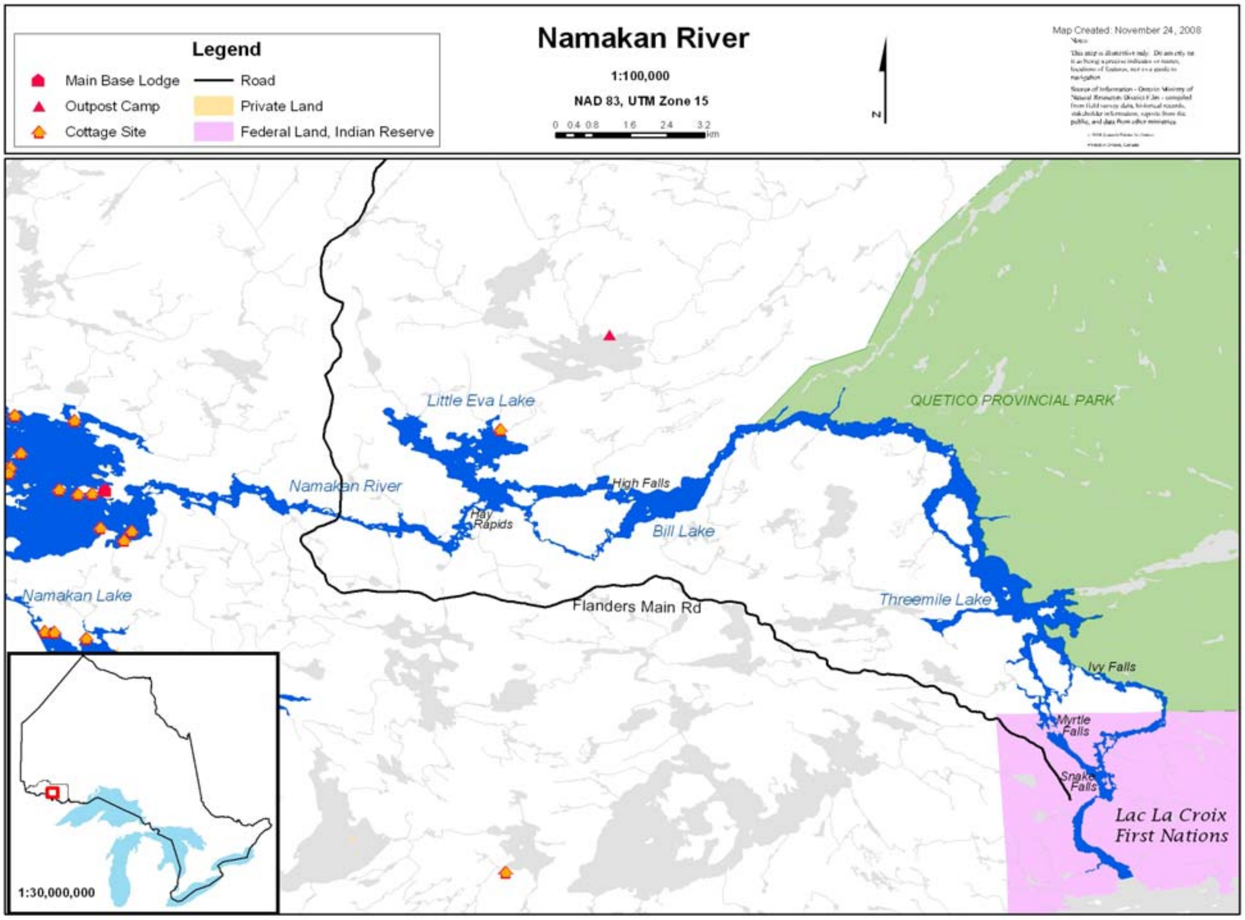

Figure 1: Location of the Namakan River, Ontario. Proposed hydro development sites are located at Hay Rapids, High Falls and Myrtle Falls.

Table 1: Physical and chemical characteristics of Namakan River, Ontario.

Parameter	Little Eva Lake	Bill Lake	Three Mile Lake	Namakan River
Surface Area (ha)	281	134	399	1,252
Mean Depth (m)	5.1	4.5	-	-
Maximum Depth (m)	18.1	23.0	-	23.0
Mean Summer Secchi Depth (m)	2.5	2.5	-	2.5
Perimeter Shoreline (km)	25.5	7.6	-	-
Island Shoreline (km)	4.0	0.7	-	-
T.D.S. (mg/L)	45	45	-	45
M.E.I.	8.82	10.0	-	-

m^3/sec respectively. Time exceeded (percentile) flows are estimated at 182 m^3/sec (20%) and 51 m^3/sec (80%). Other major inlets downstream of Lac La Croix include Bearpelt Creek and Quetico River flowing from adjacent Quetico Provincial Park, as well as Bullmoose Creek and an intermittent connection to Wisa Lake.

Little fisheries information is available and no aquatic habitat inventory (lake or river survey) has been completed. No other fisheries investigations have been completed except for a Fall Walleye Index Netting (FWIN) study on Little Eva Lake in 2006 and on Bill Lake in 2007. A diverse coolwater fish community with 13 species was found to be present (McLeod and Rob, 2008), while a total of 43 fish species are known to occur immediately downstream in the Namakan Reservoir (McLeod and Trembath, 2007).

Development on the shoreline of Namakan River consists of one private cottage/outpost camp, three commercial boat caches and several recreational boats on Little Eva Lake; and nine commercial boat caches and one recreational boat on Three Mile Lake. Portage trails exist from the Gustav Road (Little Eva Lake), Lady Rapids, Hay Rapids, High Falls (Bill Lake), Quetico River, Bearpelt Creek (Wolseley Lake), Ivy Falls and Snake Falls; as well as boat access from Wisa Lake off the Flanders Road. Lac La Croix First Nation (LLCFN) or Neguaguon Lake 25D is situated in the upper reaches of the river, with a population of 274 on-reserve and 123 off-reserve residents (INAC, November 2008). Quetico Provincial Park borders the north side of the river for approximately 13 km from LLCFN to the mouth of Quetico River. The entire inland area on the south shoreline of the river falls within the Agreement of Co-Existence between LLCFN and the Province of Ontario (Ontario, 1994).

METHODS

Lake sturgeon were first captured and sampled in Little Eva Lake using large mesh, assessment gill nets during the period of October 10-11, 2006. Fish were captured using 178 mm (7”), 203 mm (8"), 228 mm (9"), 254 mm (10") and 305 mm (12") stretched mesh, multifilament gill nets. Each net panel was 91 m (300') long and 2.8 m (9') high. All mesh sizes were white in colour with the exception of 228 mm (9”) mesh which was light green. Nine net lifts occurred at nine different sample locations, and included a random selection of mesh sizes.

Additional sampling occurred from May 14-24, 2007 at 4 locations along the Namakan River in conjunction with an acoustic telemetry, tagging and genetics study of lake sturgeon. Selected sampling locations included: below Hay Rapids; below the back channel in Little Eva Lake; below Quetico Rapids in Bill Lake; and below Ivy Falls in Three Mile Lake. Thirteen net lifts occurred at ten different locations, using a random selection of stretched mesh sizes (203-305 mm) and a similar net configuration used in October, 2006.

Lake sturgeon were also captured and sampled on Little Eva Lake during the period of October 9-19, 2007, using the same large mesh, multifilament gill nets. For the purpose of a mark-recapture study, the lake was stratified into 0.25 km^2 sampling grids, and at least one gill net was individually and randomly deployed perpendicular to shore in 17 of the 22 potential grid cells. A topographic map (1:50,000) with existing one km UTM grid lines was used to define the sample cells. Twenty-one net lifts occurred in October, 2007, and included a random selection of mesh sizes.

Sturgeon were also captured during FWIN studies on Little Eva Lake from October 2-6, 2006 and Bill Lake from October 1-4, 2007 with mesh sizes of 127 mm (5") and 152 mm (6"). Further sampling was completed from May 30-June 2, 2008 immediately below Snake Falls, in conjunction with the telemetry and tagging study. Six net lifts occurred, using a random selection of stretched mesh sizes (203-305 mm) and a similar net configuration used in October, 2006. Final sampling occurred from October 6-10, 2008 in Little Eva Lake deploying only 178 (7"), 203 mm (8") and 356 mm (14") stretched mesh gill nets. Fourteen net lifts occurred at fourteen different net locations. In all sampling events, nets were set over-night with durations ranging from 15.3 to 24.5 hours. Nets were set as close to perpendicular (90^o) from shore as each net site would allow.

