A synoptic review of the history and our knowledge of lake sturgeon in the Ottawa River.

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Cover photo: Sturgeon Sampling on the Ottawa River.

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Abstract

Lake sturgeon are indigenous to the Ottawa River and were once considered to be abundant. Populations have declined due to various stressors since the late 1800s. This report provides a synopsis of what is currently known about lake sturgeon in the Ottawa River including biology, phenology, stressors and status; identifies several gaps in our knowledge; speculates on the future of lake sturgeon in the river and identifies research needs. This study was restricted to the nine river reaches downstream of Lake Temiscaming to the Carillon Dam. Lake sturgeon were sampled in all river reaches through index netting or spawning assessment. There was significant variation in relative abundance among river reaches with the greatest abundance in unimpounded river reaches. The von Bertalanffy growth equation that best describes Ottawa River sturgeon is $L_t = 133.7(1 - \exp^{-0.058(t-(-3))})$ and the equation that best describes condition is $w = 5.6 \text{ X } 10^{-4}\ l^{3.50}$. Length and age at 50% maturity was 106.7 cm, 20.4 years for males and 112.2 cm, 25.4 years for females. Fecundity was estimated at 12 170 eggs•kg^{-1}. Annual mortality was estimated at 15%. A tagging project has tagged 843 lake sturgeon to date. Recapture rate was low suggesting exploitation rate, especially by commercial harvesters was also low. The future of lake sturgeon in the Ottawa River looks promising although several research needs have been identified to facilitate long term survival and recovery.

Résumé

L’esturgeon jaune est une espèce indigène de la rivière des Outaouais qui était autrefois considérée comme abondante. Ses populations reculent depuis la fin des années 1800, en raison de divers facteurs d’agression. Le présent rapport fait le point sur les choses que l’on sait actuellement sur l’esturgeon jaune de la rivière des Outaouais, dont sa biologie, sa phénologie, ses facteurs d’agression et son état général. Ses auteurs relèvent plusieurs lacunes dans les connaissances, avancent des hypothèses sur l’avenir de l’esturgeon jaune dans la rivière des Outaouais et indiquent les besoins à combler en matière de recherche. L’étude a été restreinte aux neuf tronçons de la rivière en aval du lac Témiscamingue, jusqu’au barrage Carillon. Dans ces neuf tronçons, les données ont été recueillies par des prises au filet ou un examen des aires de fraie. On note une variation importante de l’abondance relative de l’espèce selon le tronçon de la rivière. La plus forte abondance a été observée dans les tronçons non endigués de la rivière. L’équation de croissance de von Bertalanffy qui décrit le mieux l’esturgeon jaune de la rivière des Outaouais est celle-ci : $L_t = 133.7(1 - \exp^{-0.058(t-(-3))})$. L’équation qui décrit le mieux son état est celle-ci : $w = 5.6 \text{ X } 10^{-4}\ l^{3.50}$. La longueur et l’âge, à mi-maturité (maturité = 50 %), était de 106,7 cm et de 20,4 ans pour les mâles, et de 112,2 cm et 25,4 ans pour les femelles. Le taux de fécondité a été estimé à 12 170 $\text{eggs}\bullet\text{kg}^{-1}$. Le taux de mortalité annuel a été estimé à 15 %. Jusqu’à présent, 843 esturgeons ont été munis d’une étiquette. Le taux de recapture était faible, ce qui semble indiquer un faible taux d’exploitation de l’espèce, particulièrement par la pêche commerciale. L’esturgeon jaune semble avoir un avenir prometteur dans la rivière des Outaouais. Toutefois, les auteurs de l’étude estiment que plusieurs travaux de recherche devront être réalisés afin de favoriser la survie et le rétablissement de l’espèce.

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1.0 Introduction

Lake sturgeon (*Acipenser fulvescens*) are considered to be a prehistoric species that have ancestral links back to the Lower Jurassic period dating 200 million years (Bemis et al. 1997). Life history traits (longevity, low reproductive potential, slow growth but the ability to attain relatively large size) that evolved may have contributed to their persistence, as a species, but have also played a role in their recent decline. These life history traits, especially the large sizes they can attain, seem to capture peoples' attention when one is incidentally caught, often capturing a headline in local media (Szabo 2004).

Worldwide, there are 27 species of sturgeon including two species of paddlefish in four genera forming the order Acipenseriformes (Billard and Lecointre 2001). The plight of lake sturgeon follows a similar path to each and every species. Lake sturgeon are one of ten sturgeon species found in North America, one of five found in Canada. They are a potamodromous species (migrate strictly within freshwater) that are indigenous to North America (Harkness and Dymond 1961; Scott and Crossman 1973).

Lake sturgeon are native to the Ottawa River. Although one time considered abundant (Small 1883; Dymond 1939), lake sturgeon numbers and size have declined in the river due to multiple stressors (Toner 1943). In this report, I summarize 11 years of work on lake sturgeon in nine Ottawa River reaches (Figure 1). This report provides a

