LAKE STURGEON STEWARDSHIP & ENHANCEMENT PROGRAM

Results of Assiniboine River Lake Sturgeon Investigations, 2013

Report 13-08
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Manitoba Hydro

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By

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FOREWORD

Manitoba Hydro is committed to the conservation and enhancement of Lake Sturgeon populations in Manitoba. The Corporation has directed a substantial amount of effort towards this commitment through activities relating to existing and planned hydroelectric developments, post-project monitoring, applied and basic research and participation in multi-stakeholder sturgeon management boards. To ensure efficient and effective implementation of its sturgeon programs, the Corporation has developed a comprehensive "Lake Sturgeon Stewardship and Enhancement Plan" that will consolidate and build upon past efforts and guide new programs.

The vision of the Lake Sturgeon Stewardship and Enhancement Program is: "*To maintain and enhance Lake Sturgeon populations in areas affected by Manitoba Hydro's operations, now and in the future*." This vision will be achieved by ensuring that Manitoba Hydro's current activities do not contribute to a decline or jeopardize the sustainability of sturgeon populations in Manitoba.

The implementation strategy adopted by Manitoba Hydro for achieving the plan objectives includes developing an understanding of current Lake Sturgeon stocks and habitat in Manitoba. The following report presents the results of a Lake Sturgeon inventory study conducted on the Assiniboine River, near Brandon, Manitoba, in spring and fall, 2013.

TECHNICAL SUMMARY

Lake Sturgeon (*Acipenser fulvescens*) are believed to have been extirpated from the Assiniboine River as of the early 1970's. To evaluate post-stocking survival and attempt to re-establish a population, a stocking program was initiated by Manitoba Conservation and Water Stewardship – Fisheries Branch in the mid 1990s. Between 1996 and 2008, brood-stock collected from the Winnipeg, Saskatchewan and Nelson rivers were used to facilitate the re-introduction of approximately 16,683 Lake Sturgeon (4,000 fry, 12,416 fingerlings, 205 yearlings, 55 juveniles, and 7 adults) into the Assiniboine River near Brandon. Lake Sturgeon angling captures have increased in recent years, with large (adult sized) Lake Sturgeon being frequently reported by the Travel Manitoba "Master Angler" program. As size may be a proxy for maturity, it is conceivable that reproduction of stocked fish may be imminent. Indeed, recent photographic evidence of very small juvenile Lake Sturgeon captured, in combination with previous observations of rapid growth in the Assiniboine River, suggested reproduction of stocked fish might already have begun. The objectives of the 2013 Assiniboine River investigations were to capture Lake Sturgeon, and use ageing methods (i.e. cohort identification) to look for evidence of reproduction, and more generally, determine what stages and brood-stock have contributed to the Assiniboine River population.

Failure to capture any Lake Sturgeon during spring 2013 using large mesh gill nets was attributed to high-water levels and terrestrial debris. In fall 2013, set-lines were used to identify congregations of Lake Sturgeon. Once congregations were located, low-flow conditions allowed for small mesh gill nets to be set in certain habitats. In general, the Assiniboine River was very shallow (<1 m) at the time of the survey, but a total of 23 juveniles (427 – 531 mm fork length) and 7 subadults/adults (820 – 1040 mm) were captured in two deeper (2.5 – 6 m) holes found just downstream of the Brandon industrial sector.

Ageing analysis revealed complicated and inconsistent growth patterns, precluding confident estimates of age. Rates of modal consensus and three reader agreement were only 70 and 35%, respectively. The modal age assigned to juvenile fish tended towards four years-of-age, but assignments from individual readers ranged from 3 – 8 years for the various structures. Particularly for juvenile fish, tight outer annuli were frequently present, occasionally "overlapping" to the degree that it was sometimes hard to distinguish between them. As annuli spacing reflects growth rate, this implies relatively slow growth during recent years, particularly for juvenile fish. Furthermore, growth chronologies of juveniles were qualitatively inconsistent with those of wild fish observed in other Manitoba localities; most notably in the sense that there was wide spacing between consistently strong "first" (i.e. inner annulus) and the "second" annulus, indicative of a highly disproportionate amount of growth during that time period. While not included in annuli counts, readers noted what would typically be described as "false" annuli within the large band of growth (between counted annuli 1 and 2) for many juvenile fish, which raises questions about whether this band truly represents 1 or 2 years of growth. Should the latter be the case, ageing estimates would be systematically biased (negatively) for juvenile fish; instead of modal assigned age of 4, the true modal age might be 5. While not conclusive at this time, our interpretation is that the large band of growth between the well-defined first and “second” annuli on juvenile structures actually represents two years of growth. In concert, owing to ageing inaccuracies and speculation of potential systematic ageing error, the results of this study provide no conclusive evidence of reproduction by stocked fish; rather, it seems most likely that the juveniles captured link back to fingerlings stocked (n = 7,900) in 2008.

For the subadult/adult sized fish (820 – 1040 mm, n = 7), modal consensus ages were reached for four individuals; determined to be 9, 12, 13 and 14 years old. The nine year-old fish is potentially from the Winnipeg River fingerlings stocked in 2003 or 2004. The 13 and 14 year-old fish are potentially from the Saskatchewan River fingerlings stocked in 1999 and 2000, or perhaps the Saskatchewan River fry stocked in 2000. Finally, the 12 year-old fish is most likely a fingerling from the Nelson River progeny stocked in 2001.

STUDY TEAM

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1.0 INTRODUCTION

Lake Sturgeon (*Acipenser fulvescens*) are believed to have been extirpated from the Assiniboine River as of the early 1970's (COSEWIC 2006). To evaluate post-stocking survival and attempt to re-establish a population, a stocking program was initiated by Manitoba Conservation and Water Stewardship – Fisheries Branch. Between 1996 and 2008, brood-stock collected from the Winnipeg, Saskatchewan and Nelson rivers were used to facilitate the re-introduction of approximately 16,683 Lake Sturgeon (4,000 fry, 12,416 fingerlings, 205 yearlings, 55 juveniles, and 7 adults) into the Assiniboine River near Brandon (Manitoba Conservation and Water Stewardship [MCWS] 2012; Table 1). In addition, 15,000 fry were stocked in 2013. Lake Sturgeon angling captures reported in the vicinity of Brandon, Manitoba (Malcolm and Bruederlin 2009) indicates some level of stocking success. Furthermore, an increasing number of "Master Angler" sized Lake Sturgeon have been reported since 2004 (Travel Manitoba 2012). Since large body size may be a proxy for sexual maturity, it is conceivable that reproduction of stocked fish may be imminent. Indeed recent (2012, 2013) photographic evidence of very small juvenile Lake Sturgeon captured (K. Fehr, Brandon resident, pers. comm.), in combination with previous observations of rapid growth (B. Bruderlin, Manitoba Fisheries Branch, pers. comm.) suggested reproduction of stocked fish might already have begun.

As reproduction of stocked fish is a primary, but often elusive (due to lengthy maturation intervals of the species), indicator of stocking success, there is considerable interest in the status of the reintroduced population in the Assiniboine River. Indeed, the Assiniboine River Lake Sturgeon stocking program has the potential to serve as a model for other stocking programs in the province, including those being undertaken or supported by Manitoba Hydro and the Nelson River Sturgeon Board. To understand both if reproduction of stocked fish has begun, and in general the factors that have led to the successful reintroduction of Lake Sturgeon to the Assiniboine River, it is necessary to build an understanding of this population's age distribution. In particular, if ageing analysis allows for identification of cohorts generated in years in which stocking has not occurred, this could be interpreted as strong evidence of reproduction of stocked fish. Understanding the population's current age structure will also provide insight towards which of the stocked life stages (and perhaps which brood-stock sources) have contributed most to the current population.

One week long studies were conducted during spring and fall 2013 in a reach of the Assiniboine River between the confluence of the Souris River and the confluence of the Little Saskatchewan River near Brandon, Manitoba. Sampling methods were designed to locate congregations of Lake Sturgeon and assess age composition of the population currently inhabiting the reach.

2.0 STUDY AREA

2.1 Physical Setting

The Assiniboine is a regulated 1,070 km long, mid-size, low-gradient, meandering prairie river rising from its headwaters in Saskatchewan (Rosenberg et al. 2005). It joins the Red River in Winnipeg, Manitoba, prior to emptying into Lake Winnipeg. The river is characterized by shallow habitat, and is prone to spring flooding. Two prominent flood control structures regulate the flows of the Assiniboine River, including: the Shellmouth Dam located upstream of the study reach near Russell, MB, and the Portage Diversion located downstream of the study reach near Portage la Prairie, MB. Both of these control structures are potential barriers to upstream fish migration meaning contemporary Red River Lake Sturgeon populations are likely unable to move upstream past the Portage Diversion.

The Assiniboine River study reach was bounded at the downstream and upstream ends by the Souris River and Little Saskatchewan River confluences, respectively; most of the sampling occurred near or within the city limits of Brandon (Figure 1). Beyond city limits, land use adjacent to the study reach is predominantly agricultural (crop and forage production). In addition to urban and agricultural land use along the river, a number of industrial operations are located near the river just downstream (east) of Brandon, including a Manitoba Hydro thermal electric generating station, a Koch nitrogen fertilizer manufacturing facility, a Maple Leaf pork processing facility, and a Canexus sodium chlorate production facility. Waste-water discharge from several of these, as well as from the city of Brandon's sewage treatment facility appear to discharge into the Assiniboine just east of Brandon.

In-stream, the study reach is characterized by obtuse angle (>90°) meanders of uniform (and generally shallow) depth, with only slight scouring along the outer radius and sediment deposition along the inner radius. Bottom substrate is typically fine, silty clay, with boulder and cobble rapids interspersed throughout the course of the river. Owing to high flow (flood) conditions, large amounts of organic debris are evident throughout the reach.

Two water control structures and approximately three sets of rapids are located within the study reach. The 3rd Street dam, constructed to maintain water levels and thereby ensure an adequate water supply for Brandon residents, is located within the City of Brandon and during extremely low flow conditions may act as a barrier to sturgeon movement (MCWS 2012). In addition, a rock weir near the Manitoba Hydro thermal plant may restrict movement during periods of low flow. Rapids within the study reach include: (1) a set just upstream of the 1st Street bridge within the City of Brandon; (2) a set located near the Canexus sodium chlorate production facility where Richmond Avenue ends and intersects the Assiniboine River, and (4) a set located adjacent to a farmstead, approximately 2 km downstream from the Canexus rapids.

2.2 Historic and Contemporary Lake Sturgeon Information

Historical information on Lake Sturgeon in the Assiniboine River is somewhat limited. Records from Brandon suggest that Lake Sturgeon were locally valued for their oil, which was at one time used for fueling lamps and steamboats, and for softening wool (DFO 2007). Stories of individuals landing sturgeon on the Little Saskatchewan River and Waggle Springs (near Shilo) on the Assiniboine River during the early 1900's have also been reported (DFO 2007). Important historical spawning grounds were thought to include the mouth of the Little Saskatchewan River, Waggle Springs, and potentially the Souris and Qu'appelle rivers (Cleator et al. 2010). By the time the Shellmouth dam was constructed in 1970 on the Assiniboine River near Inglis, MB, it is believed that Lake Sturgeon had been extirpated from the river.

During the early 1990s the Assiniboine River was selected as a candidate location to conduct experimental stocking by MCWS, primarily to see if stocked Lake Sturgeon were able to survive and grow (S. Matkwoski, Manitoba Hydro, pers. comm.). Reestablishment of a population was the secondary objective. Between 1996 and 2008, approximately 16,683 Lake Sturgeon (4,000 fry, 12,416 fingerlings, 205 yearlings, 55 juveniles, and 7 adults) were stocked into the Assiniboine River near Brandon (MCWS 2012; Table 1), while in 2013 an additional 15,000 fry (larval stage) were stocked (MCWS 2013). An increased number of Lake Sturgeon angling captures reported in the vicinity of Brandon (Malcolm and Bruederlin 2009), and increasing numbers and size of Assiniboine River Sturgeon being reported to the Manitoba master angler program since 2004 (Travel Manitoba 2013; Appendix 2) indicates some level of post-stocking survival, and evidence that some Assiniboine Lake Sturgeon have attained large body sizes typical of adults in other Manitoba localities. In 2010, a LSSEP study was ineffective at locating and capturing Lake Sturgeon in the Assiniboine River (Aiken and MacDonell 2011)

3.0 METHODS

3.1 Physical Data

At each sampling site, the physical data recorded included: depth (m) using a Humminbird PiranhaMax 150 portable depth sounder (Humminbird, Eufaula, AL), water and air temperature (°C) using a handheld thermometer.

River flow conditions during the two study periods (spring and fall) were queried from Environment Canada's online database of historical and real-time hydrometric data (Environment Canada 2013).