Immediately upon capture, all fish were examined for external tags and pectoral fin ray clips. Fish with existing tags were released at the capture location after recording the individual tag number, while all other fish were temporarily retained in a large, plastic transportation bin filled with ambient lake water. As needed, fish were placed in a single compartment (12 m^3) holding net with a floating plastic frame anchored to shore near the daily sample location.

All lake sturgeon were sampled for total and fork length (mm), girth (mm) and round weight (g); tagged with an individually numbered Carlin disk dangler tag; and live released. Yellow OMNR tags were attached immediately below the centre of the dorsal fin with 0.5 mm stainless steel wire following methods outlined by Minnesota DNR (Stewig, 2005). A 3-5 cm section of the large, marginal ray of the left pectoral fin was removed for age determination, and provided a secondary mark. The only exception to this field method was in 2006, where full biological sampling (including length, weight, girth and age) was only completed on a sub-sample of fish. The remaining fish were sampled for total length only, tagged and immediately released due to inclement weather and unexpected high numbers of fish in the catch. Sex and maturity of individual fish was only determined externally for ripe fish during the spawning period, or from internal observations of gonad development during surgical implantation of acoustic transmitters (Bruch et al., 2001).

All aging structures were assessed by the OMNR Northwest Regional Aging Facility in Dryden, Ontario. Data were compiled and analyzed using FISHNET2 (Lester and Korver, 1996). Von Bertalanffy growth parameters were determined by least squares non-linear regression using Solver in Microsoft Excel with bootstrapped confidence intervals. Estimates of annual mortality/survival were derived from both catch curve analysis and Robson-Chapman methods (Ricker, 1975; Bagenal, 1978). An index of condition was developed using Fulton's condition factor described by the equation: $K = (W/L^3) \times 100{,}000$, where K is the condition factor, W is the round weight in grams and L is the total length in millimetres (Anderson and Neumann, 1996).

RESULTS

A total of 375 lake sturgeon were captured over the October, 2006 to October, 2008 sampling period (Appendix I), and a summary of the catch by mesh size is provided in Table 2. In 2006, 106 sturgeon were captured of which 97 were tagged and released, including 90 fish exceeding 1,000 mm total length. Water temperatures ranged from 9-10°C. Catches from a single gill net ranged from 2 to 29 fish. No incidental catch was observed, and only one large sturgeon died prior to release as a result of gill damage and bleeding during capture.

In May, 2007, 99 sturgeon were captured of which 98 were tagged and released, including 94 fish exceeding 1,000 mm in total length. One tagged fish from October, 2006 was recaptured below Hay Rapids. Water temperatures ranged from 14-15°C. Catches from a single gill net ranged from 0 to 20 fish. There was an incidental catch of two northern pike, and no mortality of lake sturgeon.

In October, 2007, an additional 157 sturgeon were captured. A total of 148 unmarked sturgeon were tagged and released, including 140 fish exceeding 1,000 mm in total length. Ten tagged fish were recaptured, including 4 from October, 2006; 2 from May, 2007; and 3 from October, 2007 sampling. One recaptured fish was previously tagged in May, 2007 in the Minnesota waters of Namakan Reservoir. Water temperatures ranged from 10-11°C. Catches from a single gill net ranged from 1 to 23 fish. No incidental catch or mortality was observed.

In FWIN catches from Little Eva Lake in October, 2006 and Bill Lake in October, 2007, an additional 9 sturgeon were captured and sampled. Only 3 of these fish were tagged prior to release. Water temperatures ranged from 12.0 -13.5°C. Meanwhile, 4 additional fish were captured, sampled and tagged below Snake Falls in April/May, 2008. No incidental catch or mortality was observed, and water temperatures were only 3°C over the three sample days.

In final sampling efforts in October, 2008, 55 sturgeon were captured of which 48 were tagged and released, including 38 fish exceeding 1,000 mm in total length. Seven previously tagged fish from Little Eva Lake were recaptured, including one fish that was previously tagged below Lady Rapids with a MDNR tag. Water temperatures ranged from 12-16°C. Catches from a single gill net ranged from 0 to 7 fish. There was an incidental catch of one walleye, and no mortality of the target species.

From the total catch, 397 sturgeon were tagged and subsequently released, while 19 were previously marked fish. Catch per unit effort (CUE) for all mesh gill nets was 7.2 fish/100 m (2.2 fish/100 feet) as outlined in Table 2. A total of 6,004 m (19,800 feet) of gill net were deployed over the two year sampling period. The majority of the catch (44% or 191 fish) occurred in the 228 mm (9") stretched mesh multifilament gill net, with a CUE of 12.3 fish/100 m (3.7 fish/100 feet). Incidental catch during these sampling efforts was minimal, with only two northern pike and one walleye caught and released.

Table 2: Summary of effort and catch of lake sturgeon by mesh size from multifilament and FWIN gill nets in Namakan River, 2006-08.

Mesh Size mm (inches)	Effort meters (feet)	# Sturgeon Captured	C.U.E #/100 m (#/100 ft)
127 (5")	182 (600)	2	1.1 (0.3)
152 (6")	182 (600)	7	3.8 (1.2)
178 (7")	455 (1,500)	14	3.1 (0.9)
203 (8")	1,092 (3,600)	72	6.6 (2.0)
228 (9")	1,547 (5,100)	191	12.3 (3.7)
254 (10")	1,001 (3,300)	84	8.4 (2.5)
305 (12")	1,001 (3,300)	32	3.2 (1.0)
356 (14")	544 (1,800)	28	5.1 (1.6)
Total	**6,004 (19,800)**	**430**	**7.2 (2.2)**

To evaluate size selectivity and vulnerability of sturgeon to capture in large mesh gill nets (stretched>127 mm), the girth and total length of individual fish was compared to the mesh size of capture (Figure 2 and 3 respectively). Figure 4 provides the girth and total length relationship, and exponential growth equation ($r^2 = 0.85$) for all 370 sturgeon that were measured for girth. Results suggest that fish were likely fully recruited to the large mesh sampling gear at a mean girth of 340 mm, which coincided with a mean total length of approximately 962 mm. The minimum girth of fish captured in the smallest multifilament mesh size of 178 mm (7”) was 280 mm and the lower quartile (25%) was 292 mm (Figure 2). By comparison, the minimum total length of fish captured in the smallest mesh size of 178 mm (7”) was 825 mm and the lower quartile (25%) was 852 mm (Figure 3). Insufficient netting effort occurred in the two large mesh sizes (127 and 152 mm) in the FWIN nets to evaluate size selectivity. Figure 5 provides the round weight and total length relationship and power growth equation ($r^2 = 0.93$) for all 373 sturgeon that were weighed. A maximum observed weight of 36,350 g occurred at a total length of 1,746 mm.