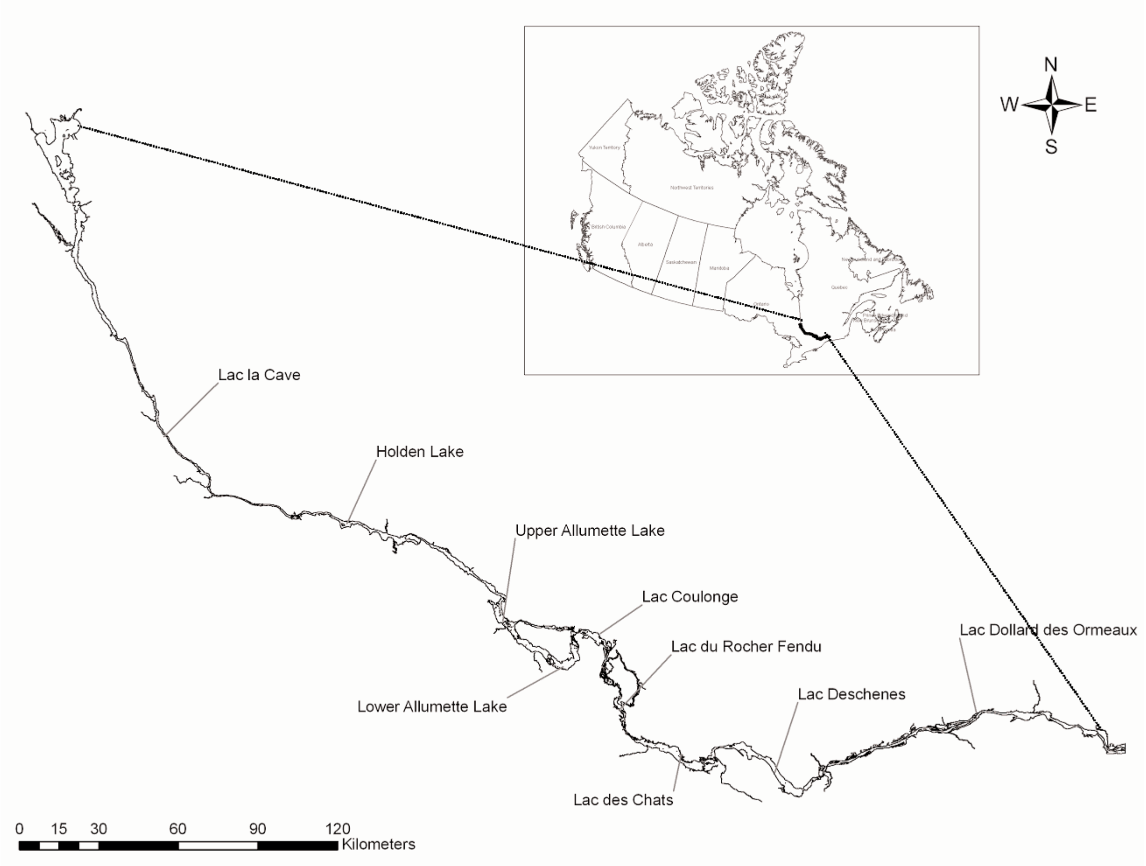


Figure 1. Location of Ottawa River reaches included in this study.

synopsis of what is currently known about lake sturgeon in the Ottawa River including biology, phenology, stressors and status; identifies several gaps in our knowledge; speculates on the future of lake sturgeon in the river; and identifies research needs.

2.0 Zoogeography

Lake sturgeon colonized the Ottawa River through the Fossmill outlet and later the North Bay outlet from the Mississipian refugia during the retreat of the Wisconsin glacier 10 000 years ago (Mandrak and Crossman 1992). The existence of the marine Champlain Sea up to 7 000 years ago precluded colonization from the St. Lawrence River (i.e., Atlantic refugia; Mandrak and Crossman 1992). Morphological differences, primarily in head measurements, suggests distinctness between Lac des Deux Montagnes (Ottawa River) and St. Lawrence River stocks (Guénette et al. 1992) however, the two populations were not significantly different genetically despite the fact that a genotype was found in Ottawa River sturgeon that was not detected in St. Lawrence River sturgeon (Guénette et al. 1993). Fortin et al. (1993) also suggests that Ottawa River lake sturgeon should be considered distinct from the St. Lawrence population based on extensive tagging studies.

3.0 Historical demand

Sturgeon were important to Native Americans as food (meat, oil and roe) and later for trade with Europeans (e.g. isinglass [a gelatinous substance found in their swim bladder used in preserves and to clear beer]; Holzkamm and Waisberg 2004). Importance of lake sturgeon varied among tribes (Harkness and Dymond 1961). Western populations (e.g. Rainy River; Holzkamm and Waisberg 2004) seemed very important, whereas there is little information on the importance of Ottawa River lake sturgeon to First Nations. Lake sturgeon was one of many fish species that the Algonquins caught (Gaffield 1997). Specimens, representing 1.9 percent (%) of all fish samples found (Clermont et al. 2003), were present in archaeological digs on Morrison and Allumette Islands (near Pembroke). The remains of 70 lake sturgeon found on Morrison Island and 105 specimens on Allumette Island indicate that they were food items for these tribes.

At one time, lake sturgeon were considered to be a nuisance species by commercial fishers (Harkness and Dymond 1961). They were plentiful and became caught up in fishermen's nets often causing extensive damage. As a result, they were persecuted and purportedly stacked like cord wood to fuel steamship boilers (Harkness and Dymond 1961) or simply burned. The value of lake sturgeon and other North American sturgeon was identified around 1860 as a smoked meat, for its caviar and isinglass. The Great Lakes populations were the first to be targeted. Their shear abundance enabled smokehouses to become operational throughout the basin. A commercial lake sturgeon fishery was first established on the Ottawa River and tributaries in 1881. Harvests peaked at 28 780 (kilogram) kg in 1898 from the Ottawa River alone (Dymond 1939) but declined precipitously shortly after, never again to reach historical levels (Figure 2). This followed a similar trend to other lake sturgeon populations across North America and exemplifies the fact that sturgeon cannot compensate for unregulated harvest, especially of the adult population.

4.0 Status

Lake sturgeon numbers have declined precipitously across their range to the level where the species is considered at risk in many states and provinces (Williams et al. 1989; Carlson 1995; Kempinger 1996; Ferguson and Duckworth 1997; Baker and Borgeson 1999; Williamson 2003). The initial review on the status of lake sturgeon in Canada suggested that they were not at risk (Houston 1987). Recently, the Committee on the Status of Endangered Wildlife in Canada divided the country into designated units (DU) for lake sturgeon. The status of lake sturgeon populations in DU 8, which includes the Ottawa River along with the Great Lakes, southern Ontario and St. Lawrence River, is currently recommended as threatened.