3.2 Fish Capture and Biological Sampling

In an effort to locate Lake Sturgeon spawning aggregations, bottom-set gillnetting was conducted shortly after the spring melt in May 2013, approximately when Lake Sturegon are known to spawn. For spring sampling, gangs consisted of various combinations of two 22.9 m (25 yd) long by 2.5 m (2.7 yd) deep panels of 203, 229, and/or 254 mm (8, 9, and 10 inch) twisted nylon stretched mesh. To start, gangs were set overnight and, weather permitting, checked at approximately 24 hour intervals. After the first overnight set, however, set times were reduced to try and decrease the amount of debris (woody debris, leaves, grass, etc.) caught in the nets. A total of 8 large mesh gangs were set during the spring sampling period.

The limited success using gill nets and a Missouri trawl in fall 2010 (Aiken and MacDonell 2011) and large mesh gill nets in spring 2013 meant a new strategy was required. In fall 2013, a three pronged approach was used to try and capture Lake Sturgeon in the Assiniboine River. The focus of this approach utilized set-lines (also called trot lines or long lines), supplemented by angling with rod and reel, and where physical conditions allowed, standard mesh gill nets.

Set-lines consisted of a 20 m section of 62.5 mm (1/4 inch) diameter braided nylon rope, onto which 6-10 trot lines (≈3 m of Power Pro Braided Line – 100 lb test, vermilion red [Innovative Textiles Inc., Grand Junction, CO]) were attached with trot line clips (Figure 2). A Mustad Demon Circle hook (O. Mustad & Son A.S., Gjövik Norway) baited with night crawlers was attached to each trot line with a swivel. Both ends of each set-line were anchored with a cinder block, with the downstream end having a buoy line running from the anchor on the river bottom to a buoy at the water's surface. Due to bait poaching by non-target species each set-line was checked one to two times during daylight hours, and then left overnight.

During fall gillnetting, gangs consisted of various combinations of two or three 22.9 m (25 yd) long by 2.5 m (2.7 yd) deep panels of 32, 51, and/or 76 mm (1½ , 2, and 3 inch) twisted nylon stretched mesh. Nets were generally checked twice a day, at approximately 12 hour intervals. A total of 10 standard mesh gangs were set during the fall sampling period. Gillnetting efforts were focused explicitly on habitats > 1 m in depth (which were found to be rare), identified using the aforementioned Humminbird PirahnaMAX 150 portable depth sounder.

In addition to set-lines and gill nets, angling was also undertaken to capture Lake Sturgeon. Angling consisted of 2-4 fishing lines in the water at any given time. A basic tackle set-up was used, and generally included Mustad Demon hooks baited with nightcrawlers attached to a 18-24 inch mono leader with a sinker positioned 18-24 inches from the hook.

All captured Lake Sturgeon were measured for fork length, total length and weight. Lake Sturgeon of sufficient size (> 350 mm fork length) were marked with an individually numbered Floy FD-94 T-bar anchor tag (Floy Tag and Manufacturing Company, Seattle, WA). Tags were inserted between the basal pterygiophores of the dorsal fin using a Dennison Mark II tagging gun.

A small pelvic fin clip (1 – 2 cm^2) was removed from each Lake Sturgeon and preserved in 95% Biological Grade Ethanol for future genetic analysis. The first ray of the right pectoral fin was removed immediately distal to the fin articulation for subsequent ageing. After drying, fin rays were dipped in epoxy resin (Cold Cure™) and allowed to harden. Using a Struers Minitom™ (Struers Inc, Cleveland, Ohio) low speed sectioning saw, two 0.7 mm sections of the fin ray were cut within 5 mm of the 'knuckle'. The fin sections were then permanently mounted on a labeled glass slide using Cytoseal-60™ (Thermo Scientific, Waltham, Massachusetts), and viewed under a dissecting microscope (30 – 40x magnification). Following preliminary examination of several ageing structures, it was observed that growth from year-to-year was inconsistent (as opposed to typical Lake Sturgeon growth chronologies; Figure 2) making the identification of true yearly annuli difficult. Ageing structures were assessed by three experienced readers, without knowledge of length or weight of the fish or the ages assigned by other readers. As field sampling was conducted in the fall, annuli observed at the outside of structure were intentionally excluded from counts because these would not represent a full year of growth. Where two or more readers agreed on an age for a particular fish, the consensus age was assigned. In instances where no consensus was reached, no age assignment was made. Digital photographs of representative ageing structures were captured using a dissecting microscope in combination with a Nikon D5100 (Nikon Corp., Tokyo, Japan).

Fish of other species were enumerated and measured to fork length (total length for Stonecat).

3.3 Catch and Effort Analysis

Catch-per-unit-effort (CPUE) was calculated separately for gill nets, set-lines and for angling, and separately for Lake Sturgeon and for all other species combined as the total number of captures per hour. For example, a set-line, gill net, or angling set of 18 hours and catching seven Lake Sturgeon (LKST) would have a CPUE of:

CPUE = #LKST/set duration
= 7/18
= 0.39 LKST/h

Length frequency distributions for Lake Sturgeon were generated using 50 mm fork length intervals (e.g., 450 – 499 mm, 500 – 549 mm, etc.), and plotted.

3.4 Size and Condition Analysis

A Lake Sturgeon fork length frequency distribution was generated using 50 mm length intervals, and additionally, mean (SD) Lake Sturgeon fork length (mm), weight (g), and condition factor (k) were estimated.

Fulton's condition factor (k; Ricker 1975) was calculated for each individual Lake Sturgeon using the following equation:

$$k = \frac{(w \times 10^5)}{fl^3}$$

where: w = round weight (g); and fl = fork length (mm).

3.5 Ageing Analysis

Due to difficulties assigning Lake Sturgeon ages caused at least in part by inconsistent growth chronologies, three reader ageing bias and precision were analyzed. Errors related to reader bias occur when a fish is aged incorrectly due to either: (a) an invalid method or (b) an reader systematically ageing a fish differently than another reader, or differently from what is known to be true (Ogle 2011). Precision is the reproducibility of estimated ages either between- or within-readers regardless of whether the estimated ages are accurate or not (Campana 2001).

A number of graphical techniques were used to assess potential systematic differences and precision between readers. First, age bias plots were constructed for all three reader combinations, plotting reader 1 or reader 2 assigned ages along the x-axis versus reader 2 or reader 3 assigned ages along the y-axis. Second, reader 1 or reader 2 age assignments were plotted on the x-axis versus all combinations of age differences, calculated by subtracting reader 1 ages from reader 2 ages, reader 1 ages from reader 2 ages, and reader 2 ages from reader 3 ages.

To statistically test for systematic differences between readers, A modified chi-square test proposed by Hoenig et al. (1995) was used to test for symmetry between all combinations of reader age assignments (i.e., reader 1 vs reader 2, reader 1 vs reader 3, and reader 2 vs reader 3 age assignments), with the significance level set at $p = 0.05$.

In addition to assessing bias, three measures of precision were computed for comparing all three reader's age determinations: (1) the percentage of all paired age assessments that were in agreement (exact agreement); (2) average percent error (APE) (Beamish and Fournier 1981) calculated as,

$$APE = \frac{\sum_{j=1}^{n} APE_j}{n}$$

where APE_j is the average percent error for the jth fish, and n is the number of fish aged; and (3) the coefficient of variation (CV) (Chang 1982) calculated as,

$$CV = \frac{\sum_{j=1}^{n} CV_j}{n}$$

where CV_j is the coefficient of variation for the jth fish. As a general rule of thumb, a CV less than 5% is considered to be acceptably precise, whereas values greater than 5% suggest that the ages are relatively imprecise (Campana 2001; Ogle 2011).

All age comparison analyses were completed using the FSA (Ogle 2012a) and NCStats (Ogle 2012b) packages for R Version 2.15.3 (R Core Team 2013).

4.0 RESULTS

4.1 Physical Data and Habitat Description

During the spring visit (15 to 18 May, 2013) water temperatures ranged from 15 to 16°C, while in the fall (22 to 29 September, 2013) water temperatures ranged from 12 to 16°C.

Assiniboine River discharge, as measured at the Brandon hydrometric station (05MH013) during the 15 to 18 May, 2013 study period, increased each day from 188.7 to 268.8 m^3/s and averaged 235.6 m^3/s (Figure 3), substantially higher than the historical (1974 – 2011) May average discharge of 108.4 m^3/s (Environment Canada 2013). As was the case during the Missouri trawl survey (Aiken and MacDonell 2011), increasing water depths and debris levels severely hampered sampling in spring 2013. High water levels limited the locations where gill nets could be set and expected to remain in place, and even then debris clogged the gill nets, making them ineffective. For these reasons no fish (of any species) were captured during the spring investigations (Table 2).

Assiniboine River discharge as measured at the Brandon hydrometric station (05MH013) during the 22 to 29 September, 2013 study period decreased each day from 28.1 to 23.8 m^3/s and averaged 25.5 m^3/s (Figure 3), slightly higher than the historical (1974 – 2011) September average discharge of 21.2 m^3/s (Environment Canada 2013). Unlike the extremely high flows encountered in fall 2010 and spring 2013, fall 2013 flow conditions were very close to average (slightly higher), and conducive to gill netting in specific habitats. A complete summary of all fall 2013 standard gillnet, set-line, and angling sets is provided in Table 2.

4.2 Catch and Effort

In the spring, a total of 134.4 hours of large mesh gillnetting effort was expended between 15 and 18 May, 2013 (Figure 4). No fish were caught during the spring survey, and as such this component is not discussed further. In the fall, between 22 and 29 September, 2013, standard gillnet effort equalled 127.7 hours, set-line effort equalled 740.6 hours, and angling effort equalled 10.9 hours (Figure 5).

During the fall survey, a total of 206 fish comprising 13 species were captured in the study area (Appendix 1). Lake Sturgeon (n = 19) comprised 25.7% of the fall standard gill net catch (n = 19), followed by Walleye (21.2%; n = 15), and Flathead Chub, Northern Pike and Shorthead Redhorse (for all three species: 9.5%; n = 7; Appendix 2). Lake Sturgeon (n = 10) comprised 10.1% of the fall set-line catch (n = 99), whereas Shorthead Redhorse was the most commonly captured species on the set-lines (24.2%; n = 24). Finally, one Lake Sturgeon was captured during angling. In total, 30 unique Lake Sturgeon were captured over the duration of the study, none were caught multiple times (Table 2). In the fall, overall mean CPUE for Lake Sturgeon equalled: 0.15 (range = 0.00 - 0.70) LKST/h for standard gill nets, 0.01 (range = 0.00 – 0.20) LKST/h for set-lines, and 0.09 (range = 0.00 – 1.00) fish/h for angling. Floy tags were applied to all 30 Lake Sturgeon captured (Appendix 3).

4.3 Size and Condition

Lake Sturgeon captured in the standard gill nets ranged from 427 to 530 mm FL, those caught on set-lines ranged from 499 to 1040 mm FL, and the lone sturgeon angled measured 825 mm FL (Appendix 3). The cumulative (i.e. all gear) length frequency distribution was bimodal, peaking at 450 – 499 mm (36.7%) and 800 and 949 mm (20.1%) fork length intervals (Figure 6). Essentially, two size classes were captured: juveniles (fl<550; n = 23) and subadults/adults (fl >550; n = 7). Juveniles had a mean fork length +/- SD of 479 +/- 36 mm, mean round weight of 691 +/- 130 g, and a mean condition factor of 0.63 +/- 0.07. Subadults/adults had a mean fork length of 902 +/-78 mm, a mean round weight of 5407 +/- 1570 g, and a mean condition factor of 0.72 +/- 0.04.

A preliminary comparison between the sub-adult Assiniboine River Lake Sturgeon populations average condition (based on Fulton's condition factor [k]) with subadults from other Manitoba localities suggests differences in mean condition between populations (Figure 7). The condition of Lake Sturgeon in the Assiniboine River at the time of the survey was the lowest observed in Manitoba. However, a temporal bias should be noted, as values for the other populations are calculated based on fish captured over sampling intervals spanning multiple seasons and years.

4.4 Ageing

Tests of symmetry indicated no systematic differences between readers (Table 3). However, measures of precision were quite poor, suggesting difficulties with age determination and little agreement between readers. Overall, three reader agreement was 35.23%, APE was 10.47%, and CV was 19.06% (Table 3). As noted previously, CV values greater than 5% suggest the ages are relatively imprecise (Campana 2001; Ogle 2011). Exact agreement was 41.38% between reader 1 and 2, 31.03% between reader 2 and 3, and 35.25% between reader 2 and 3 (Table 3).

Looking at the age bias plots, the ageing of younger fish (i.e. <550 mm FL) appears to be most problematic, which is striking given that fish ageing precision and accuracy tends to decrease with age (Hoxmeier et al. 2001). Statistically significant differences were observed between reader 1 and 2 assignments; the same 10 Lake Sturgeon aged 5 years-of-age on average by reader 1 were aged 4 years-of-age on average by reader 2 (Figure 8a). Similarly, statistically significant differences were observed between readers 2 and 3 age assignments; the same 16 Lake Sturgeon aged 4 years-of-age on average by reader 2 were aged 5 years-of-age on average by reader 3 (Figure 8a). The age difference plots suggest a small range of age differences between reader 1 and 2, and reader 1 and 3, but a larger range of differences between reader 2 and 3 (Figure 8b). For all three readers, a large range of differences was evident for fish certainly > 10 years old (i.e. subadults/adults > 800 mm FL; Figure 8b). Considering all paired age assessments (reader 1 vs 2, reader 1 vs 3, and reader 2 vs 3), 37.5% were in full agreement, 42.0% were ±1 year, and 20.5% were ±2 or more years (Figure 8c).