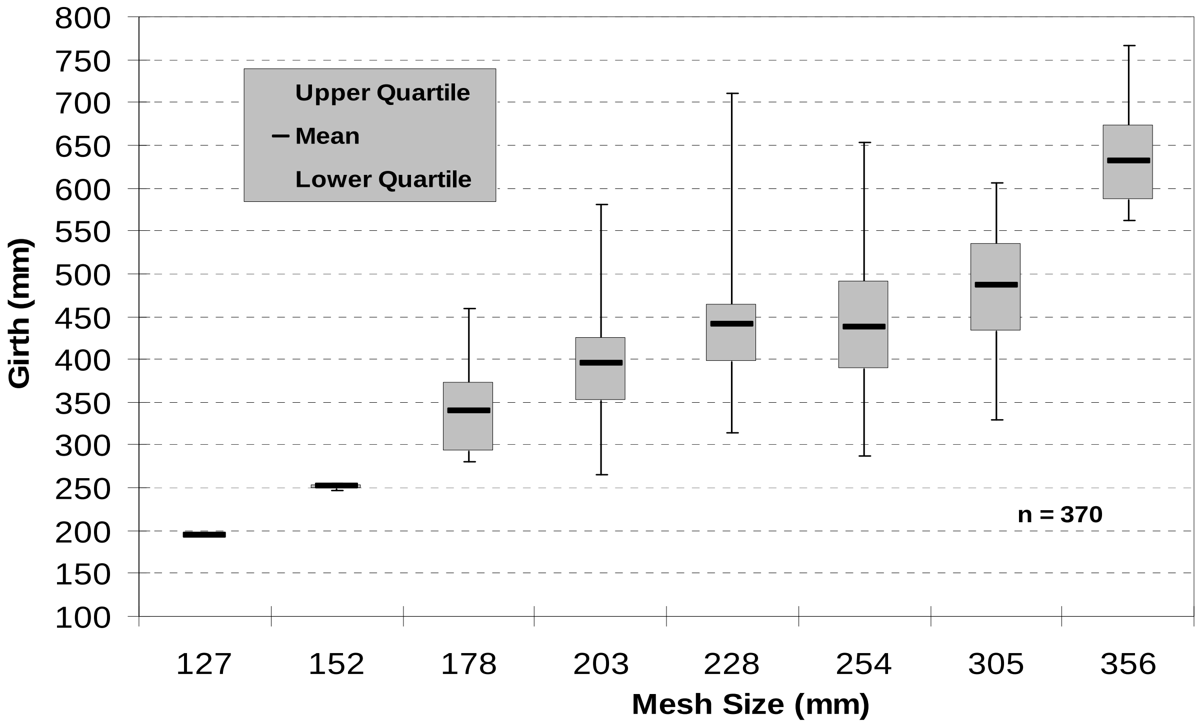

Figure 2: Girth of lake sturgeon (including mean, quartiles and range) by mesh size of capture in Namakan River, 2006-08.

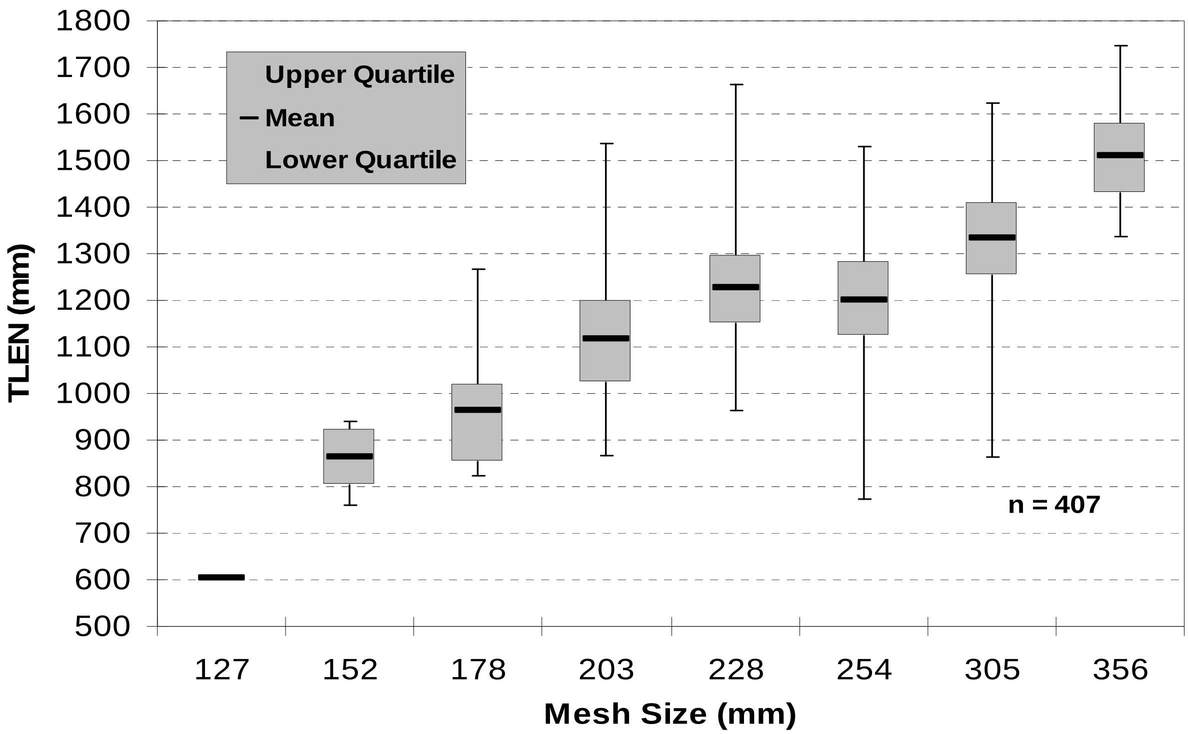

Figure 3: Total length of lake sturgeon (including mean, quartiles and range) by mesh size of capture in Namakan River, 2006-08.

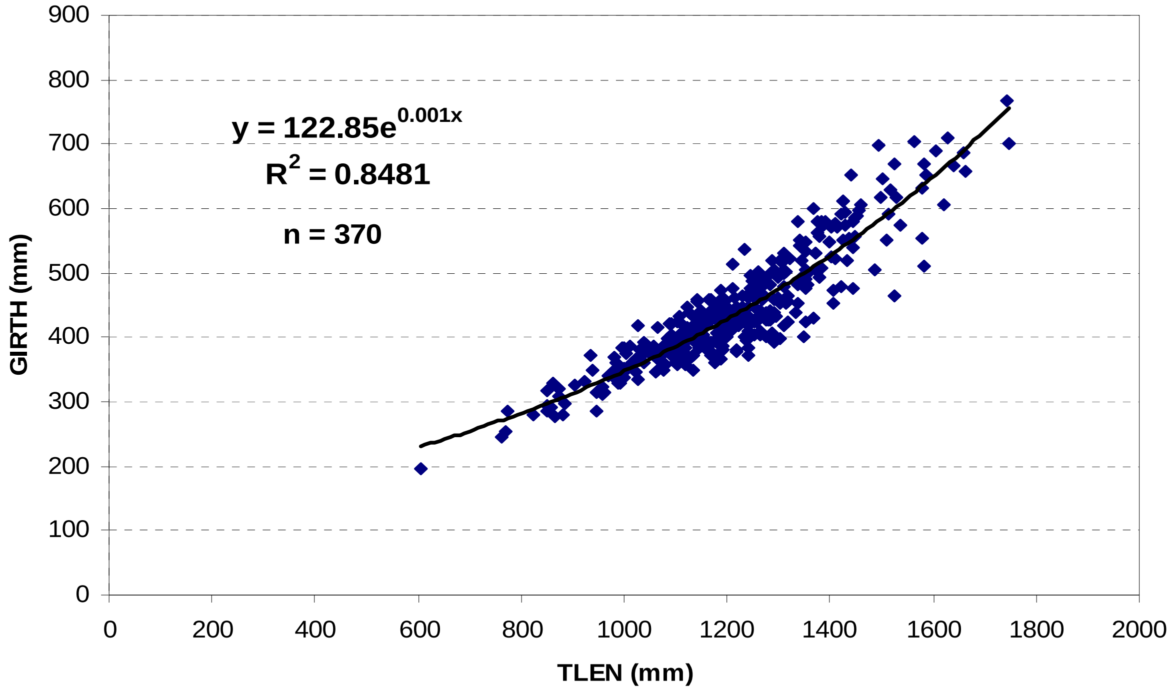

Figure 4: Girth and total length relationship for lake sturgeon captured in large mesh gill nets in Namakan River, 2006-08.