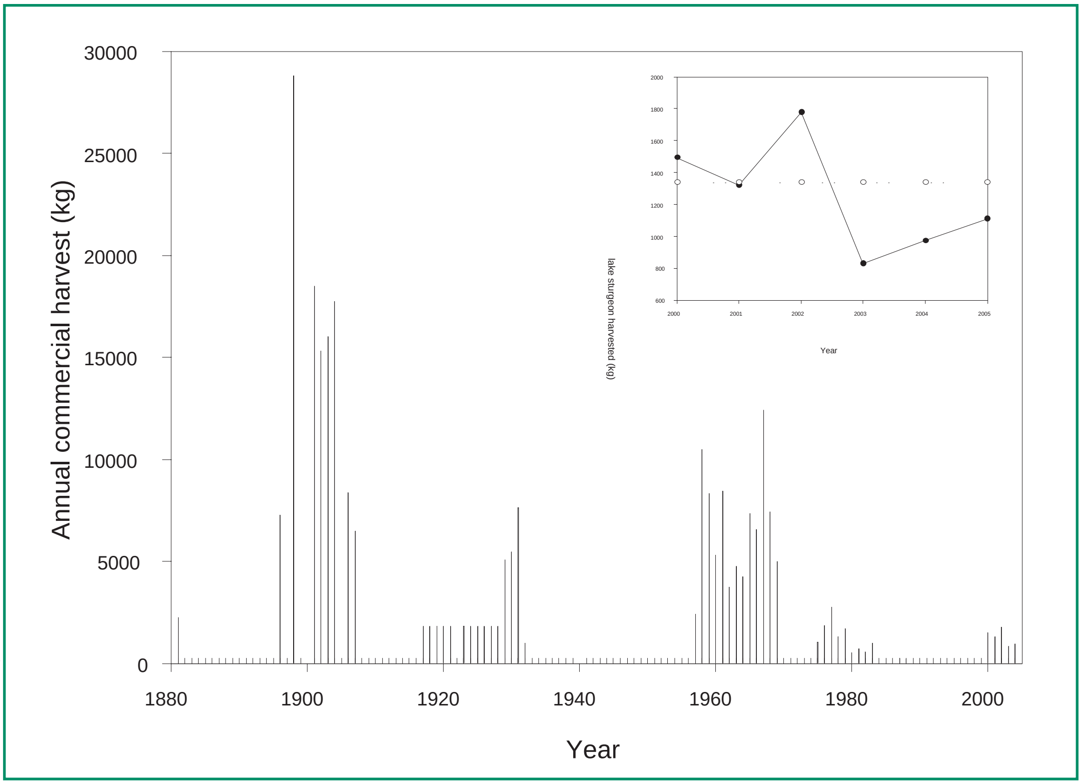


Figure 2. Reported annual commercial harvest (kg) of lake sturgeon from the Ottawa River, ON from 1880-2005. Zero catches represents missing data except for 1956, 1971-1974, 1984-1986 and 1989. For the years 1956-1975, commercial harvests are for both the Ottawa River and southern Ontario inland lakes. During the periods (1964-1974) where harvest data exists for both the Ottawa River and southern Ontario inland lakes, the Ottawa River harvest represented on average, 33.5% (+/- 49% Standard Deviation [SD]) of the total harvest. Inset: current commercial harvest of lakes sturgeon from 2000 to 2005—dashed line represents annual quota.

5.0 Biology of Ottawa River Lake Sturgeon

Lake sturgeon have been captured from the various Ottawa River reaches during a variety of assessment projects. Recent efforts to employ standardized index netting techniques, using both trapnets and gillnets, have enabled us to examine variation in abundance and size distributions for populations among river reaches. Lake sturgeon have also been sampled through concentrated efforts on spawning shoals (e.g., Haxton 2006a), during gear testing and calibration of the River Index Netting (Jones and Yunker 2007)), during electrofishing and from commercial harvest returns. Basic metrics obtained from individuals included total length (to the nearest millimetre [mm]), fork length, and weight (to the nearest 100 grams [g]). A one centimetre (cm) section of the leading pectoral ray extracted for aging (Wilson 1987) along with a small tissue sample from the pectoral fin for genetic analysis from each lake sturgeon. A numbered Monel tag was applied to the dorsal fin of each lake sturgeon sampled after 2000.

Pectoral rays were dried for at least 30 days and then 60 micrometre (µm) sections were extracted using a Buehler low speed isomet saw (Wilson 1987). Pectoral ray sections were examined under a 25X power microscope and the annuli counted. Translucent bands are deposited during summer growth and opaque bands during winter growth (Noakes et al. 1999). A drop of mineral oil was used to illuminate the zones. Ages were estimated from undamaged pectoral rays. Sex and stage of maturity were assessed (Bruch et al. 2001) for all lake sturgeon that: were collected for contaminant analysis, died from stress during netting, were turned in by anglers, or confiscated by Conservation Officers. In addition, lake sturgeon sampled on spawning shoals were examined to determine sex. Sex and stage of maturity was also assessed on select specimens by gonad inspection through abdominal incision (Bruch et al. 2001). Fecundity was determined from mature, ripe females that were sampled during contaminant analysis. A total gonad weight was first obtained and then three small samples of eggs were extracted from each individual, weighed and eggs counted. Eggs per kg of female body was estimated from these counts.

5.1 Abundance

Relative abundance was assessed by standard index netting techniques in each of the river reaches. Two techniques (Nearshore Community Index Netting (NSCIN) and Fall Walleye Index Netting (FWIN)) were employed between 1997 and 2004.

NSCIN used randomly set trapnets from early August through early October (water temperature > 13° Celsius (C); Stirling 1999). Unbaited, 1.8 metre (m) trapnets with 36.5 m leads and 2.4 m trapnets with 61.0 m leads (3.8 cm mesh) were used. Water depths were restricted to 1.7–3.5 m for the 1.8 m trapnets and 2.3–4.7 m for the 2.4 m trapnets. The shoreline of each reach was partitioned into 2000 m sections, numbered and then randomly selected. Trapnets were set at random locations which were perpendicular to the shore at least 500 m apart for a 24 hr period. At the end of the sampling period, each net was lifted, all fish were identified, enumerated, measured and weighed; an aging structure obtained for select species and the fish released. Nets were then reset in another random location. Attempts were made to sample each reach with at least 40 net sets. No sampling sites were reused if possible. If this was not possible, a minimum of four days needed to have elapsed from the previous netting before the sampling site was reused (two sites were reused in this study). NSCIN was conducted from 1998–2004.

FWIN involved the use of randomly set monofilament gillnets during the fall when surface water temperatures were between 10°C and 15°C. Gillnets had eight panels of different (25–152 mm stretched) mesh and were set perpendicular to the shore. Nets were randomly set in two depth strata, 2–5 m and 5–15 m, with each depth stratum sampled equally (Morgan 2002). Sample sites were determined by partitioning the reach into 1 km by 1 km numbered quadrats and randomly selecting a quadrat. Nets were fished overnight and picked up early the following day for a maximum duration of 24 hours. Nets were then reset in other random locations. Lake sturgeon mortality was very low using the FWIN protocol. FWINs were conducted from 1998–2003.

In river reaches where sample sizes were small, or recruitment obviously limited (i.e., few juvenile lake sturgeon sampled during standardized index netting), large mesh gillnets were randomly set in attempts to capture remnant, large lake sturgeon. Monofilament gillnets composed of 17.8–30.5 stretched mesh 76 m long, 2 m high, were randomly set during FWIN (Lac des Chats and Lac Deschênes) or NSCIN (Lac la Cave) over night. The objective of this netting was to confirm the presence/absence of lake sturgeon within these reaches, assess the effectiveness of large mesh gillnets as a means to assess mature lake sturgeon, and increase sample sizes. Lake sturgeon were sampled similar to other netting techniques.

Catch curves were constructed for each sampling technique to assess gear selectivity (Van den Avyle 1993). Size classes were partitioned into 5 cm total length (TL) bins and plots constructed of frequency versus size class. Lake sturgeon were considered fully vulnerable to this gear at the calculated mode of this length frequency distribution. Lake sturgeon were found to be fully vulnerable to NSCIN at 85 cm TL, and fully vulnerable to FWIN at 80 cm TL. NSCIN sampled larger lake sturgeon, whereas FWIN was selective for lake sturgeon less than 115 cm TL but sampled smaller fish (Figure 3). There was also gear selectivity due to depth as significantly smaller lake sturgeon were caught in the deeper depth (5–15 m) strata ($t = 4.07$, d.f. = 125, $P < 0.001$).