Of the 30 Lake Sturgeon aged, agreement by two or more readers was made for 21 fish (70%). Twelve of these fish were aged 4 years, and one fish fell into each of the 5, 9, 12, 13, and 14 age-classes (Figure 9). Similar to length, age followed a bimodal distribution: juveniles (fl<550; n = 23) and sub-adults/adults (fl>550; n = 7). Ages assigned by each of the three readers to the same 23 juvenile Lake Sturgeon ranged from 3 to 8 years (modal age = 4).

5.0 DISCUSSION

This study details the assessment of the Lake Sturgeon population between the Souris River and the Little Saskatchewan River, a stretch of the upper Assiniboine River reasoned to have been extirpated due to historical exploitation and the construction of potential barriers to fish migration. A stocking program that commenced in 1996 has seen large numbers of Saskatchewan River, Nelson River and Winnipeg River progeny transferred into the Study Area, but prior to 2013 the success of these initiatives, aside from angler reports, remained largely unknown.

Lake Sturgeon were found to be concentrated during the fall study in two relatively deep-water pools on outside bends. One pool was located just downstream of the Manitoba Hydro thermal plant rapids, and the other just downstream of the Highway 110 bridge. Given that juvenile Lake Sturgeon (including stocked fish) typically utilize deep water habitat in apparent exclusion of the shallows on other large riverine systems in Manitoba (Barth et al. 2009; Barth et al. 2013; McDougall 2011b; McDougall and Pisiak 2012; McDougall et al. 2013), efforts focused on identification and sampling of these habitats, with encouraging results. Deep water is a relative term when referring to average fall flow conditions on the Assiniboine River. Average depth was found to be shallow during this study (often <1 m) especially when compared to other riverine sturgeon habitat in the province of Manitoba (i.e., Winnipeg River, Nelson River, Saskatchewan River). The deeper holes located (which contained Lake Sturgeon) were only 2.5 – 6 m, which certainly would not meet criteria defining juvenile habitat in the Winnipeg River (>13.9 m; Barth et al. 2009) and Nelson River (>10 m; McDougall and Pisiak 2012). Once located using sonar, gill nets, set-lines and fishing rods designed to target a wide size range were all effective to various degrees in capturing Lake Sturgeon.

The low precision encountered reading the sturgeon ageing structures makes conclusions based on their assigned ages difficult. The modal age assigned to juvenile fish, tended towards four years-of-age, but assignments from individual readers ranged from 3 – 8 years for the various structures. Particularly for juvenile fish, tight outer annuli were frequently present (Appendix 6), occasionally "overlapping" to the degree that it was sometimes hard to distinguish between them, as the readers qualitatively noted. As annuli spacing reflects growth rate, this implies relatively slow growth during recent years for juvenile fish. Furthermore, growth chronologies of juveniles were qualitatively inconsistent with those of wild fish observed in other Manitoba localities (Figure 10); most notably in the sense that there was wide spacing between consistently strong "first" (i.e. inner annulus) and the "second" annuli, indicative of a highly disproportionate amount of growth during that time period. While not included in annuli counts, readers noted what would typically be described as “false” annuli within the large band of growth (between counted annuli 1 and 2) for many juvenile fish, which raises questions about whether this band truly represents 1 or 2 years of growth. Should the latter be the case, ageing estimates would be systematically biased (negatively) for juvenile fish; instead of modal assigned age of 4, the true modal age might actually be 5. While certainly not conclusive at this time, our interpretation is that the large band of growth between the well-defined first and “second” annulus on juvenile structures actually represents two years of growth. Therefore, considering the assigned ages and size distribution of juveniles, these captures might all belong to the 2008 cohort. While several hypotheses can be posed to explain what would have to amount to overwinter growth (and therefore the lack of deposition of an anticipated annulus), because these fish were captured downstream of the City of Brandon, the role of multiple warm-water effluent discharges is particularly suspicious. In concert, owing to ageing inaccuracies and speculation of potential systematic ageing error, the results of this study provide no conclusive evidence of reproduction by stocked fish; rather, it seems most likely that the juveniles captured link back to fingerlings stocked (n = 7,900) in 2008.

The second group of seven fish referred to as subadults/adults (based on body size) were assigned ages of 9 to 16 by the three readers, with modal consensus occurring for four adults. Modal consensus indicated individuals that were 9, 12, 13 and 14 years old. The nine year-old fish is potentially from the Winnipeg River fingerlings stocked in 2003 or 2004. The 13 and 14 year-old fish are potentially from the Saskatchewan River fingerlings stocked in 1999 and 2000, or perhaps the Saskatchewan River fry stocked in 2000. Finally, the 12 year-old fish is most likely a fingerling from the Nelson River progeny stocked in 2001. Genetic analysis would likely provide additional insight into the cohort/brood-stock from which these captured sturgeon belong.

The condition (k) of the Assiniboine River population at the time of the survey appears to be lower than that observed at other Manitoba populations (Figure 7), which is generally indicative of a lower growth rate on a short term scale. This result is broadly consistent with the presence of tight outer annuli (particularly on juvenile fish). Additional data collection in subsequent years may shed some light on the intrinsic (i.e., health and reproductive cycles) and extrinsic (i.e., temperature, flow) factors influencing growth of individual Lake Sturgeon, and the population as a whole in the Assiniboine River. Further in-depth analysis is needed on this topic before conclusions can be made, but at present our results suggest there is evidence of both years of relatively rapid juvenile growth, and years of markedly reduced juvenile growth in this system, a trend which has not yet been observed in other Manitoba Lake Sturgeon populations.

6.0 REFERENCES

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TABLES

Table 1. Summary of Assiniboine River Lake Sturgeon stocking, 1996 – 2013 (adapted from MCWS 2012 and 2013; and Gallagher 2004).

Year	Fry	Fingerlings	Yearlings	Juveniles	Adults	Source
1996		1,000				Winnipeg River
1997		1,000	200*			Winnipeg River
1998						
1999		1,000				Saskatchewan River
2000	2,000	1,000				Saskatchewan River
2001		156				Nelson River
2002	2,000					Winnipeg River
2003		160			7*	Winnipeg River
2004		200		55*		Winnipeg River
2005						
2006			5*			Winnipeg River
2007						
2008		7,900				Winnipeg River
2009						
2010						
2011						
2012						
2013	15,000					Winnipeg River
Total	19,000	12,416	205	55	7	

*Tagged.

Table 2. Catch-per-unit-effort for Lake Sturgeon and by-catch caught by angling, set-lining and gill netting in the Assiniboine River during fall 2013, and large mesh gill netting during spring 2013.

Site	Easting (14U)	Northing	Set Date	Pull Date	Duration (h)	# non-LKST	non-LKST CPUE (#non-LKST/h)	# LKST	LKST CPUE (#LKST/h)
Angling									
A-001.1	459048	5501615	22-Sep-13	22-Sep-13	1.50	3	2.00	0	0
A-002.1	435242	5522254	23-Sep-13	23-Sep-13	1.50	10	6.67	0	0
A-003.1	434368	5522468	23-Sep-13	23-Sep-13	0.47	3	6.43	0	0
A-004.1	434417	5522465	23-Sep-13	23-Sep-13	0.43	5	11.54	0	0
A-005.1	433487	5523009	24-Sep-13	24-Sep-13	0.75	4	5.33	0	0
A-006.1	437481	5522482	25-Sep-13	25-Sep-13	1.00	3	3.00	0	0
A-007.1	439023	5521469	26-Sep-13	26-Sep-13	1.27	3	2.37	0	0
A-008.1	436241	5522405	27-Sep-13	27-Sep-13	1.50	1	0.67	0	0
A-009.1	436331	5522423	27-Sep-13	27-Sep-13	1.50	0	0.00	0	0
A-010.1	436166	5522397	28-Sep-13	28-Sep-13	1.00	0	0.00	1	1
Total					10.92	32	2.93	1	0.09
Fall Gill Netting									
GN-001.1	459175	5501627	22-Sep-13	23-Sep-13	17.35	0	0	0	0
GN-002.1	438219	5522384	25-Sep-13	26-Sep-13	18.85	2	0.11	0	0
GN-003.1	438129	5521709	26-Sep-13	27-Sep-13	25.27	5	0.20	0	0
GN-004.1	436079	5522371	27-Sep-13	28-Sep-13	15.33	7	0.46	7	0.46
GN-004.2	436079	5522371	28-Sep-13	28-Sep-13	4.58	4	0.87	3	0.65
GN-004.3	436079	5522371	28-Sep-13	29-Sep-13	17.43	9	0.52	5	0.29
GN-004.4	436079	5522371	29-Sep-13	29-Sep-13	5.23	4	0.76	0	0
GN-005.1	436193	5522370	28-Sep-13	28-Sep-13	3.93	4	1.02	0	0
GN-005.2	436193	5522370	28-Sep-13	29-Sep-13	16.33	14	0.86	4	0.24
GN-005.3	436193	5522370	29-Sep-13	29-Sep-13	3.42	6	1.76	0	0
Total					127.73	55	0.43	19	0.15

Table 2. Continued.

Site	Easting (14U)	Northing	Set Date	Pull Date	Duration (h)	# non-LKST	non-LKST CPUE (#non-LKST/h)	# LKST	LKST CPUE (#LKST/h)
Set-lining									
SL-001.1	458873	5501671	22-Sep-13	23-Sep-13	16.58	1	0.06	0	0
SL-002.1	459083	5501638	23-Sep-13	24-Sep-13	23.87	0	0	0	0
SL-003.1	459196	5501634	23-Sep-13	24-Sep-13	23.67	2	0.08	0	0
SL-004.1	459290	5501624	23-Sep-13	24-Sep-13	22.92	3	0.13	0	0
SL-005.1	457581	5501750	23-Sep-13	24-Sep-13	21.80	5	0.23	0	0
SL-006.1	434429	5522504	23-Sep-13	24-Sep-13	24.00	3	0.13	0	0
SL-007.1	435280	5522305	23-Sep-13	23-Sep-13	1.63	1	0.61	0	0
SL-007.2	435280	5522305	23-Sep-13	24-Sep-13	22.33	1	0.04	0	0
SL-008.1	433389	5523143	24-Sep-13	25-Sep-13	18.97	4	0.21	0	0
SL-009.1	433466	5523068	24-Sep-13	25-Sep-13	18.90	1	0.05	0	0
SL-010.1	435439	5522539	24-Sep-13	25-Sep-13	18.67	0	0	0	0
SL-011.1	434148	5523572	24-Sep-13	25-Sep-13	17.68	0	0	0	0
SL-012.1	432417	5522464	24-Sep-13	25-Sep-13	16.08	0	0	0	0
SL-013.1	432681	5522535	24-Sep-13	25-Sep-13	16.08	2	0.12	0	0
SL-014.1	438919	5521481	25-Sep-13	26-Sep-13	16.27	1	0.06	0	0
SL-015.1	438635	5521640	25-Sep-13	26-Sep-13	16.17	2	0.12	0	0
SL-015.2	438635	5521640	26-Sep-13	26-Sep-13	3.03	7	2.31	0	0
SL-015.3	438635	5521640	26-Sep-13	26-Sep-13	3.43	1	0.29	0	0
SL-015.4	438635	5521640	26-Sep-13	26-Sep-13	2.45	1	0.41	0	0
SL-016.1	438016	5521769	25-Sep-13	26-Sep-13	16.30	1	0.06	0	0
SL-016.2	438016	5521769	26-Sep-13	26-Sep-13	2.33	2	0.86	0	0
SL-016.3	438016	5521769	26-Sep-13	26-Sep-13	4.17	3	0.72	0	0
SL-016.4	438016	5521769	26-Sep-13	27-Sep-13	16.83	3	0.18	0	0
SL-016.5	438016	5521769	27-Sep-13	27-Sep-13	5.88	1	0.17	0	0
SL-016.6	438016	5521769	27-Sep-13	28-Sep-13	20.37	1	0.05	0	0
SL-017.1	438181	5522341	25-Sep-13	26-Sep-13	16.72	1	0.06	0	0

Table 2. Continued.