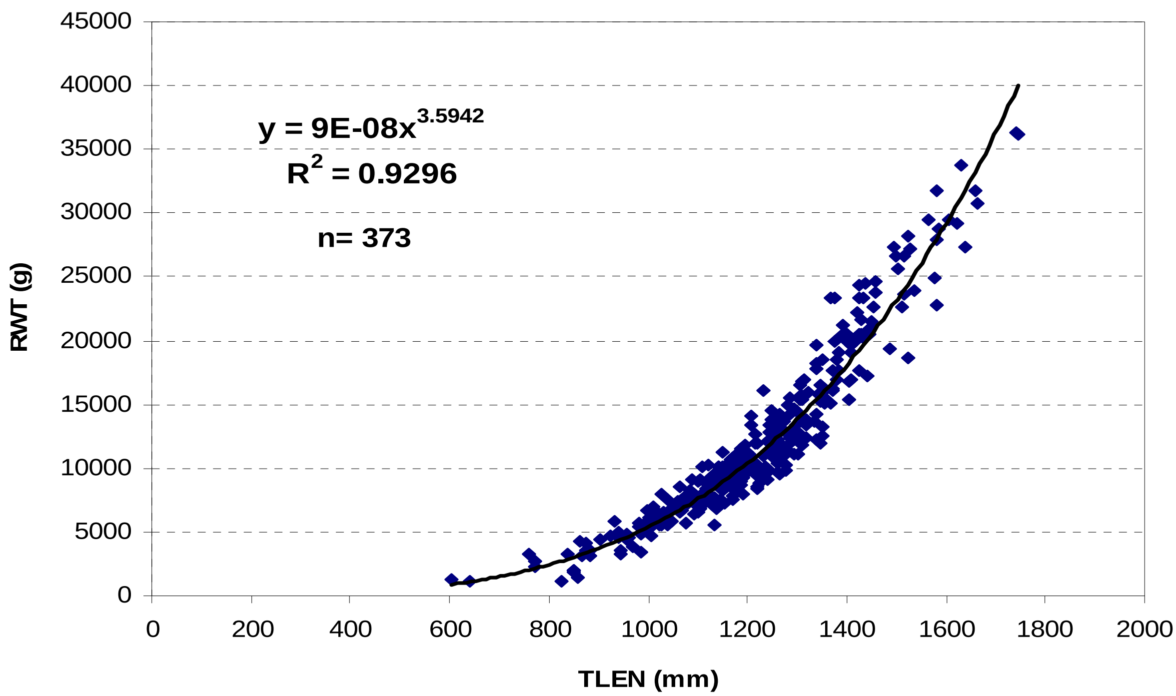

Figure 5: Round weight and total length relationship for lake sturgeon captured in large mesh gill nets in Namakan River, 2006-08.

Of the 430 fish captured, 407 were biologically sampled for total length (376 for fork length) while weight and girth information was obtained from 373 and 370 fish respectively. Sex and maturity data was obtained from only 27 fish, including 6 mature (developing) males, 14 mature (ripe) males, 4 mature (developing) females and 3 mature (gravid) females. Sample size was too small to conduct a separate analysis by sex and maturity. Mean total length of fish captured was 1,211 mm (605-1,746 mm), while mean fork length was 1,092 (531-1,577). Mean round weight was 11,858 g (1,100-36,350 g) and mean girth was 442 mm (195-766 mm). A total of 362 fish (88.9%) exceeded 1,000 mm in total length, and 56 fish (13.8%) exceeded 1,400 mm. Length composition of the catch is provided in Figure 6 (based on percent of fish in 100 mm size bins) and Figure 7 (based on number of fish in 20 mm size bins). The majority of the catch (25.8%) in Figure 6 was in the 1100 mm size bin (1100 to 1199 mm), while 27 fish from Figure 7 were observed in the 1190 size bin (1180-1200 mm).

Age determination was completed for 349 fish, providing a mean age of 26.1 years (range of 7-61 years). Figure 8 provides the age composition (%) of the catch for all fish sampled from spring 2006 to fall 2008, with no age adjustments made based on the year of sampling. The majority of the catch (80%) was between 16 to 33 years of age, with age 21 fish representing the highest proportion at 7.2%. Meanwhile, Figure 9 provides the year class composition based on the number of fish sampled, with adjustments made to the year of actual recruitment. The majority of the catch (86%) originated from annual recruitment over the 20 year period from 1972 to 1991; however consistent annual recruitment did occur over the period from 1963 to 1995. The highest representation

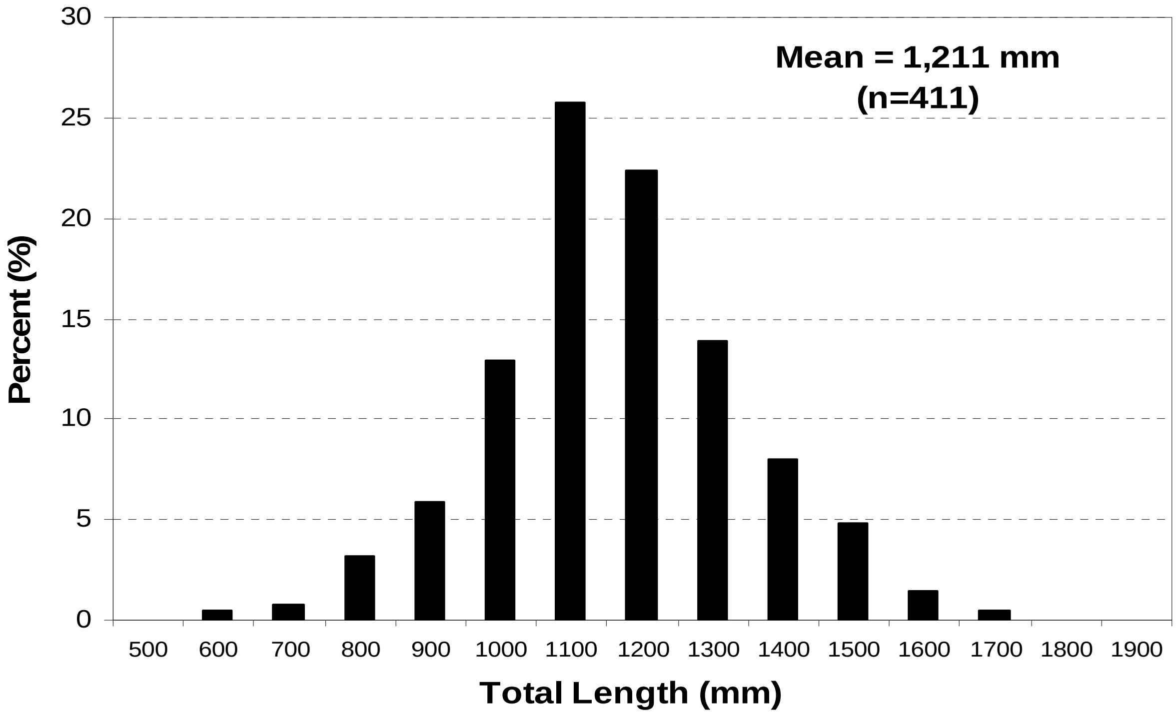

Figure 6: Length composition of lake sturgeon sampled in the Namakan River, Ontario (based on percent of fish in 100 mm size groups)

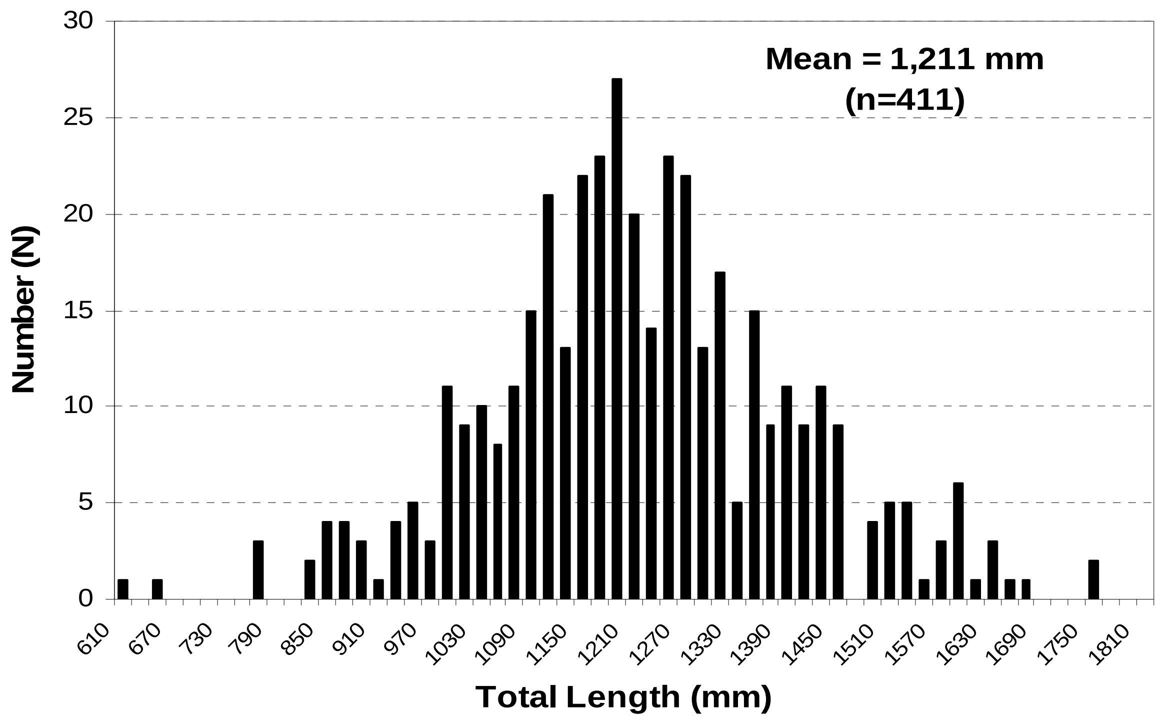

Figure 7: Length composition of lake sturgeon sampled in the Namakan River, Ontario (based on number of fish in 20 mm size groups).