Lake sturgeon were sampled in all river reaches in the study through the various sampling techniques, including spawning assessment. Overall, 601 lake sturgeon were sampled using standard index netting techniques; 182 by FWIN (CUE 0.75 ± 0.1 (S.E.)) and 419 by NSCIN (CUE 1.04 ± 0.1 (S.E.)). Lake sturgeon relative abundance was greatest in Upper Allumette Lake, Lower Allumette Lake and Lac Coulonge; relative abundance was lowest in Lac la Cave, Holden Lake and Lac Deschênes (Figures 4 and 5).

Few lake sturgeon (n=9) were sampled with the large mesh nets (Table 1). However, lake sturgeon presence was confirmed in river reaches (i.e., Lac la Cave and Lac Deschênes) where they were not caught using standardized techniques.

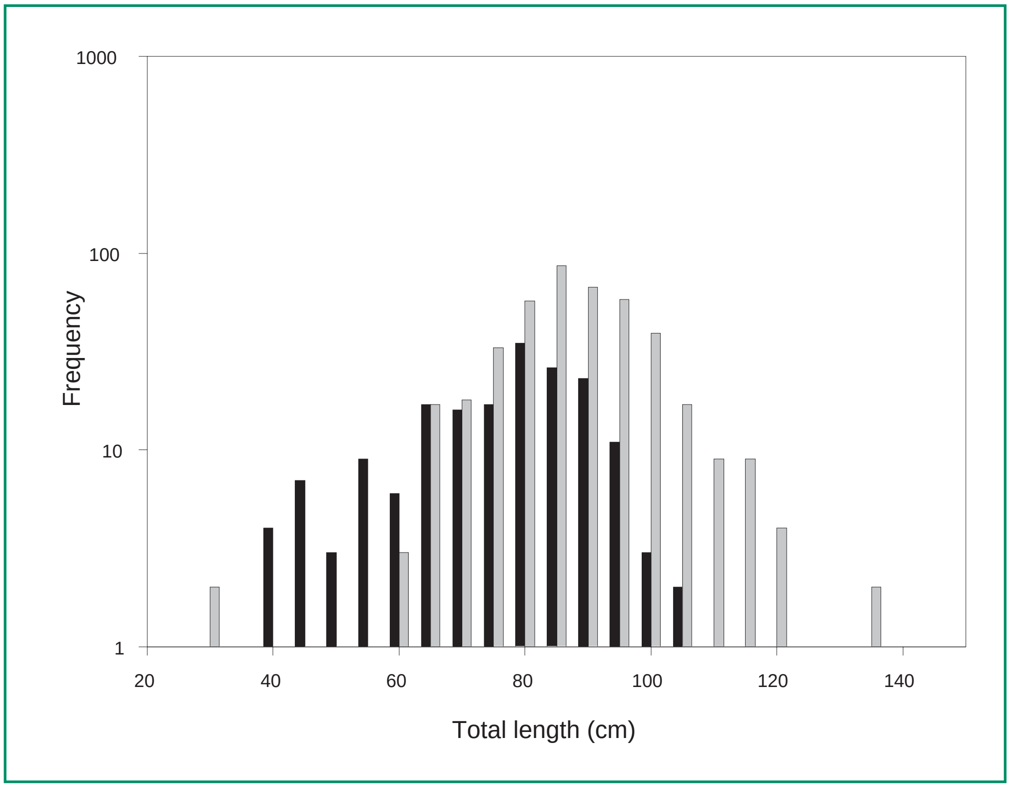


Figure 3. Size class frequency distributions of lake sturgeon sampled in gillnets (black bars) and trapnets (grey bars) during 1997—2005 in the Ottawa River, ON.

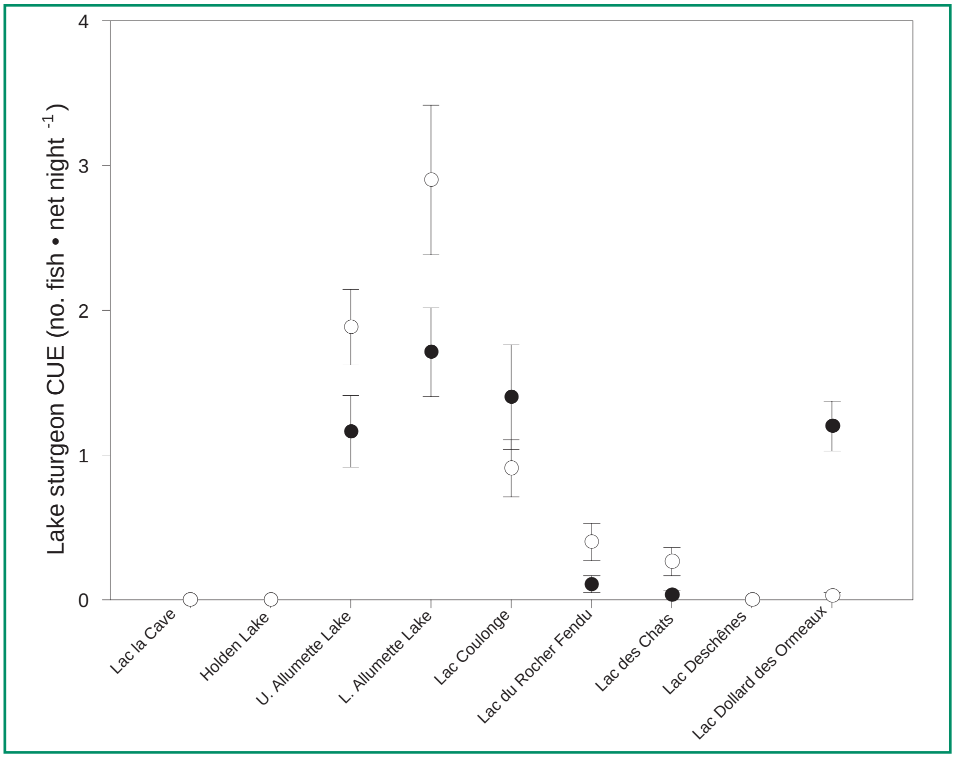


Figure 4. Average lake sturgeon CUE (# sturgeon per net night +/- 1 Standard Error [SE]) in different reaches of the Ottawa River, ON as estimated by FWIN (closed dots) and NSCIN (open dots) from 1998 through 2005.