Site	Easting (14U)	Northing	Set Date	Pull Date	Duration (h)	# non-LKST	non-LKST CPUE (#non-LKST/h)	# LKST	LKST CPUE (#LKST/h)
SL-018.1	437658	5522639	25-Sep-13	26-Sep-13	16.83	3	0.18	0	0
SL-018.2	437658	5522639	26-Sep-13	26-Sep-13	6.20	4	0.65	1	0.16
SL-018.3	437658	5522639	26-Sep-13	27-Sep-13	16.63	0	0	0	0
SL-018.4	437658	5522639	27-Sep-13	27-Sep-13	5.77	2	0.35	0	0
SL-018.5	437658	5522639	27-Sep-13	28-Sep-13	19.58	2	0.10	0	0
SL-018.6	437658	5522639	28-Sep-13	28-Sep-13	6.83	1	0.15	0	0
SL-018.7	437658	5522639	28-Sep-13	29-Sep-13	15.97	1	0.06	0	0
SL-019.1	435925	5522204	26-Sep-13	26-Sep-13	6.75	2	0.30	0	0
SL-020.1	438080	5521732	26-Sep-13	26-Sep-13	4.23	1	0.24	0	0
SL-020.2	438080	5521732	26-Sep-13	27-Sep-13	16.83	1	0.06	0	0
SL-021.1	436140	5522376	26-Sep-13	27-Sep-13	15.80	3	0.19	0	0
SL-021.2	436140	5522376	27-Sep-13	27-Sep-13	5.77	3	0.52	0	0
SL-021.3	436140	5522376	27-Sep-13	28-Sep-13	19.08	3	0.16	1	0.05
SL-021.4	436140	5522376	28-Sep-13	28-Sep-13	3.22	1	0.31	0	0
SL-021.5	436140	5522376	28-Sep-13	29-Sep-13	19.62	0	0	0	0
SL-022.1	437741	5522640	26-Sep-13	27-Sep-13	15.67	0	0	2	0.13
SL-022.2	437741	5522640	27-Sep-13	27-Sep-13	5.33	4	0.75	0	0
SL-022.3	437741	5522640	27-Sep-13	28-Sep-13	16.97	1	0.06	1	0.06
SL-022.4	437741	5522640	28-Sep-13	28-Sep-13	6.25	1	0.16	1	0.16
SL-023.1	436187	5522388	27-Sep-13	27-Sep-13	5.13	0	0	0	0
SL-023.2	436187	5522388	27-Sep-13	28-Sep-13	16.80	1	0.06	1	0.06
SL-023.3	436187	5522388	28-Sep-13	28-Sep-13	8.77	1	0.11	0	0
SL-023.4	436187	5522388	28-Sep-13	29-Sep-13	14.77	1	0.07	1	0.07
SL-024.1	436254	5522410	27-Sep-13	28-Sep-13	16.28	0	0	0	0
SL-024.2	436254	5522410	27-Sep-13	28-Sep-13	32.88	2	0.06	0	0
SL-025.1	436219	5522391	28-Sep-13	29-Sep-13	16.53	0	0	0	0
SL-026.1	436295	5522399	28-Sep-13	29-Sep-13	15.28	2	0.13	2	0.13
SL-026.2	436295	5522399	29-Sep-13	29-Sep-13	3.63	2	0.55	0	0
Total					740.55	89	0.12	10	0.01

Table 2. Continued.

Site	Easting (14U)	Northing	Set Date	Pull Date	Duration (h)	# non-LKST	non-LKST CPUE (fish/h)	# LKST	LKST CPUE (fish/h)
Spring Gill Netting									
GN-006.1	458200	5501278	15-May-13	16-May-13	23.75	0	0	0	0
GN-007.1	458216	5501334	15-May-13	16-May-13	23.67	0	0	0	0
GN-008.1	459048	5501615	15-May-13	16-May-13	22.95	0	0	0	0
GN-009.1	457475	5501719	15-May-13	16-May-13	21.83	0	0	0	0
GN-010.1	442264	5517244	17-May-13	17-May-13	3.00	0	0	0	0
GN-011.1	442589	5517225	17-May-13	17-May-13	3.00	0	0	0	0
GN-012.1	442264	5517244	17-May-13	18-May-13	18.17	0	0	0	0
GN-013.1	442589	5517225	17-May-13	18-May-13	18.00	0	0	0	0
Total					134.37	0	0	0	0
Grand Total					1013.57	176	0.17	30	0.03

Table 3. Summary of comparisons between reader 1 and reader 2, reader 1 and reader 3, reader 2 and reader 3, and all three readers Lake Sturgeon age estimates. Data were collected in fall 2013.

n	*p*	Agree (%)	APE	CV
Reader 1 vs Reader 2				
29	0.17	41.38	6.09	8.61
Reader 1 vs Reader 3				
29	0.3	31.03	8.21	11.61
Reader 2 vs Reader 3				
30	0.3	33.33	11.32	16.01
All				
29		35.25	10.47	19.06

n = sample size;
p = p-value calculated for Bowker's (Hoenig's) chi-square test of symmetry ($p \leq 0.05$ indicates systematic differences between between age estimates);
Agree = percentage of age estimates that were in exact agreement;
CV = coefficient of variation (Chang 1982).

FIGURES

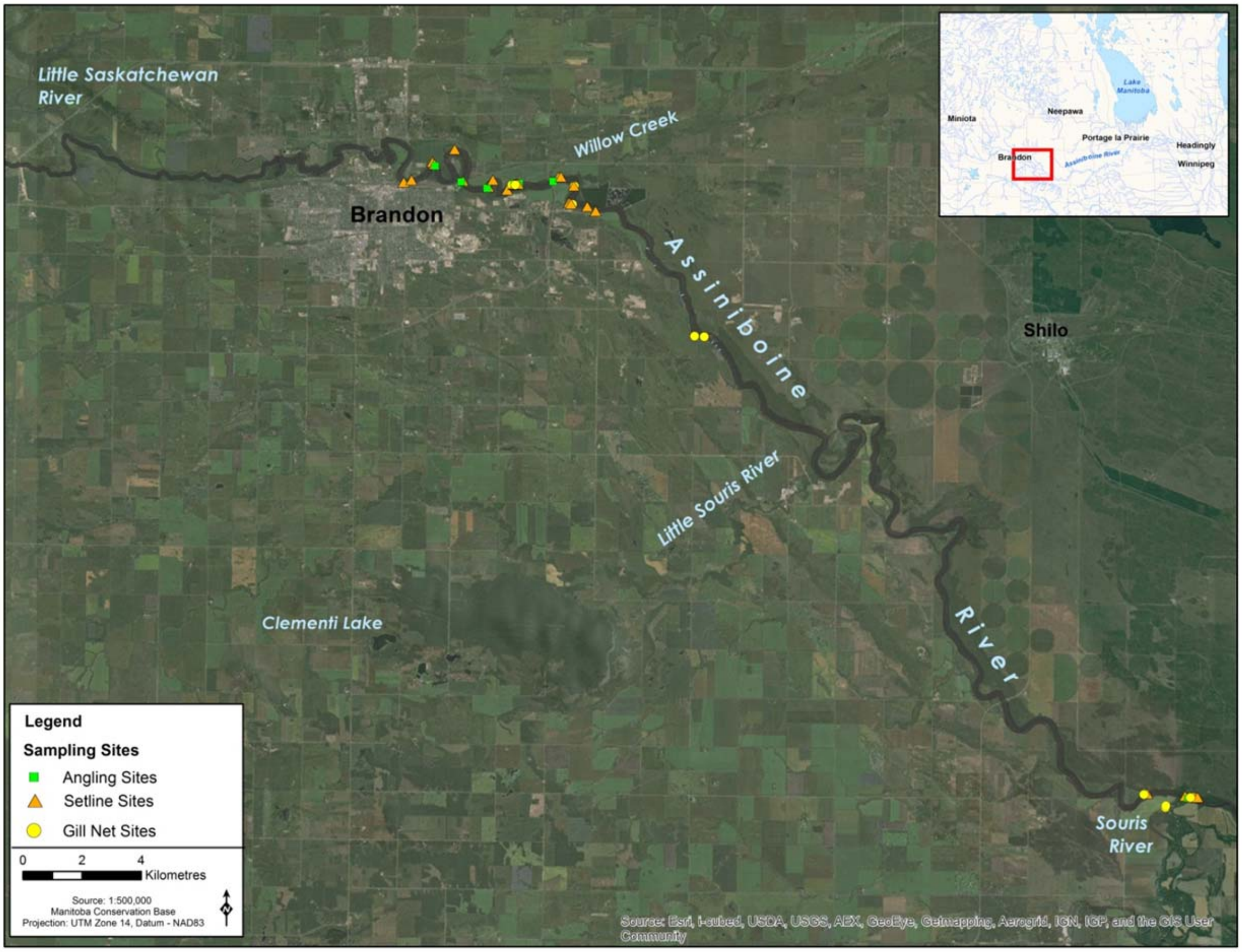


Figure 1. Map depicting the Assiniboine River – Souris River to Little Saskatchewan River 2013 study reach and study sites.

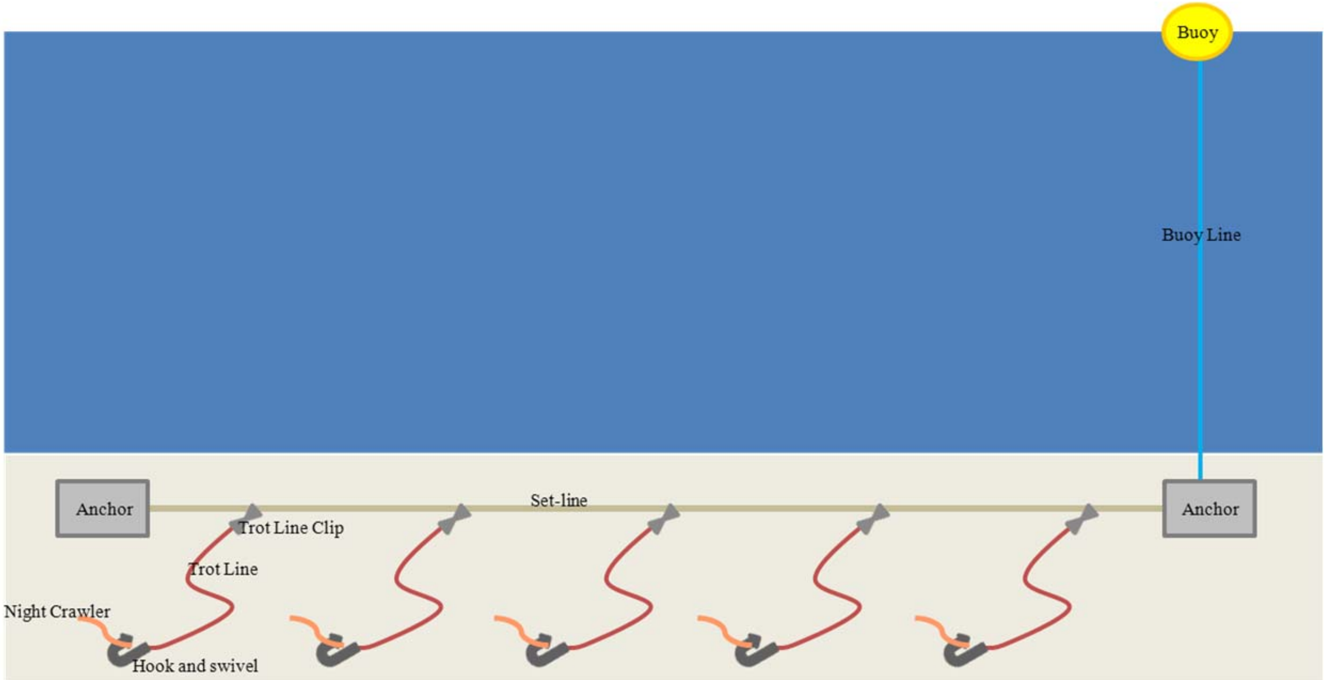


Figure 2. Schematic of a typical set-line.

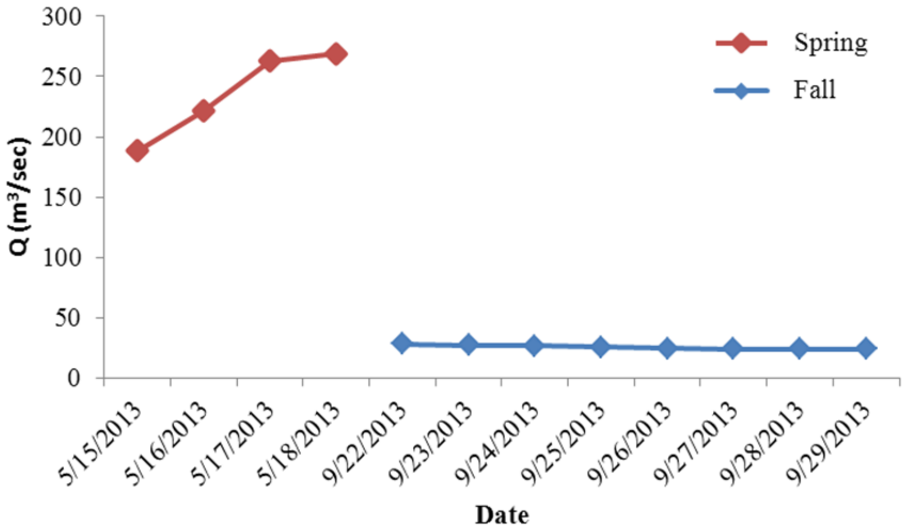


Figure 3. Mean daily discharge for the Assiniboine River at Brandon (05MH013) estimated for the spring (15 May – 18 May, 2013) and fall (22 September – 29 September, 2013) sampling periods. Data are from Environment Canada 2013.