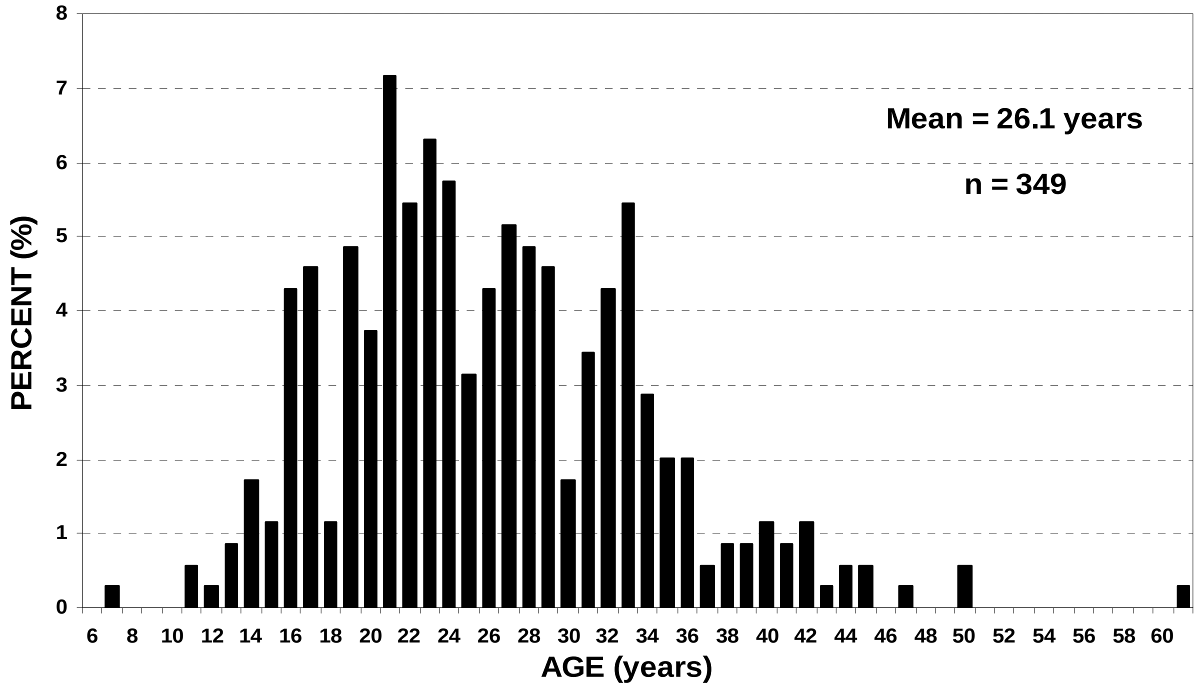

Figure 8: Age composition (percent) of lake sturgeon sampled in the Namakan River, Ontario.

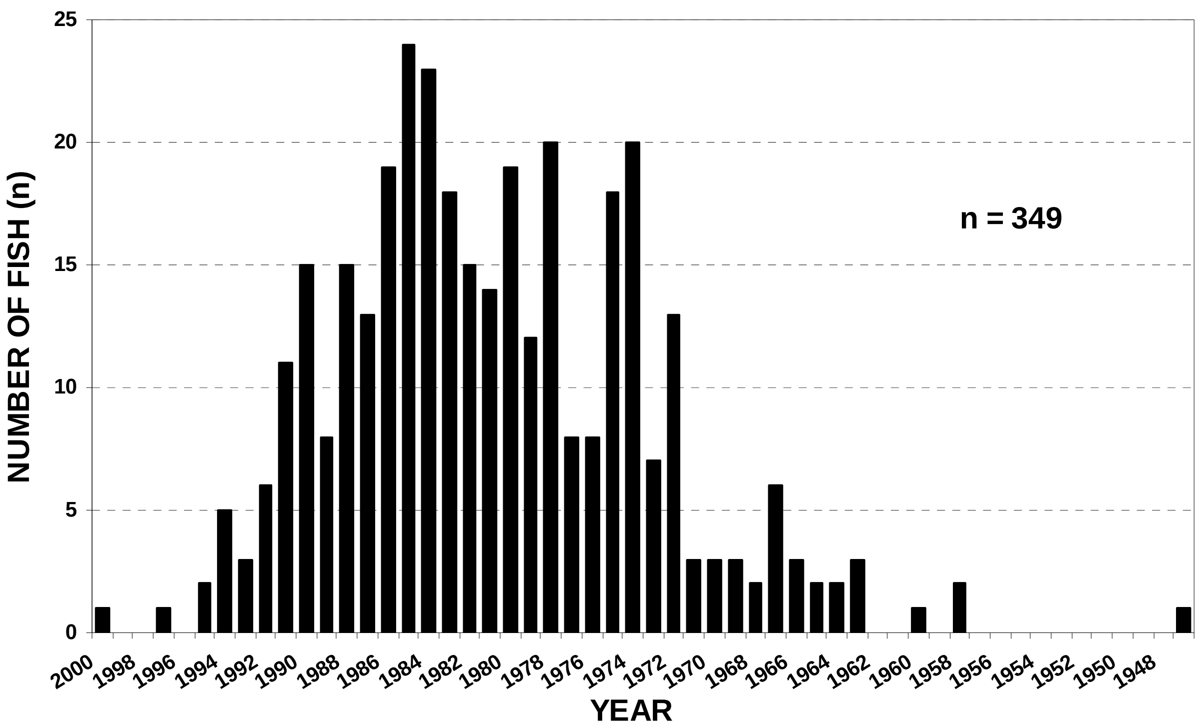

Figure 9: Year class composition (number) of lake sturgeon sampled in the Namakan River, Ontario.

was from the 1985 year class with 24 fish (6.9%).

Total annual mortality (A) was estimated from the descending limb of the catch curve regression for age 21 to 35 years, following Stewig (2005). Annual mortality was estimated at 5.6% ($Z = -0.058$, $r^2 = .40$), or conversely an annual rate of survival (S) of 94.4% (Figure 10). Mortality estimates derived from the Robson-Chapman method (Ricker, 1975; Bagenal, 1978) were higher at 14.2%, with annual survival at 85.8% over the same age classes. The catch curve for the Namakan River sturgeon population indicates variation in recruitment patterns among years. Negative residuals (i.e. weaker year classes) may have occurred in five year intervals for ages 25, 30 and 35 years, and may have affected the slope of the regression curve.