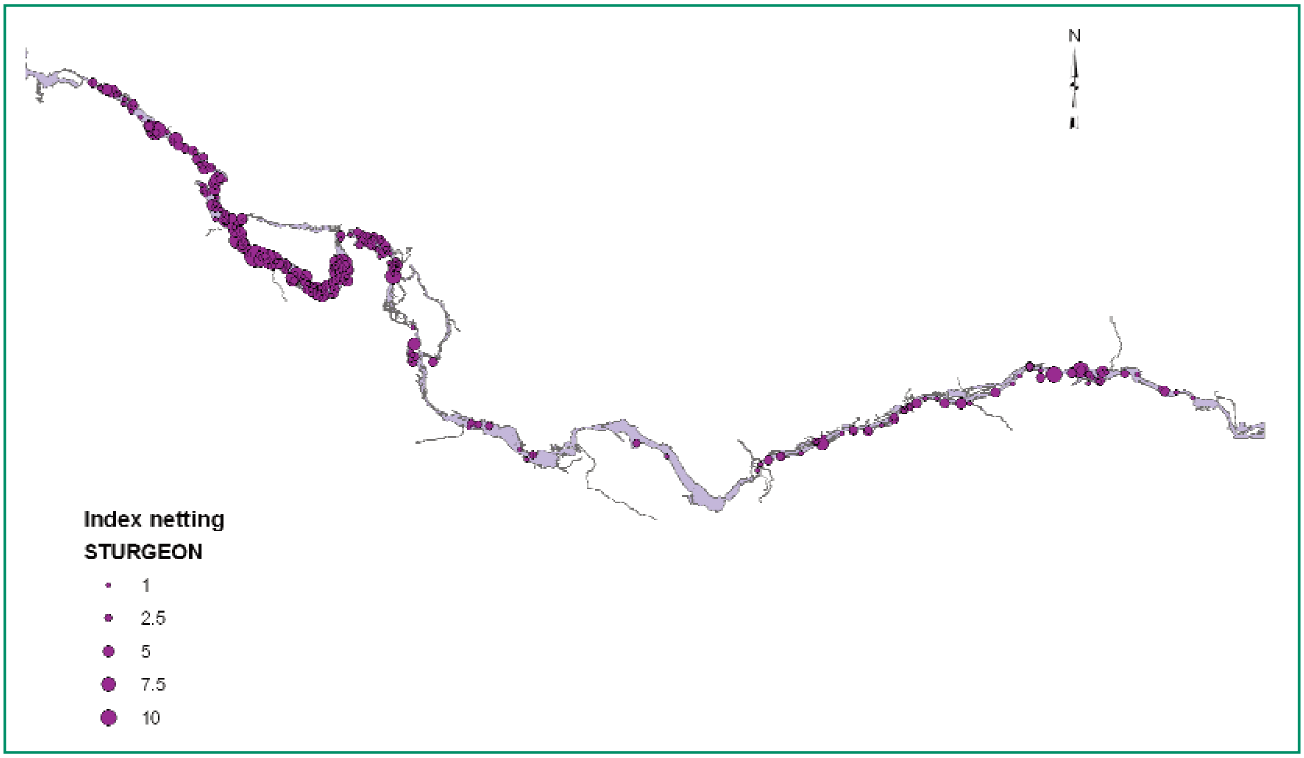


Figure 5. Index netting locations where lake sturgeon were sampled from Carillon dam to Rolphton during 1997—2005 in the Ottawa River, ON. Netting was randomly conducted throughout each reach. Size of the dot represents the number of lake sturgeon sampled. Upper Ottawa River (Holden Lake and Lac La Cave) were not included as lake sturgeon were not sampled during index netting.

Table 1. River reach and year in which additional netting was conducted using large mesh gillnets for lake sturgeon in the Ottawa River, ON. The number and mean size (with standard deviation) of lake sturgeon caught are also given.

Reach	Year	CUE*	n	$\bar{x}$ TL (cm)
Lac la Cave	2004	0.13	2	110.5 ± 27.5
Lower Allumette Lake	2003	0.25	1	90.7
Lac Coulonge	2003	0.75	3	88.0 ± 2.2
Lac des Chats	2003	0		
Lac Deschênes	2003	0.27	3	131.6 ± 27.2

*CUE-# lake sturgeon per net

5.2 Spawning assessment

Lake sturgeon spawning habitat was not well documented in the Ottawa River prior to hydroelectric development. Anecdotally, sturgeon were harvested from an island immediately upstream from Portage du Fort (Lac du Rocher Fendur) where they congregated annually in early summer (Kirby Punt pers. comm.) and therefore potentially spawning. This area has been altered (i.e., flooded) by the instalment of the Chenaux Generating Station (G.S.) in 1948. Lake sturgeon spawned at the rapids at Hawkesbury (Lac Dollard des Ormeaux) but abandoned this area after the construction of the Carillon Dam in 1964 which increased water levels up to 7 m (Easton 1968). Lake sturgeon may have also spawned at Chats Rapids (Lac Deschênes) prior to the development of the Chats G.S. in 1932, although the exact location remains unknown. After the construction of the dam, sturgeon congregated downstream of the generating station (Dubreuil and Cuerrier 1950). Over 400 lake sturgeon were sampled during a spawning assessment study of this area in 1949 (Dubreuil and Cuerrier 1950). Lake sturgeon are believed to spawn at the base of Chaudière Falls (Easton 1968). A sturgeon egg sampled by drift nets in the vicinity of Victoria Island confirmed spawning activity in the area (Henri Fournier pers. comm.).

Spawning is believed to occur at the base of most generating stations. Spawning assessment has been conducted at four sites throughout the Ottawa River from 2001 through 2006: Chats G.S (Lac Deschênes); Allumette Rapids (Lower Allumette Lake); Mattawa (Holden Lake); and Chenaux G.S. (Lac des Chats).

Spawning assessment was conducted at the Chats G.S. over three years (2001, 2003 and 2004). Attempts were made to repeat the study by Dubreuil and Cuerrier (1950) who placed nets parallel to the flow in the tailrace of the generating stations and were able to sample over 400 lake sturgeon of various sizes. Over the three years, 83 lake sturgeon were sampled (Table 2) and a spawning population of 202 (93 – 378; 95% CI) was estimated in 2003 (Haxton 2006a). However, nets had to be set in eddies in order to sample sturgeon as net placements similar to those by Dubreuil and Cuerrier (i.e., parallel to flow) did not sample lake sturgeon. Mean size of lake sturgeon was significantly greater in the current study than in 1949 (Haxton 2006a) while many more juvenile fish were sampled during the 1949 study (Figure 6).

Allumette Rapids (which separates Lower and Upper Allumette Lakes at Highway 148 interprovincial bridge) was assessed in 2001, 2004 and 2007. Although the sampling protocol was identical to the one used below the Chats G.S., many more fish were

Table 2. Location and year in which lake sturgeon spawning assessments were conducted in the Ottawa River, ON. The number and mean total length with standard deviation of sturgeon sampled are also given.