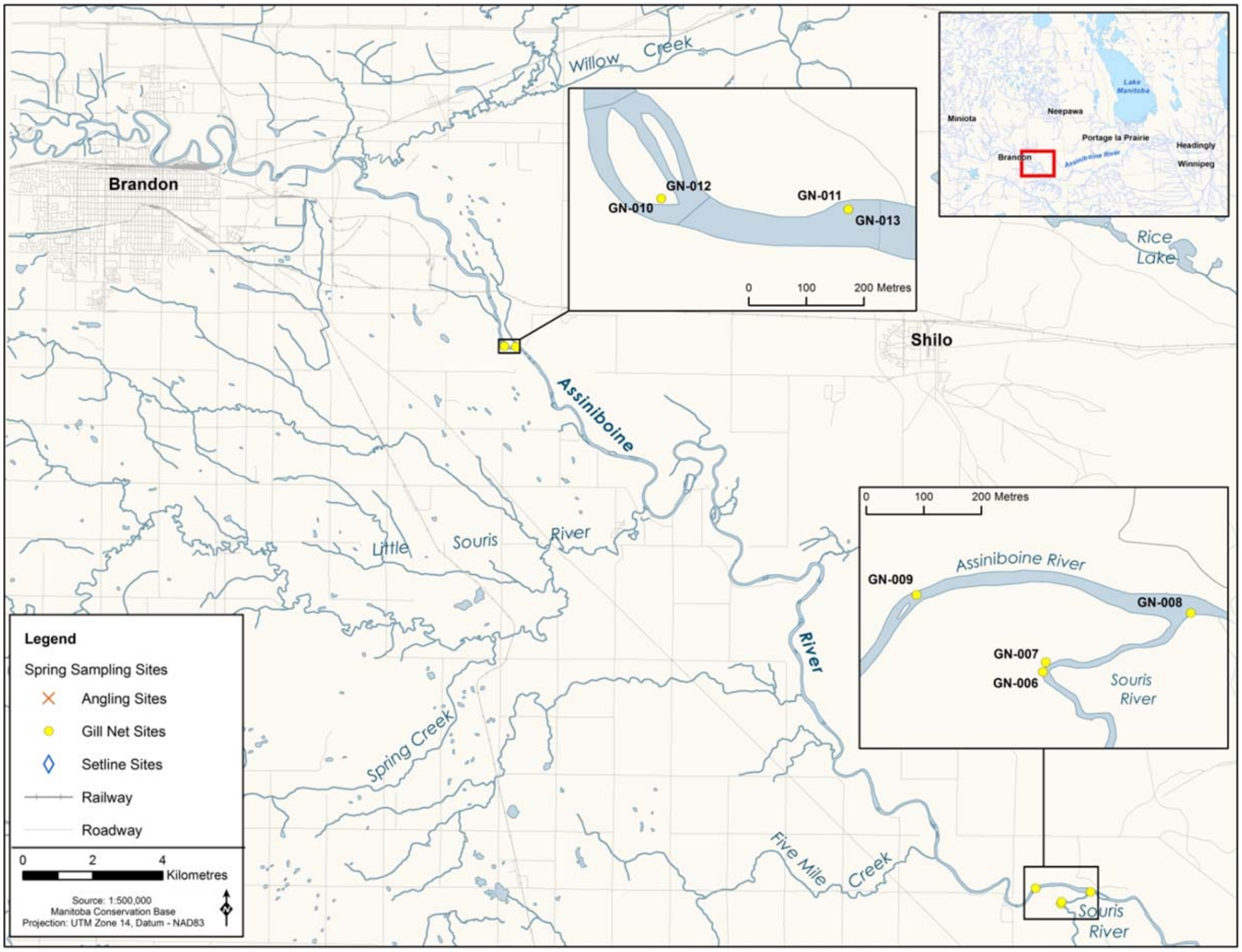


Figure 4. Assiniboine River - Souris River to Little Saskatchewan River large mesh gill net set locations, spring 2013.

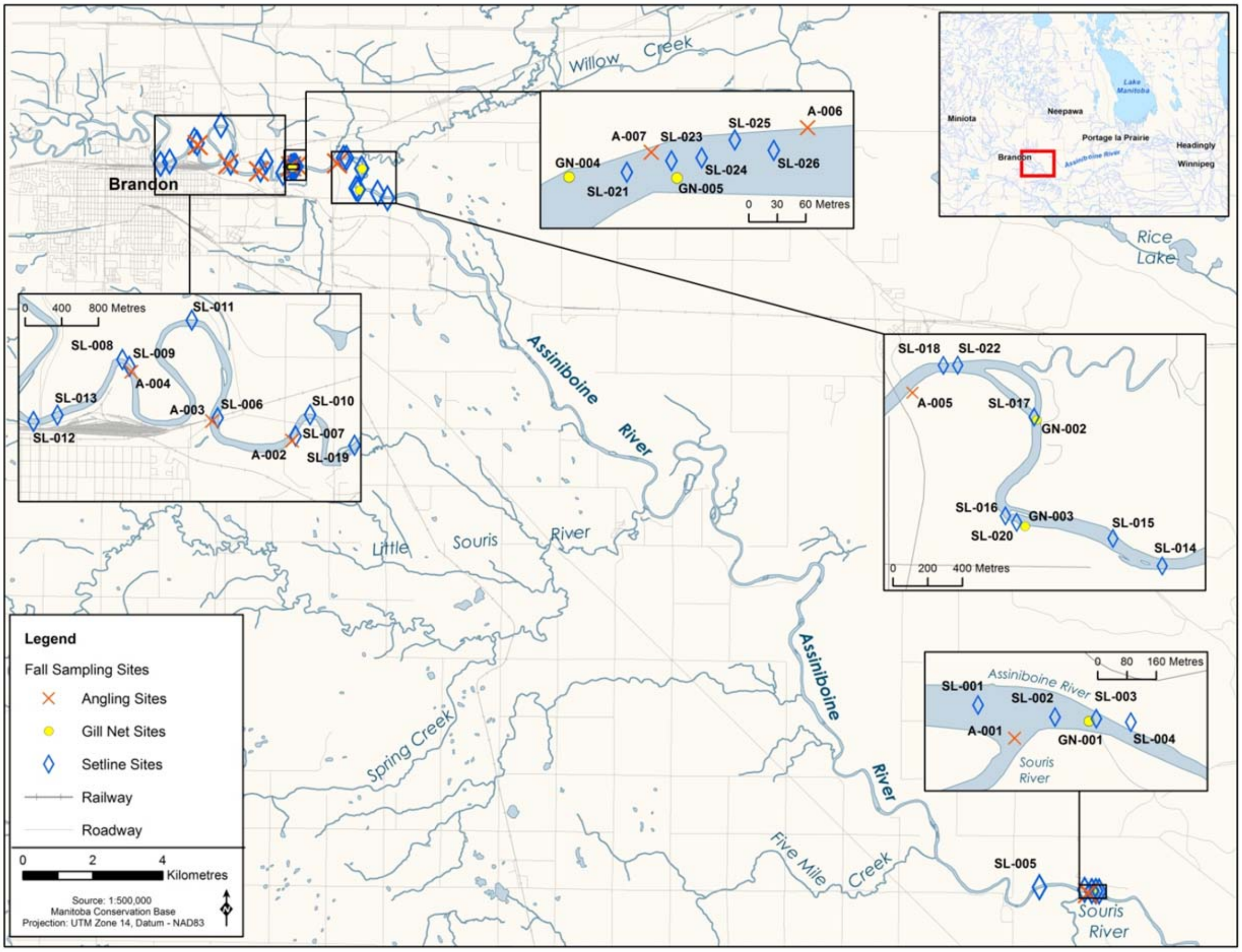


Figure 5. Map of fall 2013 angling, gill net, and set-line locations on the Assiniboine River between Souris River and Little Saskatchewan River.

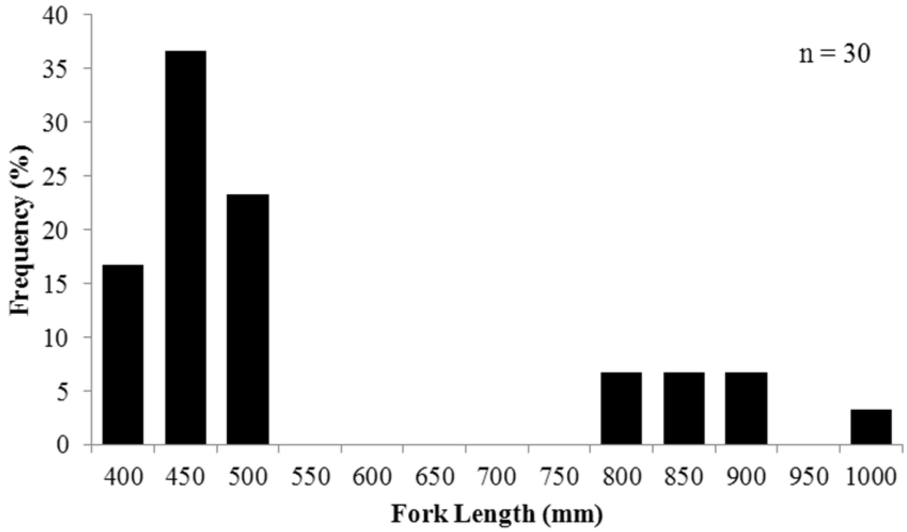


Figure 6. Fork length-frequency distribution divided into 50 mm length-classes for Lake Sturgeon captured via angling, gill net, and set-line in the Assiniboine River between the Souris River and the Little Saskatchewan River, spring and fall 2013.

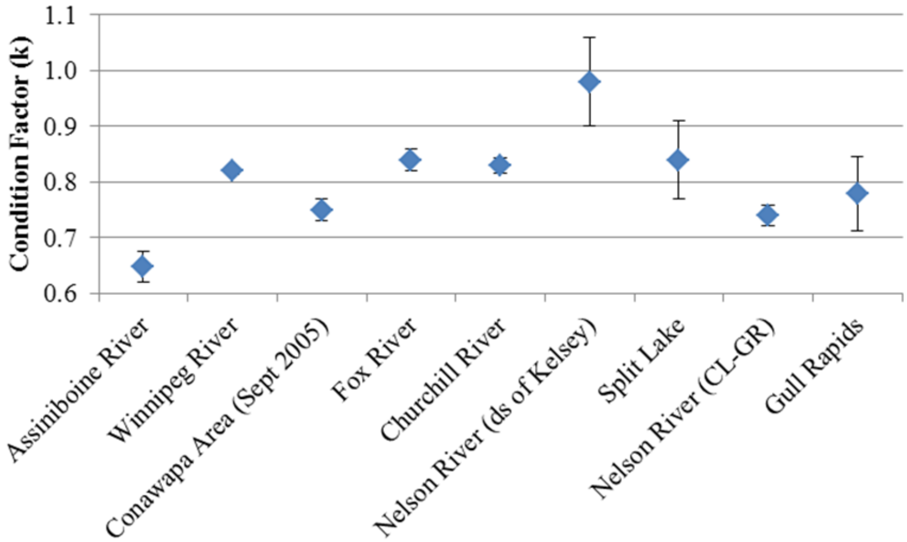


Figure 7. Mean (±95% CI) condition factor (k) estimated for sub-adult and sub-adult+ Lake Sturgeon from various Manitoba populations. Non-Assiniboine data are from Keeyask (2012).