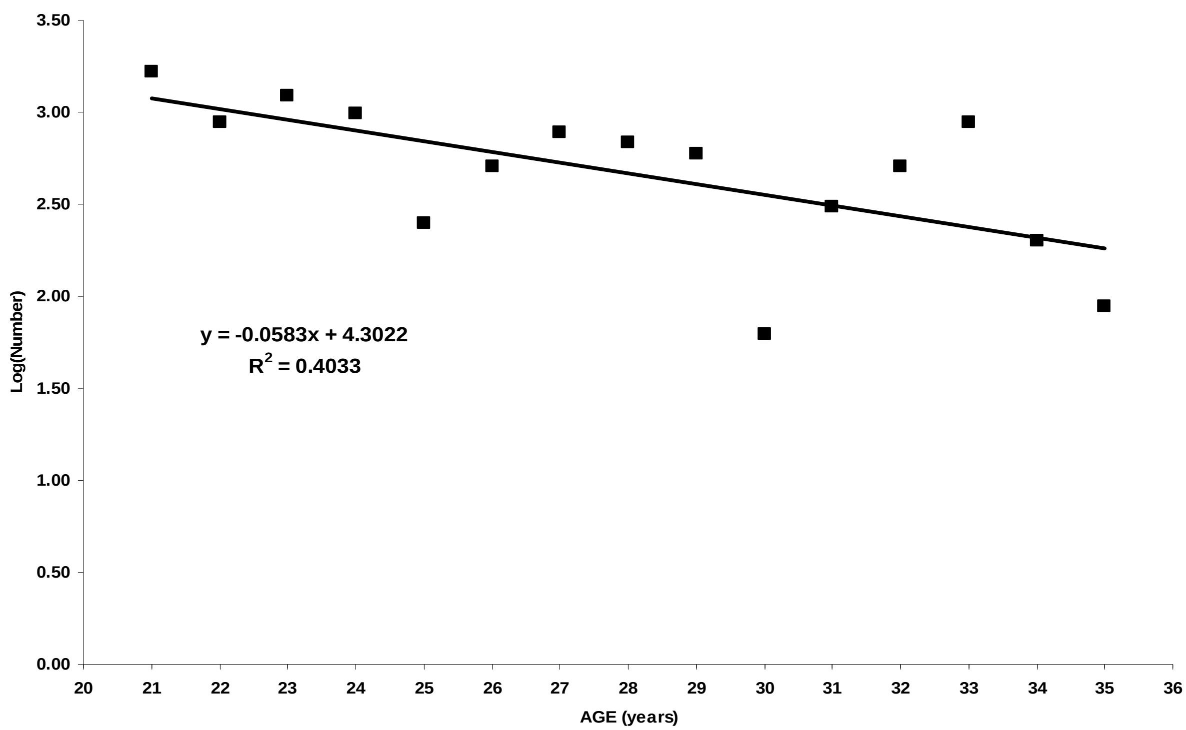

Figure 10: Catch curve for lake sturgeon sampled from the Namakan River from May 2006 to October 2008. Annual mortality (A) was generated based on the slope of the descending limb for ages 21-35 years.

Table 3 provides a summary of the growth of lake sturgeon based on the mean total length and weight at age, while Figure 11 provides a summary of the mean total length at age for all fish sampled and sexes combined (7 to 61 years, n=349). A power growth equation (r^2 = .80) suggests rapid early growth is possible for younger sturgeon (<7 years). The von Bertalanffy growth equation for lake sturgeon (7 to 47 years, n=346) was calculated with unweighted data by age-interval as follows:

$$\mathbf{L_t = 1{,}298\ [\ 1 - e^{-0.1102\ (\ t - 2.2668\ )}\ ]} \quad \text{(Figure 12).}$$

The asymptotic or maximum attainable total length ($L\infty$) was estimated at 1, 298 mm (with a 95% bootstrapped confidence interval of 1,249 to 1,354 mm), while the average values for K (intrinsic growth rate) and t_0 (age at length 0) were 0.1102 and -2.2668 respectively.

Table 4 provides a summary of all population parameters that were evaluated for lake sturgeon in the Namakan River, in comparison to other populations sampled in the Lake of the Woods/Rainy River drainage basin or Designatable Unit (DU) 6 as identified under the COSEWIC review and SARA public consultation workbook.

Fulton's condition factor was also examined for 372 fish that were weighed and measured for total length during the sampling period. Condition factors ranged from 0.21 to 0.91 with a mean condition of 0.608 ± 0.010 (2SE) (Table 4).

Table 3: Mean total length and mean round weight at age for lake sturgeon sampled in the Namakan River, 2006-08.

Age (years)	Total Length (mm)	Round Weight (g)	Number (#)	Percent (%)
7	605	1250	1	0.3
11	753	2100	2	0.6
12	962	4500	1	0.3
13	1015	5500	3	0.9
14	1077	7175	6	1.7
15	1154	9625	4	1.1
16	1102	7960	15	4.3
17	1113	8931	16	4.6
18	1145	7963	4	1.1
19	1164	9997	17	4.9
20	1096	7988	13	3.7
21	1163	11096	25	7.2
22	1216	12134	19	5.4
23	1137	10045	22	6.3
24	1202	10877	20	5.7
25	1254	11918	11	3.2
26	1163	9603	15	4.3
27	1244	12986	18	5.2
28	1214	11547	17	4.9
29	1178	9944	16	4.6
30	1199	10425	6	1.7
31	1344	16000	12	3.4
32	1267	14307	15	5.0
33	1250	12092	19	5.4
34	1289	14775	10	2.9
35	1227	11786	7	2.0
36	1351	13107	7	2.0
37	1623	30300	2	0.6
38	1479	14883	3	0.9
39	1469	18233	3	0.9
40	1417	17988	4	1.1
41	1344	18283	3	0.9
42	1422	16938	4	1.1
43	1254	11600	1	0.3
44	1552	23300	2	0.6
45	1525	24975	2	0.6
47	1662	30800	1	0.3
50	1473	22600	2	0.6
61	1428	20450	1	0.3
Total	**-**	**-**	**349**	**100.0**

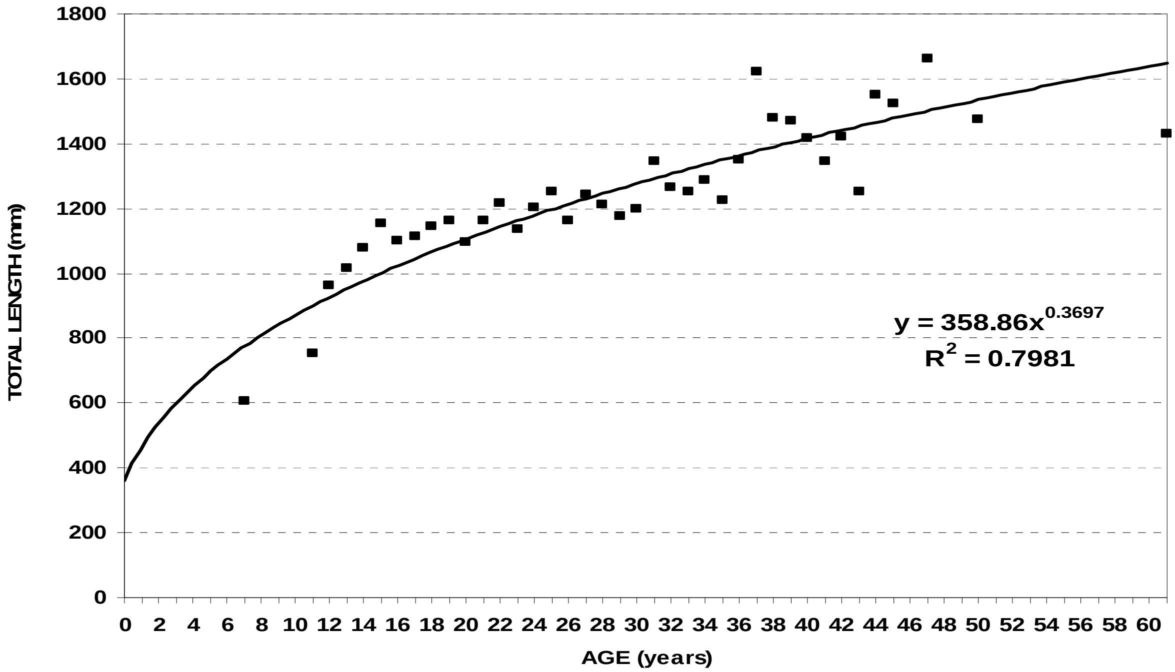

Figure 11: Mean total length at age for lake sturgeon (sexes combined) captured in large mesh gill nets in Namakan River, 2006-08.