Reach	year	peak spawn	n	$\bar{x}$ TL (cm)
Holden Lake	2003		1	118
	2006	June 8 - 9	28	116.2 ± 10.1
Lower Allumette Lake	2001	June 10	113	86.2 ± 15.9
	2004	June 4 - 10	56	97.5 ± 12.6
	2007	June 7 - 15	32	103.2 ± 14.1
Lac des Chats	2006	June 12	5	121.0 ± 13.3
	2007	June 5 - 15	18	115.2 ± 16.8
Lac Deschênes	2001	June 4 - 8	8	121.2 ± 18.1
	2003	June 4 - 12	58	117.6 ± 12.8
	2004	June 8 - 14	17	118.4 ± 11.2
Lac Dollard des Ormeaux	2004		3	72.5 ± 30.9

sampled at Allumette Rapids (Table 2) and the size distribution was not skewed to the larger, older fish (Figure 7). Several males were sampled in reproductive condition (i.e., expressing milt), suggesting that Allumette Rapids is a spawning area. In general, more lake sturgeon have been caught in Allumette Rapids compared to Beckett's Rapids suggesting that the former is the more "suitable" site. The precise spawning location has not yet been determined. No eggs or larvae were sampled in egg mats and drift nets in 2007 although high river flows may have impeded success.

Potential spawning areas at Mattawa (Holden Lake) were assessed in 2003 (Belfry 2003) and 2006 (Haxton 2006b). Only one lake sturgeon was caught in 2003 (Belfry

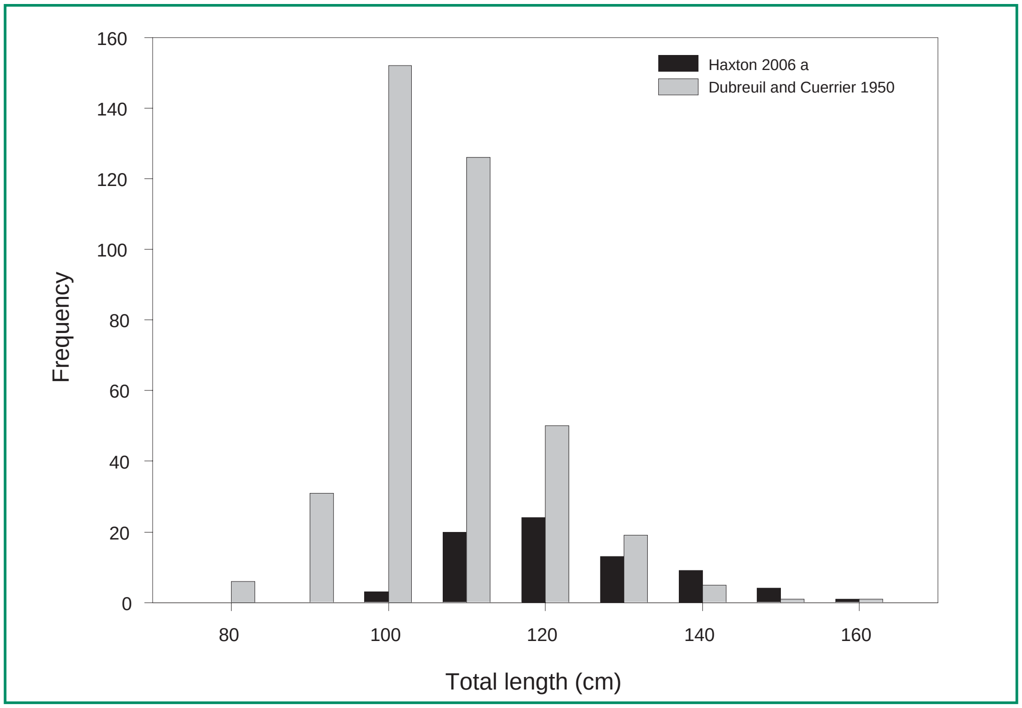


Figure 6. A comparison of size class frequencies of lake sturgeon during spawning surveys by Dubreuil and Cuerrier (1950; gray bars) and Haxton (2006a; black bars) at Chats Generating Station, Ottawa River, ON.

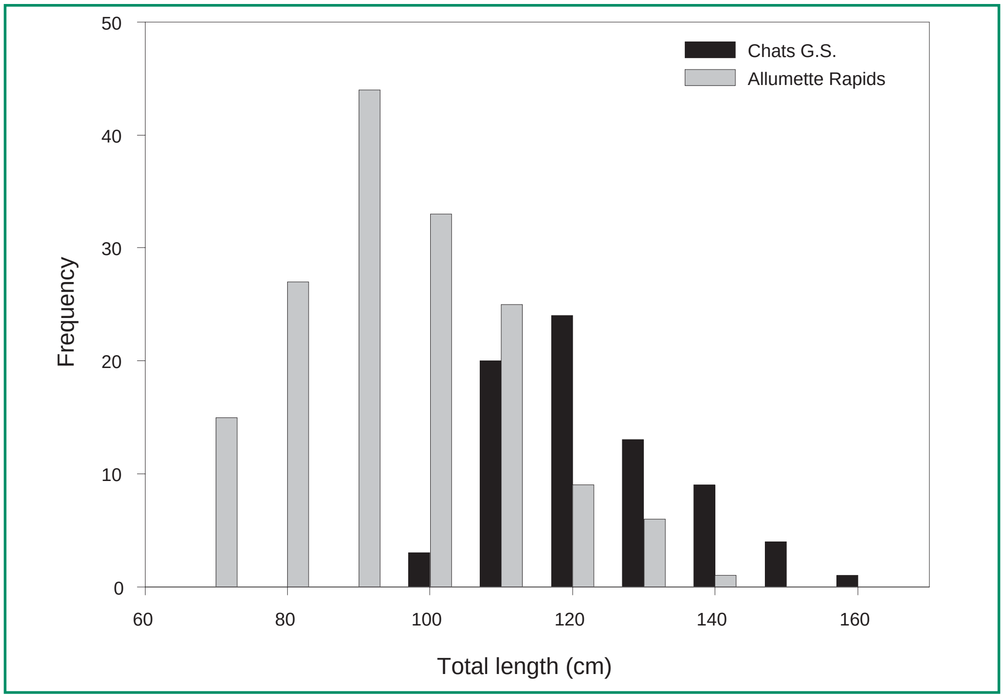


Figure 7. A comparison of size class frequencies of lake sturgeon sampled during spawning assessment at Chats Generating Station and Allumette Rapids, Ottawa River, ON from 2001—2004.

2003). Three traditional spawning areas identified at Mattawa: the island downstream of the train trestle; the base of Herdman's Dam; and downstream of Otto Holden Dam (Belfry 2003). Despite extensive netting effort in 2006, lake sturgeon were only caught downstream of Otto Holden Dam (Haxton 2006b) where 28 lake sturgeon were sampled (Table 2).