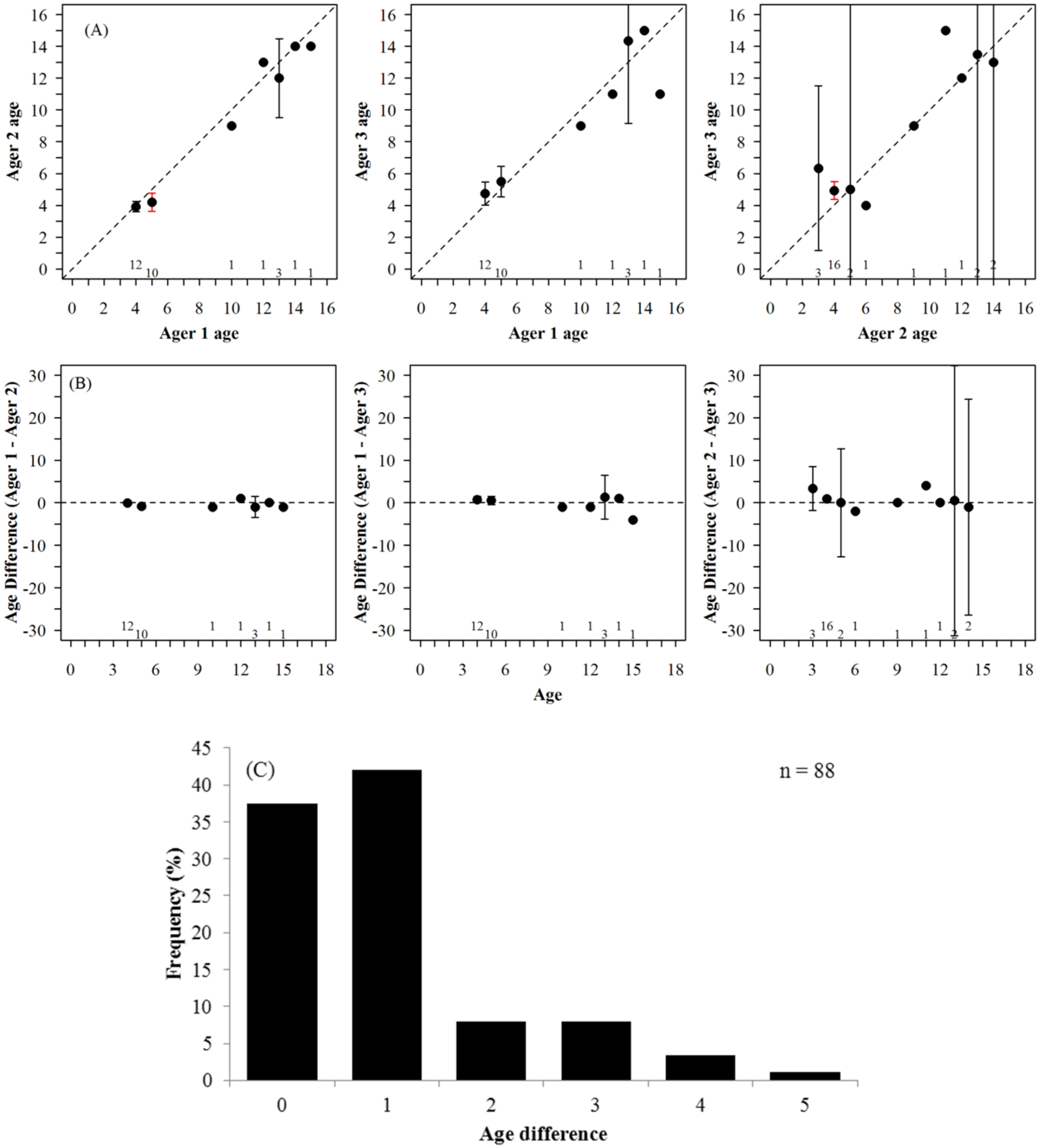


Figure 8. Plots depicting: (A) comparisons of age estimates; (B) age differences; and (C) the frequency of absolute differences between age assignments made by all readers. Error bars represent 95% confidence intervals, and the 1:1 line represents perfect agreement between readers. Sample sizes are denoted below each error bar.

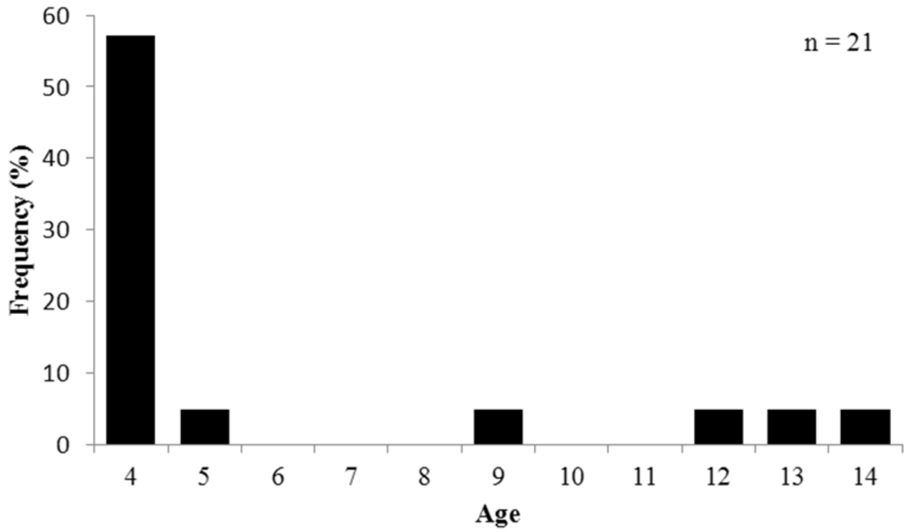


Figure 9. Age-frequency distribution for Lake Sturgeon captured via angling, gill net, and set-line in the Assiniboine River between the Souris River and the Little Saskatchewan River, spring and fall 2013. Ages presented are only from fish ageing structures that had agreement by two or more readers.

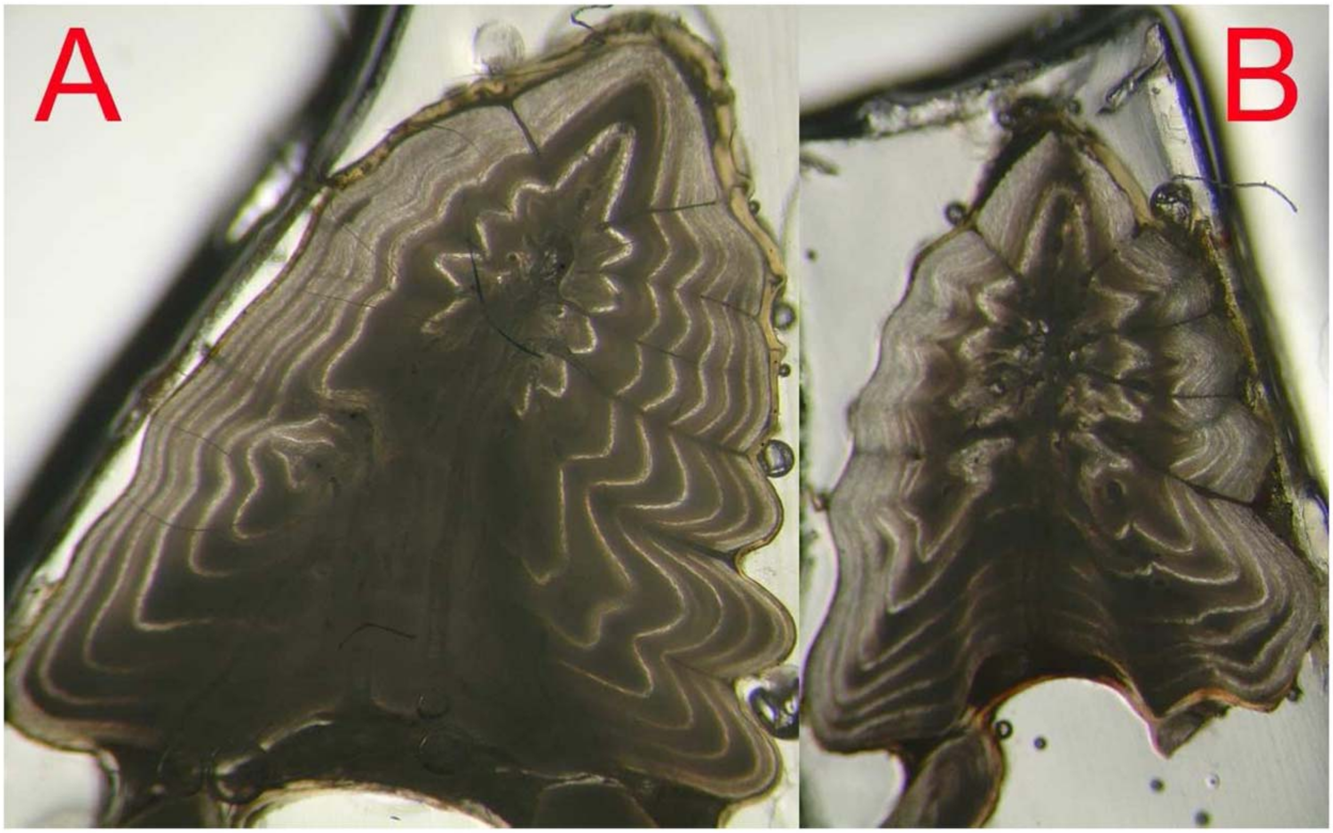


Figure 10. Examples of Lake Sturgeon pectoral fin-ray sections from fish captured in the Winnipeg River, Manitoba. Panel A is from a typical fast-growing age 8 captured from the Slave Falls Reservoir, and panel B is from a typical slow-growing age 7 captured downstream of the Slave Falls Generating Station. Both photo's are taken at 40x magnification. Excerpt from McDougall (2011a). Note average growth between first and second annuli on both structures.

APPENDICES

Appendix 1. Scientific names, common names and abbreviations for fish species captured in the Assiniboine River between Souris River and Little Saskatchewan River, spring and fall 2013.

Family	Common Name	Scientific Name	ID Code
Acipenseridae	Lake Sturgeon	*Acipenser fulvescens*	LKST
Hiodontidae	Mooneye	*Hiodon tergisus*	MOON
Cyprinidae	Common Carp	*Cyprinus carpio*	CARP
	Flathead Chub	*Platygobio gracilis*	FLCH
Catostomidae	White Sucker	*Catostomus commersonii*	WHSC
	Shorthead Redhorse	*Moxostoma macrolepidotum*	SHRD
Ictaluridae	Channel Catfish	*Ictalurus punctatus*	CHCT
	Stonecat	*Noturus flavus*	STON
Esocidae	Northern Pike	*Esox lucius*	NRPK
Centrarchidae	Rock Bass	*Ambloplites rupestris*	RCBS
Percidae	Yellow Perch	*Perca flavescens*	YLPR
	Sauger	*Sander canadensis*	SAUG
	Walleye	*Sander vitreus*	WALL

Appendix 2. Summary of species captured in gill nets set in the Assiniboine River between Souris River and Little Saskatchewan River, spring and fall 2013. Species abbreviations are presented in Appendix 1.

Site	CARP	CHCT	FLCH	LKST	MOON	NRPK	RCBS	SAUG	SHRD	SLRD	STON	WALL	WHSC	Total
Angling														
A-001.1			1				1					1		3
A-002.1	5	1	1						1		1	1		10
A-003.1	1		2											3
A-004.1	2		3											5
A-005.1	1	2	1											4
A-006.1	1		1							1				3
A-007.1	2								1					3
A-008.1	1													1
A-009.1				0										0
A-010.1				1										1
Angling total	13	3	9	1	0	0	1	0	2	1	1	2	0	33
Angling PFO	39.39	9.09	27.27	3.03	0.00	0.00	3.03	0.00	6.06	3.03	3.03	6.06	0.00	
Gill net														
GN-001.1				0										0
GN-002.1			1									1		2
GN-003.1	2		1						1			1		5
GN-004.1			1	7				2			1	3		14
GN-004.2			2	3			1					1		7
GN-004.3			2	5			1	4			2			14
GN-004.4					2							2		4
GN-005.1					1	1			2					4
GN-005.2	1	1		4		4			1			7		18
GN-005.3					1	2			3					6
GN-006.1				0										0
GN-007.1				0										0
GN-008.1				0										0
GN-009.1				0										0
GN-010.1				0										0
GN-011.1				0										0
GN-012.1				0										0
GN-013.1				0										0
Gill net total	3	1	7	19	4	7	2	6	7	0	3	15	0	74
Gill net PFO	4.05	1.35	9.46	25.68	5.41	9.46	2.70	8.11	9.46	0.00	4.05	20.27	0.00	

Appendix 2. Continued.

Site	CARP	CHCT	FLCH	LKST	MOON	NRPK	RCBS	SAUG	SHRD	SLRD	STON	WALL	WHSC	Total
Set-line														
SL-001.1												1		1
SL-002.1				0										0
SL-003.1									1			1		2
SL-004.1		1					2							3
SL-005.1			1							2		2		5
SL-006.1										1		2		3
SL-007.1	1													1
SL-007.2	1													1
SL-008.1	1	3												4
SL-009.1									1					1
SL-010.1				0										0
SL-011.1				0										0
SL-012.1				0										0
SL-013.1											1		1	2
SL-014.1												1		1
SL-015.1	2													2
SL-015.2		1							5	1				7
SL-015.3										1				1
SL-015.4									1					1
SL-016.1									1					1
SL-016.2			1						1					2
SL-016.3									1	1		1		3
SL-016.4							1				1		1	3
SL-016.5										1				1
SL-016.6											1			1
SL-017.1			1											1

Appendix 2. Continued.

Site	CARP	CHCT	FLCH	LKST	MOON	NRPK	RCBS	SAUG	SHRD	SLRD	STON	WALL	WHSC	Total
SL-018.1		1									1	1		3
SL-018.2	1			1					2			1		5
SL-018.3				0										0
SL-018.4	1	1												2
SL-018.5	1	1												2
SL-018.6									1					1
SL-018.7									1					1
SL-019.1			1									1		2
SL-020.1	1													1
SL-020.2		1												1
SL-021.1	1								1		1			3
SL-021.2									1		1	1		3
SL-021.3			1	1		1			1					4
SL-021.4			1											1
SL-021.5				0										0
SL-022.1				2										2
SL-022.2	2								1	1				4
SL-022.3		1		1										2
SL-022.4				1					1					2
SL-023.1				0										0
SL-023.2				1						1				2
SL-023.3			1											1
SL-023.4				1					1					2
SL-024.1				0										0
SL-024.2									2					2
SL-025.1				0										0
SL-026.1				2							1	1		4
SL-026.2									1				1	2
Set-line total	12	10	7	10	0	1	3	0	24	9	7	13	3	99
Set-line PFO	12.12	10.10	7.07	10.10	0.00	1.01	3.03	0.00	24.24	9.09	7.07	13.13	3.03	
Total	28	14	23	30	4	8	6	6	33	10	11	30	3	206
Total PFO	13.59	6.80	11.17	14.56	1.94	3.88	2.91	2.91	16.02	4.85	5.34	14.56	1.46	

Appendix 3. Biological and tagging data for Lake Sturgeon captured in the Assiniboine River between Souris River and Little Saskatchewan River, spring and fall 2013.