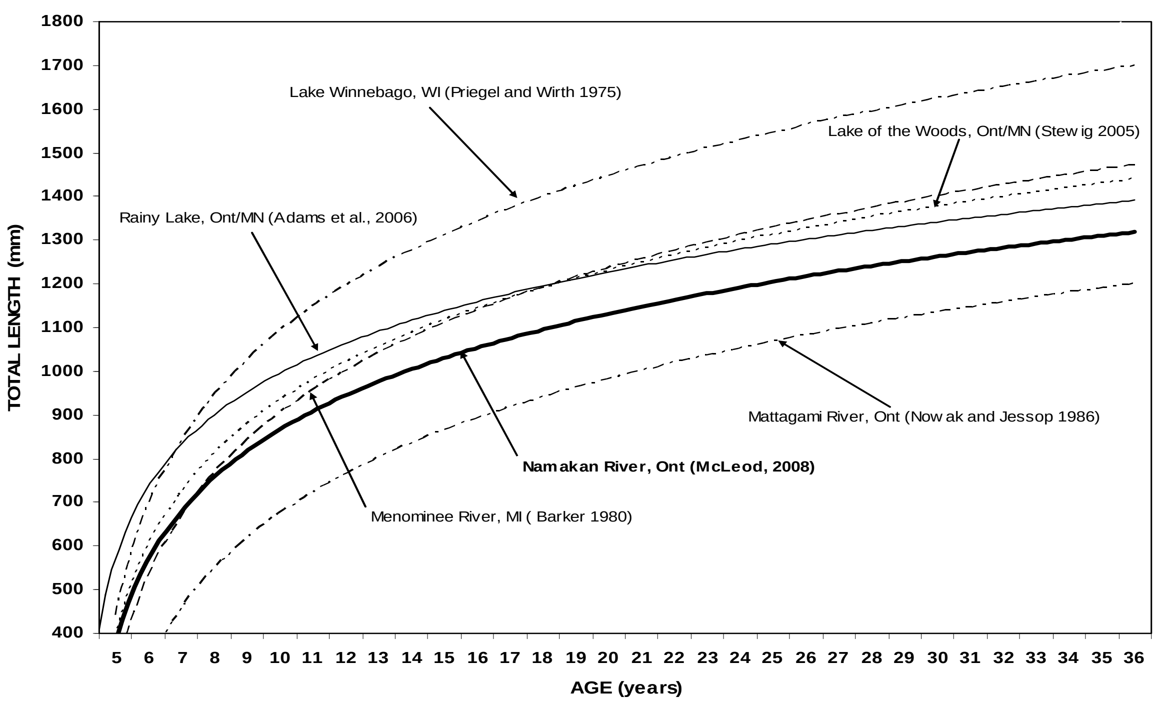

Figure 12: Comparison of von Bertalanffy growth curve for lake sturgeon sampled in Namakan River to populations in Lake of the Woods/Rainy River, MN (Stewig, 2005); Rainy Lake, ONT/MN (Adams et al., 2006); Lake Winnebago, WI (Priegel and Worth, 1975); Menominee River, MI (Baker, 1980); and Mattagami River, ONT (Nowak and Jessop, 1987).

Table 4: Comparison of lake sturgeon population characteristics from the Namakan River, to other populations in Designatable Unit (DU) 6, including Lake of the Woods/Rainy River (Stewig, 2005), Rainy Lake (Adams, et al, 2006) and Seine River (McLeod, 1999).

Parameter	Namakan River (2006-08)	Lake of the Woods/Rainy River (2004)	Rainy Lake (2002-04)	Seine River (1993-95)
Mean age (yrs)	26.1	18.7	26.5	19.3
Maximum age (yrs)	61	38	59	42
No. age classes	39	33	42	27
No. age classes (n>1)	34	32	32	14
Mean total length (mm)	1,211	1,061	1,289	1,124
Maximum total length (mm)	1,746	1,810	1,660	1,676
% catch >1,000 mm	88.9	-	98.5	-
% catch >1,400 mm	13.8	5.0	21.6	14.0
% catch >1,780 mm	0.0	0.1	0.0	0.0
Mean round weight (g)	11,858	10,500	13,720	10,874
Maximum weight (g)	36,350	40,500	48,000	29,900
$L\infty$ (predicted) (mm)	1,298	1,776	1,404	1,343
K	0.110	0.048	0.110	0.102
To	-2.267	-3.857	-0.560	-0.858
Age @ 1,000 mm (yrs)	12.8	13.4	11.0	12.4
S	0.944	0.877	0.953	0.922
A	.0056	0.123	0.047	0.078
Z	-0.058	-0.132	-0.048	-0.081
Age group	21-35	20-31	18-39	12-35
Mean Condition Factor (K)	0.608	0.674	0.617	0.630

DISCUSSION

The lake sturgeon population sampled in the Namakan River upstream of Lady Rapids appears to be healthy in both abundance and population structure, and has achieved short term goals established by the Border Waters Lake Sturgeon Management Committee (OMNR and MDNR, 1995; OMNR and MDNR, 2004; Stewig, 2005) (Appendix II). However, the limited availability of population diagnostics and biological indicators for this species makes interpretation of population status difficult. The sampled population in 2006-2008 contained predominantly young fish with very few older fish (> 50 years) present. Annual recruitment appears to have been consistent over the 34 year period from 1963 to 1995, based on fish that were fully recruited to the sampling gear and the selected mesh sizes. This observation is consistent with recent population assessments on the Rainy River/Lake of the Woods (Stewig, 2005) and on Rainy Lake (Adams et al., 2006).

Further comparison of biological parameters (age, size, growth and mortality) to adjacent populations in the Rainy River/Lake of the Woods drainage basin (DU6) reflects those of recovering populations. Lake sturgeon populations are reported to be recovering in the Seine River (McLeod, 1999), Rainy Lake (Adams et al., 2005) and Rainy River/lake of the Woods (Stewig, 2005). Populations in these border waters collapsed in the early 1900's, primarily due to commercial over-fishing (OMNR and MDNR, 2004). Although commercial harvest records are not available prior to 1924, exploitation was likely a factor in the current status of lake sturgeon in the Namakan Reservoir and upstream in Lac La Croix. Water control dams were also constructed at the outlet of Namakan Reservoir in 1914 and may have affected sturgeon migration and spawning conditions

(Kallemeyn et al., 2003). Recent bio-telemetry, tagging and genetic studies in both Namakan River and Namakan Reservoir suggest that there is a single sturgeon population that uses both the river and the reservoir on a seasonal basis (McLeod, *in prep*; Welsh, 2008).

Commercial fishing for lake sturgeon previously existed on the Namakan Reservoir and Lac La Croix in the 1890's. Pearson (1963) reported that pound net lifts up to 10 ton of sturgeon were taken. One large fish provided a washtub full of roe; however the only maximum weight available was a fish of 80.9 kg (178 lbs). Commercial harvest records from Namakan Reservoir indicate a total Ontario harvest of 33,090 kg over the period 1924 to 1999. Mean annual reported harvest was 435 kg/yr, with a peak harvest of 2,184 kg occurring in 1960. Estimates of potential yield, based on 0.04 kg/ha/yr of available habitat, suggest that long-term sustainable harvest levels might approach 200 kg/yr on the Namakan Reservoir (OMNR and MDNR, 2004). On Lac la Croix, commercial harvest records indicate a total harvest of 4,340 kg over the period 1959 to 1966. Mean annual reported harvest was 723 kg/yr, and some of these fish may have been harvested in the upstream portions of the Namakan River (OMNR, file records).

Population density and biomass were also estimated to be high within Little Eva Lake relative to other populations across the species range in North America (McLeod, 2008). However, the Namakan River is currently undeveloped and lightly exploited in comparison to many other studied populations. Haxton and Findlay (2008) reported that relative abundance of lake sturgeon was greater in unimpounded than impounded reaches, and that water power management appears to the primary factor for lake sturgeon in the Ottawa River. Mean catch per unit effort (CUE) from all large mesh gill nets in the Namakan River was 7.2 sturgeon/100m (all efforts and seasons combined). This catch rate was considerably higher than the 3.5 sturgeon/100m observed in Rainy Lake, Ontario (Adams et al., 2006), 2.0 sturgeon/100m in Rainy River/Lake of the Woods (Stewig, 2005) and 0.2 sturgeon/100m in Seine River (McLeod, 1999).

Improvement in the population structure with older fish is expected to occur, based on the elimination of commercial fishing downstream in the Namakan Reservoir in 2001 and recreational angling harvest in 2008. In relation to short-term management goals (Appendix II), the Namakan River population already contains male fish over age 30, female fish over age 50 and greater than 30 age classes (34 ages with $n>1$). The age composition of the catch would also suggest there is an abundant brood stock with good recruitment potential in future years. Previous research on the Rainy River/Lake of the Woods population suggests that the mean age of first maturity was 16.8 years for males and 25.8 years for females (Mosindy and Rusak, 1991). These findings are similar to that observed in the Winnebago System, WI; where the population also exhibits a protracted maturation period with males reaching 50% maturity at age 20 (1,200 mm) and females at age 27 (1,390 mm) (Bruch, 2008). Based on combined growth data for the Namakan River, males would mature at approximately 1,100 mm total length with females approaching 1,250 mm total length. Although no fish were sampled greater than 1,780 mm (70”) in total length, an estimated 77% of the catch exceeded 1,100 mm and 40% exceeded 1,250 mm.