The Chenaux G.S. is one of the best locations for determining the timing of spawning in the Ottawa River since lake sturgeon can be observed off the tail race deck congregating along the west shore at the base of the dam. Visual observations have been conducted for several years (Table 3). Sturgeon are generally congregate in this area from early to mid-June (water temperatures 16-18°C; Table 3). The exception was in 2002 when high flows didn't recede until late June and sturgeon were observed on the shoals as late as early July (Table 3). Several attempts have been made to verify spawning activity including underwater surveillance in 2003 using an Aqua Vu camera. We noted congregations of lake sturgeon but no spawning behaviour as detailed by Bruch and Binkowski (2002) was observed. Examination of a dewatered shoal in the potential spawning area in 2004 did not reveal any lake sturgeon eggs. The placement

Table 3. Time of peak spawning for lake sturgeon and water temperatures, based on visual observations, at Chenaux Generation Station, Ottawa River, ON.

Year	Peak spawn	Water temperature
2002	July 5 - 9	20°C
2003	June 17	17°C
2004	June 10	
2006	June 5 - 12	16-18°C
2007	June 4 - 22	16-18°C

of egg mats and preliminary netting in 2006 failed to collect any eggs or pinpoint spawning locations (Table 2). Eighteen lake sturgeon in varying degrees of reproductive status were sampled during spawning assessment in 2007. High flows precluded the use of egg mats and hampered drift nets. However, three larval lake sturgeon were sampled downstream of Chenaux GS suggesting that spawning is occurring at the base of the dam. A study is proposed for 2008 to determined whether larval lake sturgeon are drifting from upstream sections.

5.3 Size

Differences in the size of lake sturgeon among river reaches were assessed using standard index netting and spawning data. The two methods of sampling were kept separate during analysis due to biases in size distribution (i.e., larger lake sturgeon would be expected to be sampled on spawning shoals). An analysis-of-variance was conducted on $\log_{10}$ transformed length data to assess difference among river reaches using both standard index netting techniques (NSCIN and FWIN). Tukey's pairwise comparison was used to determine which reaches differed where significance was determined at $P = 0.05$. Analysis of spawning data was restricted to Chats G.S., Allumette Rapids and Mattawa populations due to sample sizes (Table 2). Length frequency charts for both index netting and spawning assessment were constructed to assess size distribution among river reaches (Figures 8 and 9).

Total length frequency distributions of sampled sturgeon varied among river reaches with some demonstrating a Gaussian distribution and others skewed to larger fish (Figure 8). Mean total length varied significantly among river reaches (Figure 10; ANOVA $F_{5,741} = 43.5$ $P<0.001$). The mean total length of lake sturgeon in Lac des Chats was significantly greater than all other river reaches, whereas lake sturgeon in Lac Coulonge were significantly smaller than all the other river reaches (Table 4).

The mean size of spawning populations differed significantly (ANOVA: $F_{2,276} = 78.0$ $P<0.001$). Mean size of the Allumette Rapids spawning population was significantly smaller than Mattawa and Chats G.S. spawning lake sturgeon (Figure 11; $P<0.001$).

5.4 Growth

Von Bertalanffy's growth curves (Ricker 1975) were constructed for lake sturgeon with parameters determined by a least squares nonlinear regression using Solver in Microsoft Excel (Microsoft Corporation, Redmond, CA). Constraints were placed on parameters (e.g. where $100 \text{ cm} < L_\infty < 150 \text{ cm}$; $0.001 < k < 1.0$; $-3 < t_0 < 0$) to ensure convergence. Bootstrapped confidence intervals (CI) on estimated growth parameters were obtained by sampling n individuals (where n is the actual sample size) with replacement, estimating growth parameters, and estimating the CIs based on the parameter distribution over the 1000 trials. Growth parameters were determined for those river reaches with a sample size of aged sturgeon greater than 20, and overall with all aged sturgeon from various river reaches pooled. Generalized linear model (GLM) was used to assess lake sturgeon growth rates among different river reaches. Tukey's pairwise comparison was conducted when a significance difference at $P = 0.05$ was noted.