Date	Site	Fish #	Fork Length (mm)	Total Length (mm)	Weight (g)	Condition Factor (k)	Floy Tag #
9/26/2013	SL-018.2	1	499	557	775	0.62	NSC91578
9/27/2013	SL-022.1	2	1040	1152	8550	0.76	NSC91579
9/27/2013	SL-022.1	3	892	1000	5375	0.76	NSC91580
9/28/2013	SL-023.2	4	857	950	4700	0.75	NSC91581
9/28/2013	SL-022.3	5	942	1040	5525	0.66	NSC91582
9/28/2013	GN-004.1	6	484	548	625	0.55	NSC91583
9/28/2013	GN-004.1	7	451	502	550	0.60	NSC91584
9/28/2013	GN-004.1	8	491	560	800	0.68	NSC91585
9/28/2013	GN-004.1	9	435	507	550	0.67	NSC91586
9/28/2013	GN-004.1	10	528	592	875	0.59	NSC91587
9/28/2013	GN-004.1	11	515	583	825	0.60	NSC91588
9/28/2013	GN-004.1	12	491	557	750	0.63	NSC91589
9/28/2013	SL-021.3	13	521	582	800	0.57	NSC91590
9/28/2013	GN-004.2	14	434	498	550	0.67	NSC91591
9/28/2013	GN-004.2	15	530	609	900	0.60	NSC91592
9/28/2013	GN-004.2	16	441	510	600	0.70	NSC91593
9/28/2013	SL-022.4	17	939	1031	5800	0.70	NSC91594
9/28/2013	A-010.1	18	825	915	4000	0.71	NSC91595
9/29/2013	SL-023.4	19	531	600	800	0.53	NSC91596
9/29/2013	SL-026.1	20	505	579	625	0.49	NSC91597
9/29/2013	SL-026.1	21	820	915	3900	0.71	NSC105001
9/29/2013	GN-004.3	22	429	492	500	0.63	NSC105002
9/29/2013	GN-004.3	23	451	521	550	0.60	NSC105003
9/29/2013	GN-004.3	24	450	520	600	0.66	NSC105004
9/29/2013	GN-004.3	25	476	539	550	0.51	NSC105005
9/29/2013	GN-004.3	26	459	519	625	0.65	NSC105006
9/29/2013	GN-005.2	27	469	521	800	0.78	NSC105007
9/29/2013	GN-005.2	28	525	593	900	0.62	NSC105008
9/29/2013	GN-005.2	29	479	548	750	0.68	NSC105009
9/29/2013	GN-005.2	30	427	480	600	0.77	NSC105010
			578	651	1792	0.65	

Appendix 4. Summary of juvenile Lake Sturgeon pit tagged, floy tagged, Vemco tagged and then released into the Assiniboine River near Brandon, MB in 2003 and 2004. Data provided by C. Gallagher (unpublished data).

Surgery Date	Weight (g)	Total Length (mm)	Release Date	Release Location	Pit Tag	Floy Tag	Vemco Tag			
					#	#	#	Type	Initiation Date	Life (d)
14-Oct-03	1968	643	5-Nov-03	Brandon, MB	123266446A	RRTS 00590	125	V16-4H-Ro4K	14-Oct-03	570
20-Oct-03	2012	649	5-Nov-03	Brandon, MB	122945492A	RRTS 00591	122	V16-4H-Ro4K	20-Oct-03	570
20-Oct-03	1791	629	5-Nov-03	Brandon, MB	122548185A	RRTS 00589	119	V16-4H-Ro4K	20-Oct-03	570
20-Oct-03	1873	633	5-Nov-03	Brandon, MB	122468140A	RRTS 00584	121	V16-4H-Ro4K	20-Oct-03	570
20-Oct-03	2358	676	5-Nov-03	Brandon, MB	123324393A	RRTS 00587	127	V16-4H-Ro4K	20-Oct-03	570
20-Oct-03	1854	621	5-Nov-03	Brandon, MB	123435553A	RRTS 00586	126	V16-4H-Ro4K	20-Oct-03	570
22-Oct-03	1750	604	5-Nov-03	Brandon, MB	*006*003*087	RRTS 00585	123	V16-4H-Ro4K	22-Oct-03	570
4-Jun-04	1264	536	5-Jul-04	Brandon, MB	134646547A	508	169	V16-4H-Ro4K	4-Jun-04	770
4-Jun-04	1266	547	5-Jul-04	Brandon, MB	135132217A	501	172	V16-4H-Ro4K	4-Jun-04	770
4-Jun-04	1345	532	5-Jul-04	Brandon, MB	134912097A	506	190	V16-4H-Ro4K	4-Jun-04	770
4-Jun-04	1170	515	5-Jul-04	Brandon, MB	133933130A	503	192	V16-4H-Ro4K	4-Jun-04	770
4-Jun-04	1086	528	5-Jul-04	Brandon, MB	135118771A	510	195	V16-4H-Ro4K	5-Jun-04	770
4-Jun-04	1016	493	5-Jul-04	Brandon, MB	133576283A	502	197	V16-4H-Ro4K	5-Jun-04	770
4-Jun-04	1103	522	5-Jul-04	Brandon, MB	133625296A	507	199	V16-4H-Ro4K	5-Jun-04	770
4-Jun-04	1435	548	5-Jul-04	Brandon, MB	135144171A	511	202	V16-4H-Ro4K	5-Jun-04	770
13-Jun-04	1054	488	5-Jul-04	Brandon, MB	142162562A	513	22	V8SC-2H-R256	10-Jun-04	125
13-Jun-04	1005	495	5-Jul-04	Brandon, MB	142848185A	509	23	V8SC-2H-R256	10-Jun-04	125
13-Jun-04	951	482	5-Jul-04	Brandon, MB	142424554A	505	25	V8SC-2H-R256	10-Jun-04	125
13-Jun-04	993	488	5-Jul-04	Brandon, MB	142872444A	514	51	V8SC-2H-R256	10-Jun-04	125
13-Jun-04	1129	513	5-Jul-04	Brandon, MB	142261515A	512	20	V8SC-2H-R256	11-Jun-04	125
13-Jun-04	968	484	5-Jul-04	Brandon, MB	142435530A	504	39	V8SC-2H-R256	11-Jun-04	125
13-Jun-04	1063	505	5-Jul-04	Brandon, MB	142253761A	515	42	V8SC-2H-R256	11-Jun-04	125
No surgery	1068	496	5-Jul-04	Brandon, MB	142261115A	528	No tag	No tag	No tag	No tag
No surgery	671	434	5-Jul-04	Brandon, MB	142871215A	553	No tag	No tag	No tag	No tag
No surgery	877	478	5-Jul-04	Brandon, MB	142272516A	518	No tag	No tag	No tag	No tag
No surgery	1034	513	5-Jul-04	Brandon, MB	142764356A	550	No tag	No tag	No tag	No tag
No surgery	885	474	5-Jul-04	Brandon, MB	142746260A	524	No tag	No tag	No tag	No tag
No surgery	591	430	5-Jul-04	Brandon, MB	142209352A	529	No tag	No tag	No tag	No tag
No surgery	1104	514	5-Jul-04	Brandon, MB	142764114A	545	No tag	No tag	No tag	No tag
No surgery	1016	498	5-Jul-04	Brandon, MB	142247164A	536	No tag	No tag	No tag	No tag
No surgery	969	507	5-Jul-04	Brandon, MB	142272760A	541	No tag	No tag	No tag	No tag
No surgery	739	456	5-Jul-04	Brandon, MB	142871152A	547	No tag	No tag	No tag	No tag
No surgery	1102	516	5-Jul-04	Brandon, MB	142461454A	523	No tag	No tag	No tag	No tag
No surgery	1087	516	5-Jul-04	Brandon, MB	142463364A	542	No tag	No tag	No tag	No tag
No surgery	959	493	5-Jul-04	Brandon, MB	142736134A	522	No tag	No tag	No tag	No tag
No surgery	1013	492	5-Jul-04	Brandon, MB	142824725A	535	No tag	No tag	No tag	No tag
No surgery	1072	494	5-Jul-04	Brandon, MB	142273614A	517	No tag	No tag	No tag	No tag
No surgery	897	489	5-Jul-04	Brandon, MB	142414746A	548	No tag	No tag	No tag	No tag
No surgery	1196	518	5-Jul-04	Brandon, MB	142409126A	530	No tag	No tag	No tag	No tag
No surgery	1015	508	5-Jul-04	Brandon, MB	142722095A	537	No tag	No tag	No tag	No tag
No surgery	1005	500	5-Jul-04	Brandon, MB	142848473A	552	No tag	No tag	No tag	No tag

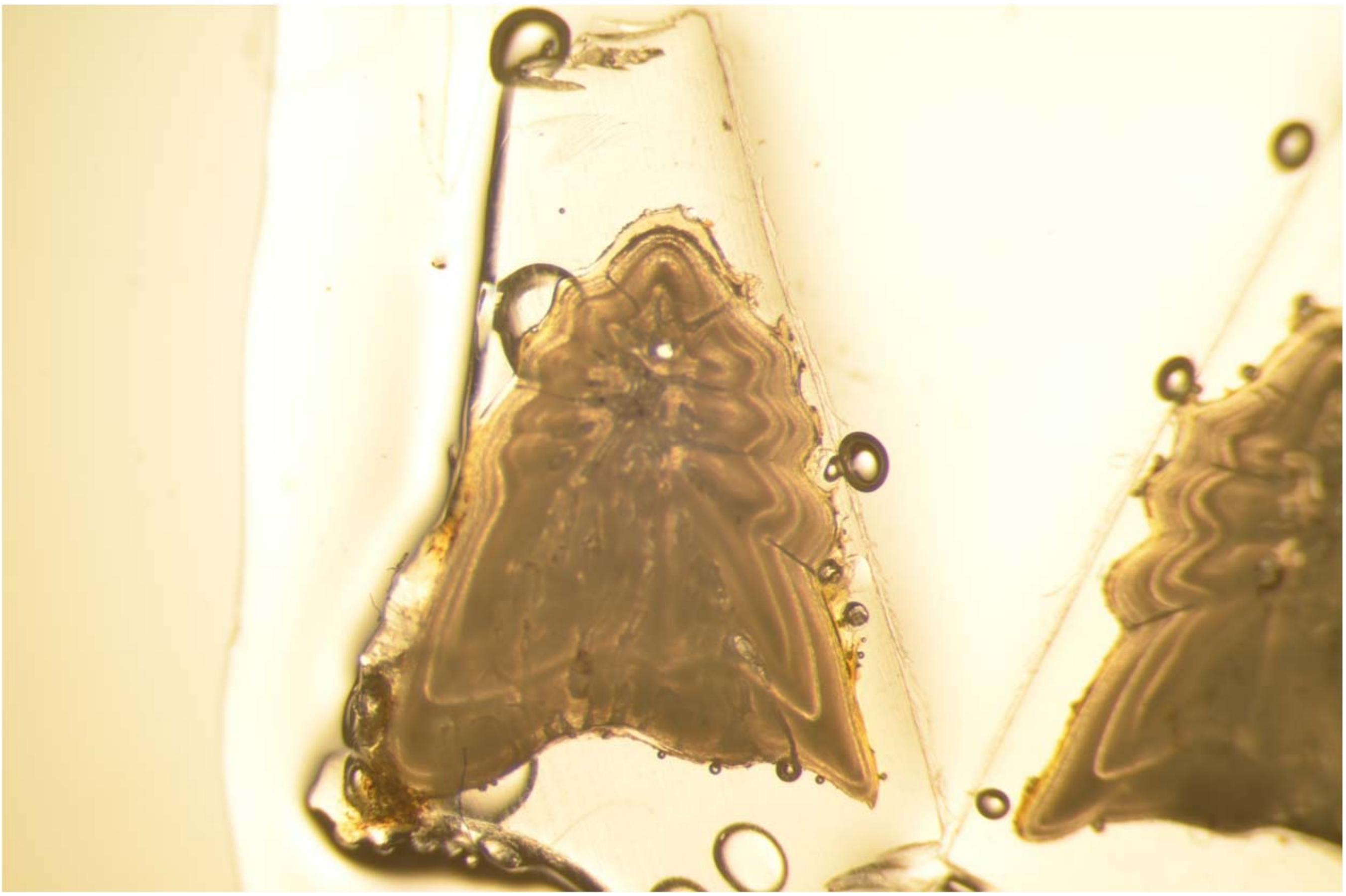
Appendix 4. Continued.