Mosindy and Rusak (1991) also reported that spawning periodicity was evident in Rainy River/Lake of the Woods sturgeon, with males reproducing every 2-3 years and females every 4-9 years. Secor (2008) recently investigated the influence of skipped spawning and reproductive schedules in establishing biological reference points for sustainable fisheries. Study results suggested that as fisheries management increases focus on thresholds that promote resiliency, increased recognition of the variation in reproductive schedules will probably place greater emphasis on conservation of age structure. This factor may be especially important for lake sturgeon, which have greater longevity and frequency of skipped (i.e. non-annual) spawning than all other sturgeon species and most freshwater fish.

Growth of lake sturgeon in Namakan River is slower in comparison to other populations, with only the Mattagami River in northern Ontario showing slower growth. Based on von Bertalanffy growth analysis, the maximum attainable length ($L\infty$) was estimated at only 1,298 mm (1,249-1,354 mm, 95% CI). This value is lower than in downstream populations in DU6 (Lake of the Woods/Rainy River drainage) including Rainy Lake (Adams et al., 2006) and Lake of the Woods/Rainy River (Stewig, 2005), but similar to the lower Seine River (McLeod, 1999). This slower growth could be related to lower productivity in upstream portions of the watershed or other density-dependent factors. Mosindy and Rusak (1991) attributed the relatively faster growth rates in the Lake of the Woods/Rainy River to the high productivity of both the Big Traverse basin and the river, resulting in good abundance of quality prey items in diet analysis. The largest fish actually sampled in this study was 1,746 mm and greatly exceeded the predicted $L\infty$ value. A length at age comparison (to age 61) would also suggest that maximum attainable length ($L\infty$) was likely under-estimated in the von Bertalanffy growth analysis (to age 35). A mean condition factor (K) of 0.61 was also the lowest value reported in DU6 and could be density dependent or food supply related. By comparison, a condition factor of 0.72 and 0.95 were recently reported for lake sturgeon in the Manistee River, MI and in the Winnebago System, WI respectively, and values did not differ by sex or spawning status (Lallaman et al., 2008; Bruch, 2008).

Low natural mortality is expected for most sturgeon species. Annual mortality in this study was 5.6% based on catch-curve analysis. This value is slightly lower than that reported in the Rainy River (2004) and Seine River (1993-95) but similar to mortality rates derived for Rainy Lake (2002-04). Due to the lack of previous research, comparison of population characteristics derived from this study with other populations is crucial to properly ascertain the current state of lake sturgeon in the Namakan River. For example, the characteristics of a self-sustaining population in Michigan include a minimum of 1,500 mature adults, an equal sex ratio, a broad range of year classes, evidence of successful reproduction, and recruitment to juvenile stages (Galarowicz, 2003).

An important consideration in the assessment of fish populations based on age parameters is the overall accuracy of aging, especially for a long-lived species such as lake sturgeon. In Wisconsin, ages estimated from pectoral fin rays sections were found relatively accurate for fish up to 15 years of age (1,030 mm), but generally under-estimated the true age of fish older than 15 years (Bruch, 2008). The validation of true age shows the species grows slower and matures later than previously reported. Lake sturgeon life history parameters used in management decision-making need to be based on accurate age estimation data to prevent over-harvest of the species.

Fish tagging, telemetry and genetics have already helped confirm that lake sturgeon inhabit and move throughout the Namakan River system, and validates this single population assessment based on data from multiple sampling efforts and locations along the river (McLeod, *in prep*). Recent genetic data also suggests that spawning groups within the Namakan River represent a single population (Welsh, 2008). No significant difference in genetic diversity was observed between five distinct spawning locations, indicating that migration is likely occurring in both directions along the river. The numerous rapids and falls do not represent reproductive barriers to lake sturgeon and future management actions should preserve the integrity of this population.

The purpose of this study was to evaluate the overall health and status of lake sturgeon in the Namakan River between Namakan Reservoir and Lac La Croix. Most biological indicators indicate a healthy population; however these same parameters are consistent with, and reflect, those observed in adjacent populations recovering from exploitation stress (McLeod, 1999; OMNR and MDNR, 2004; Stewig, 2005; Adams et al, 2006). Most short-term management goals have been achieved (male fish to age 30; female fish to age 50; and greater than 30 year classes present). However, several indicators are still below long-term management goals including the number of female fish over 2,030 mm (80 inches); female fish to age 70; greater than 40 year classes present; and annual mortality less than 5% (Appendix II).

In combination with other investigations on movement, habitat use, genetics and population size, this information will help evaluate the potential impacts of hydroelectric development. However, it is recognized that single, short-term population assessments can be difficult to interpret due to natural fluctuations in recruitment, changing environmental conditions and selectivity of the sampling gear. Inherent biological characteristics of longevity, delayed maturation and infrequent spawning make this species highly susceptible to losses and slow to rebound from low population levels (ASRD, 2002). The continuation of a more frequent, long-term assessment program is recommended to evaluate and/or model future population levels and trends, especially if development proposals proceed.

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Appendix I: Effort, catch and catch per unit effort (CUE) of lake sturgeon for each temporal sampling period on the Namakan River, 2006-2008.

October, 2006

Mesh Size mm (inches)	Effort meters (feet)	# Sturgeon Captured	C.U.E #/100 m (#/100 ft)
178 (7”)	91 (300)	5	5.5 (1.67)
203 (8”)	91 (300)	7	7.7 (2.3)
228 (9")	273 (900)	57	20.9 (6.3)
254 (10”)	273 (900)	35	12.8 (3.9)
305 (12”)	91 (300)	2	2.2 (0.7)
Total	**819 (2,700)**	**106**	**12.9 (3.9)**

May, 2007

Mesh Size mm (inches)	Effort meters (feet)	# Sturgeon Captured	C.U.E #/100 m (#/100 ft)
203 (8”)	91 (300)	10	11.0 (3.3)
228 (9")	546 (1,800)	77	14.1 (4.3)
254 (10”)	455 (1,500)	9	2.0 (0.6)
305 (12”)	91 (300)	3	3.3 (1.0)
Total	**1,183 (3,900)**	**99**	**8.4 (2.5)**

October, 2007

Mesh Size mm (inches)	Effort Meters (feet)	# Sturgeon Captured	C.U.E #/100 m (#/100 ft)
203 (8”)	455 (1,500)	35	7.7 (2.3)
228 (9")	546 (1,800)	57	10.4 (3.2)
254 (10”)	273 (900)	40	14.7 (4.4)
305 (12”)	637 (2,100)	25	3.9 (1.2)
Total	**1,911 (6,300)**	**157**	**8.2 (2.5)**

April, 2008

Mesh Size mm (inches)	Effort meters (feet)	# Sturgeon Captured	C.U.E #/100 m (#/100 ft)
203 (8”)	182 (600)	2	1.1 (0.3)
228 (9")	182 (600)	0	0 (0)
305 (12”)	182 (600)	2	1.1 (0.3)
Total	**546 (1,800)**	**4**	**0.7 (0.2)**

October, 2008

Mesh Size mm (inches)	Effort meters (feet)	# Sturgeon Captured	C.U.E #/100 m (#/100 ft)
178 (7”)	364 (1,200)	9	2.5 (0.8)
203 (8")	273 (900)	18	6.6 (2.0)
356 (14”)	544 (1,800)	28	5.1 (1.6)
Total	**1,181 (3,900)**	**55**	**4.7 (1.4)**

Appendix II: Management objective and short and long-term goals for lake sturgeon as recommended by the Border Waters Lake Sturgeon Management Committee (OMNR and MDNR, 2004; Stewig, 2005).

Management Objective	- *re-establish and maintain self-sustaining stocks of lake sturgeon in all suitable habitats* - *provide a subsistence and limited recreational fishery, with opportunities to encounter large (trophy) fish >1,830 mm (72”)* - *age, size, abundance and genetic diversity of mature fish (>1,400 mm or 55”) should approach those found in unexploited or lightly exploited populations*
Short-Term Goals **(5 to 10 years)**	- male fish up to age 30 - female fish up to age 50 - female fish exceeding 1,780 mm (70”) total length - at least 30 year classes present - support harvest level of 0.04 kg/ha of available habitat
Long-Term Goals **(20 to 30 years)**	- male fish up to age 40 - female fish up to age 70 - 10-15% of population are mature fish - female fish exceeding 2,030 mm (80”) total length - at least 40 year classes present - densities of age 2+ fish at 150 fish/km in rivers and 3.7 fish/ha in lake systems - fish mortality less than 5% - support harvest level of 0.10 kg/ha of available habitat