Surgery Date	Weight (g)	Total Length (mm)	Release Date	Release Location	Pit Tag	Floy Tag	Vemco Tag			
					#	#	#	Type	Initiation Date	Life (d)
No surgery	1272	523	5-Jul-04	Brandon, MB	142427734A	551	No tag	No tag	No tag	No tag
No surgery	1014	498	5-Jul-04	Brandon, MB	142421357A	519	No tag	No tag	No tag	No tag
No surgery	1133	506	5-Jul-04	Brandon, MB	142721517A	531	No tag	No tag	No tag	No tag
No surgery	915	481	5-Jul-04	Brandon, MB	142266565A	538	No tag	No tag	No tag	No tag
No surgery	802	437	5-Jul-04	Brandon, MB	142727246A	527	No tag	No tag	No tag	No tag
No surgery	1066	504	5-Jul-04	Brandon, MB	142455317A	532	No tag	No tag	No tag	No tag
No surgery	953	488	5-Jul-04	Brandon, MB	142828721A	543	No tag	No tag	No tag	No tag
No surgery	1055	486	5-Jul-04	Brandon, MB	142822322A	549	No tag	No tag	No tag	No tag
No surgery	860	463	5-Jul-04	Brandon, MB	142446313A	540	No tag	No tag	No tag	No tag
No surgery	1034	490	5-Jul-04	Brandon, MB	142757350A	521	No tag	No tag	No tag	No tag
No surgery	936	479	5-Jul-04	Brandon, MB	142738391A	533	No tag	No tag	No tag	No tag
No surgery	974	486	5-Jul-04	Brandon, MB	142167350A	534	No tag	No tag	No tag	No tag
No surgery	953	486	5-Jul-04	Brandon, MB	142464737A	544	No tag	No tag	No tag	No tag
No surgery	1007	487	5-Jul-04	Brandon, MB	142722367A	526	No tag	No tag	No tag	No tag
No surgery	920	488	5-Jul-04	Brandon, MB	142433794A	539	No tag	No tag	No tag	No tag
No surgery	1015	485	5-Jul-04	Brandon, MB	142811096A	516	No tag	No tag	No tag	No tag
No surgery	1132	529	5-Jul-04	Brandon, MB	142735253A	555	No tag	No tag	No tag	No tag
No surgery	1103	500	5-Jul-04	Brandon, MB	142839583A	520	No tag	No tag	No tag	No tag
No surgery	938	483	5-Jul-04	Brandon, MB	142265765A	546	No tag	No tag	No tag	No tag
No surgery	915	482	5-Jul-04	Brandon, MB	142262650A	554	No tag	No tag	No tag	No tag
No surgery	1207	508	5-Jul-04	Brandon, MB	142262477A	525	No tag	No tag	No tag	No tag

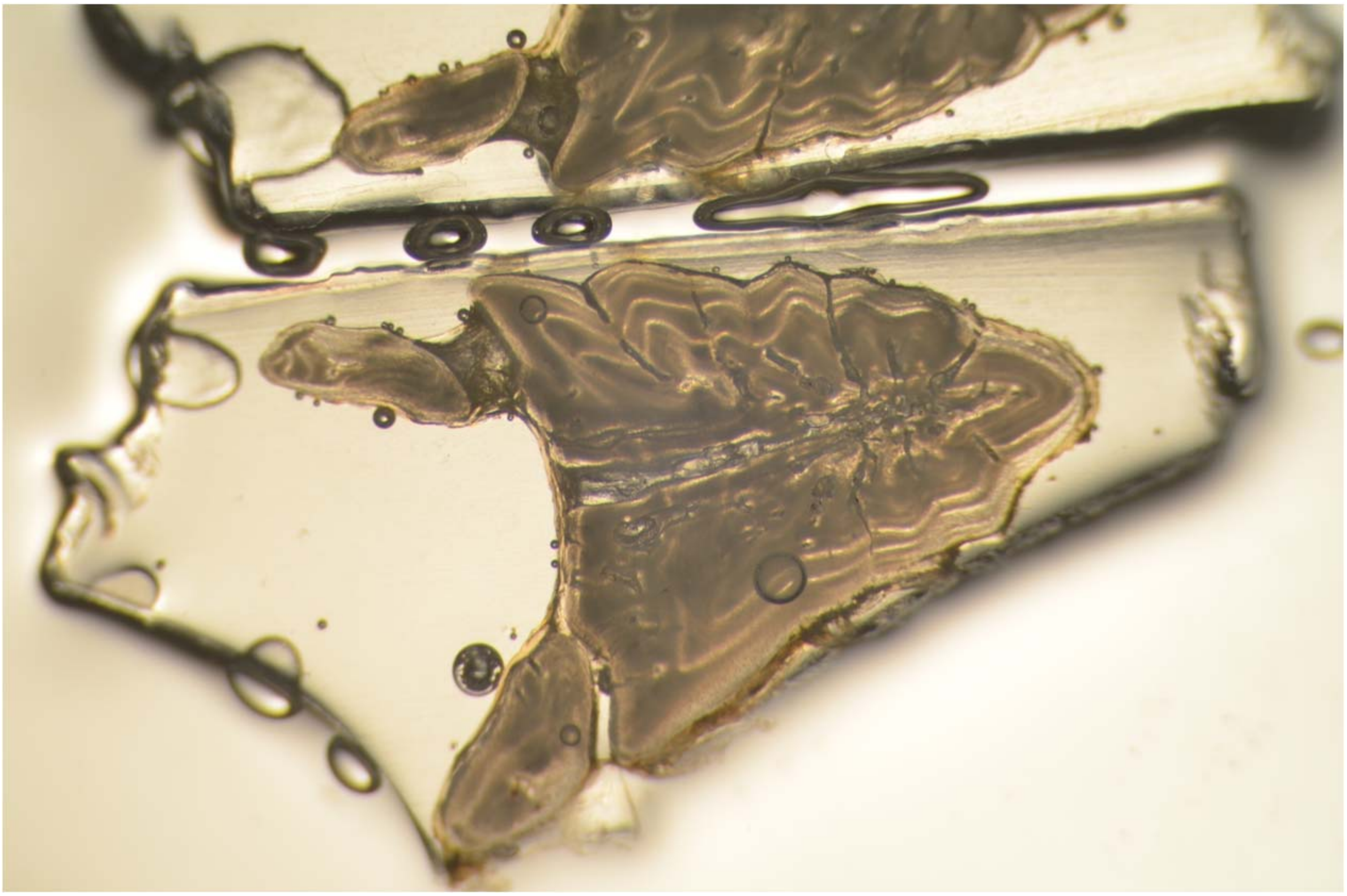
Appendix 5. Date of capture and total length for Lake Sturgeon angled from the Assiniboine River and reported to the Manitoba Master Angler program. Data are from Travel Manitoba (2013).

Date	Total Length (mm)
22-Oct-13	1295.4
21-Oct-13	1155.7
8-Oct-13	1276.4
8-Oct-13	1149.4
6-Oct-13	1308.1
6-Oct-13	1219.2
5-Oct-13	1143
4-Oct-13	1117.6
20-Oct-12	1092.2
15-Sep-12	1181.1
5-Aug-12	1092.2
7-Jun-12	1206.5
31-May-12	1117.6
23-Nov-11	1270
17-Oct-11	1244.6
24-Aug-11	1168.4
19-May-11	1130.3
22-May-10	1181.1
27-May-09	1104.9
23-Oct-08	1168.4
18-Oct-08	1117.6
23-Sep-08	1124
24-Jun-08	1117.6
10-Jun-08	1155.7
29-May-08	1104.9
22-May-08	1092.2
20-May-08	1117.6
16-May-08	1130.3
15-May-08	1124
14-Oct-07	1149.4
4-Oct-07	1149.4
4-Oct-07	1136.7
3-Oct-07	1136.7
3-Oct-07	1111.3
3-Oct-07	1098.6
2-Oct-07	1124
30-Sep-07	1092.2
31-Aug-07	1092.2
17-Aug-04	1117.6

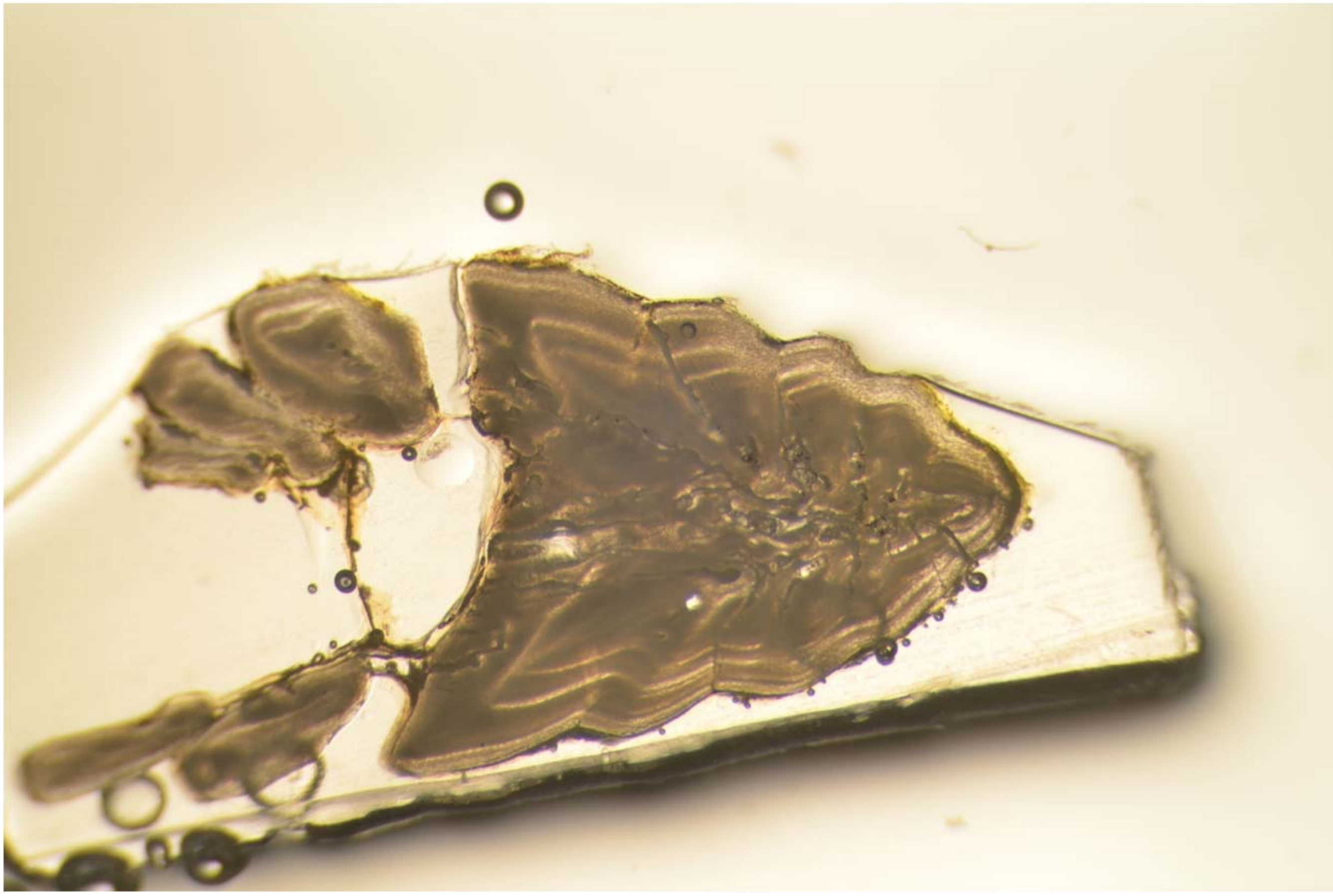
Appendix 6. Ageing structures of representative Lake Sturgeon captured in the Souris River to the Saskatchewan River reach of the Assiniboine River, fall 2013. Shown below is LKST #1 (499 mm FL) determined to be from the 2009 cohort (age 4). Readers noted excessive growth between strong first and “second” annuli, which may actually represent 2 years of growth. Tight outer annuli were also observed.



Appendix 6. Continued. Shown below is LKST #6 (484 mm FL), determined to be from the 2009 cohort (age 4). Readers noted excessive growth between strong first and "second" annuli, which may actually represent 2 years of growth. Tight outer annuli were also observed.



Appendix 6. Continued. Shown below is LKST #7 (451 mm FL), determined to be from the 2009 cohort (age 4). Readers noted excessive growth between strong first and “second” annuli, which may actually represent 2 years of growth. Tight outer annuli were also observed.



Appendix 6. Continued. Shown below is LKST #9 (435 mm FL). No age was assigned as readers 1 to 3 read the structure as age 5, 6 and 4, respectively. Readers noted excessive growth between year 1 and 2 or a weak "second" annuli, and little growth in 2013. The condition of this ageing structure was also somewhat poor.