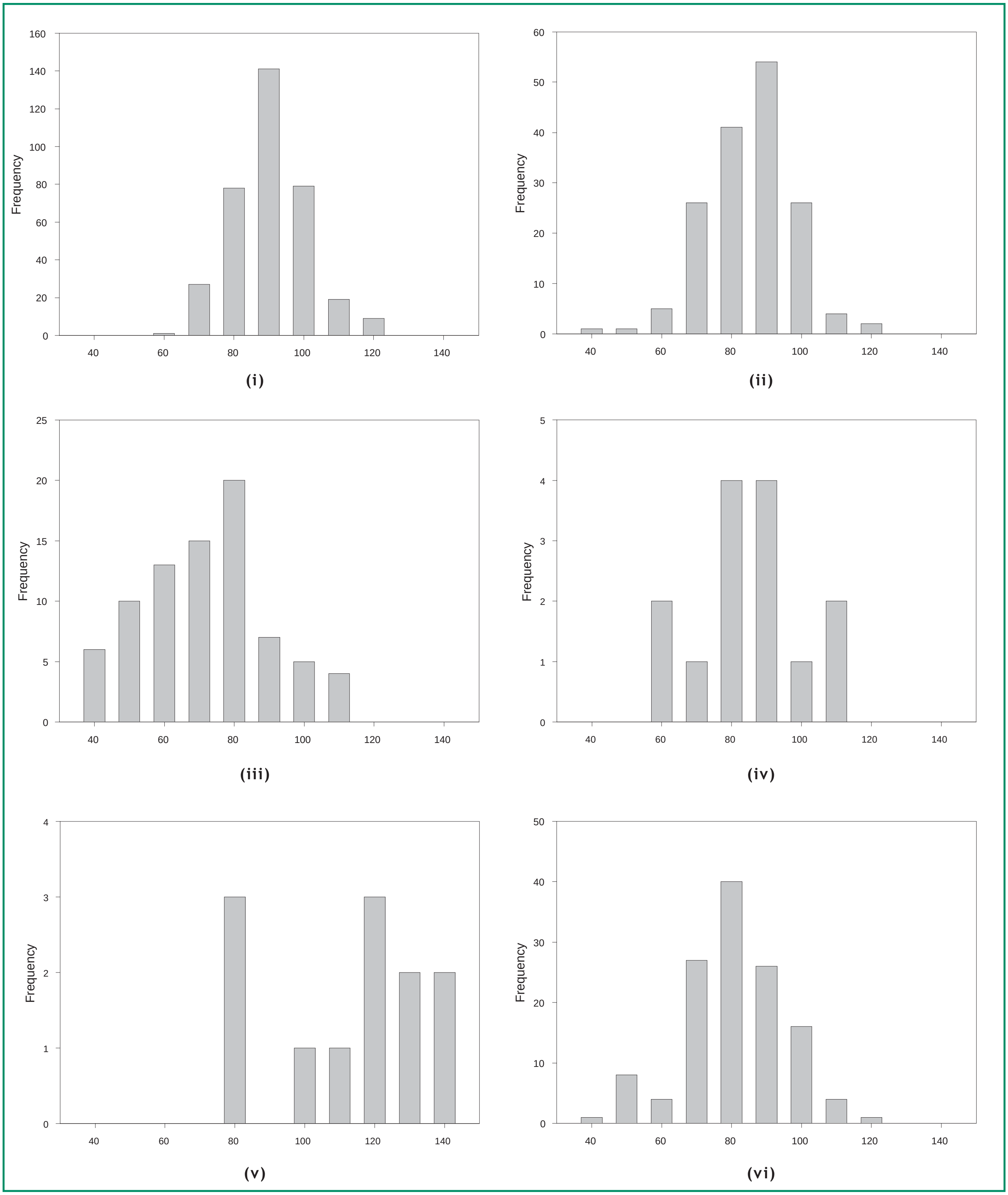


Figure 8. A comparison of length frequency distributions of lake sturgeon sampled by index netting during 1997—2007 in i) Upper Allumette Lake; ii) Lower Allumette Lake; iii) Lac Coulonge; iv) Lac du Rocher Fendu; v) Lac des Chats; and vi) Lac Dollard des Ormeaux, Ottawa River, ON.

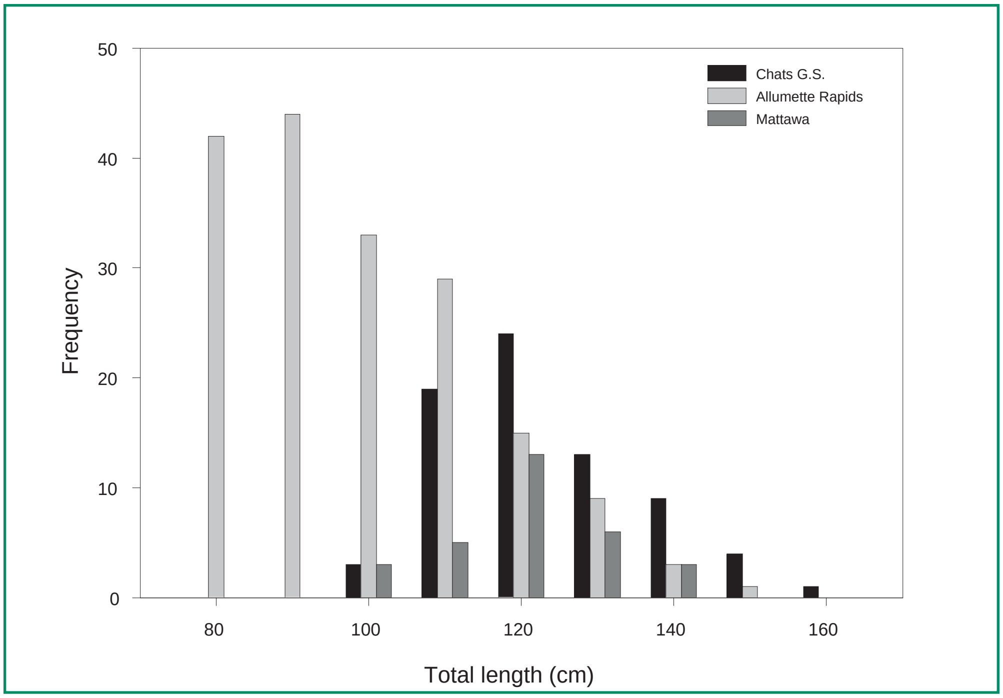


Figure 9. A comparison of size class distributions of lake sturgeon spawning populations sampled using both trap and gill nets during 1997—2007 in the Ottawa River, ON.

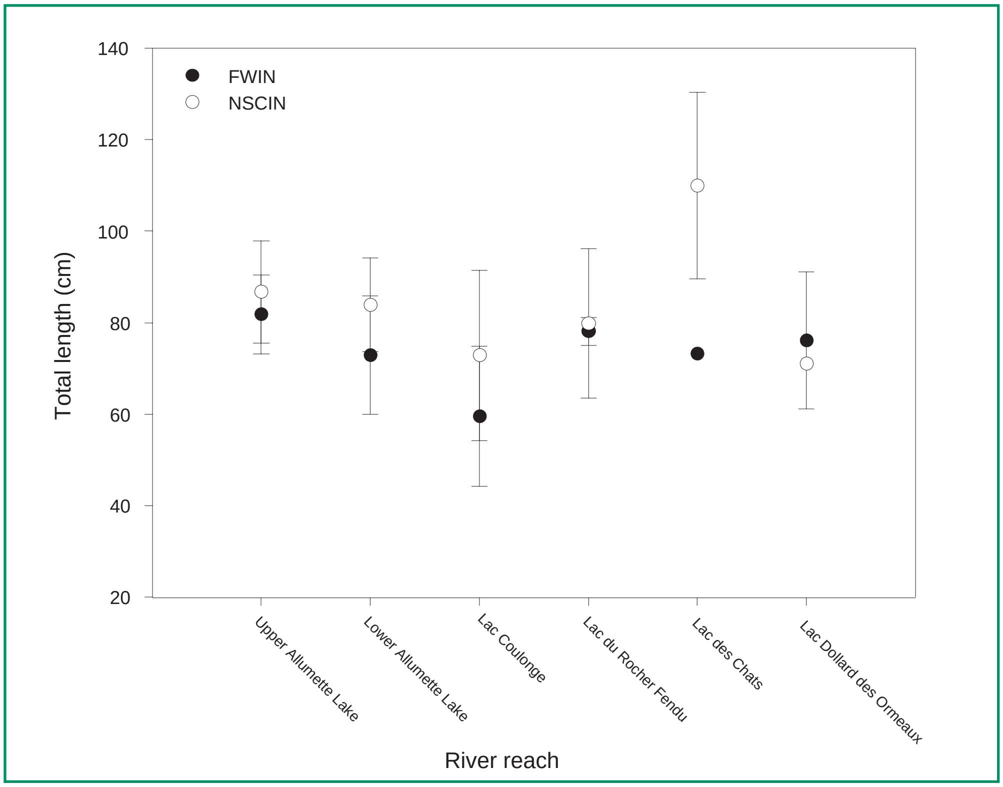


Figure 10. Mean total length (cm ± 1 standard deviation) of lake sturgeon sampled by different index netting techniques among Ottawa River reaches.

Table 4. Significance of lake sturgeon length analyses based on Tukey's pairwise comparison (P<0.001), for samples from various locations, Ottawa River, ON. "+" signifies significantly greater; "-" signifies significantly less; "≡" signifies not significantly different.

	Upper Allumette Lake	Lower Allumentte Lake	Lac Coulonge	Lac du Rocher Fendu	Lac des Chats
Lower Allumette Lake	-				
Lac Coulonge	-	-			
Lac du Rocher Fendu	≡	≡	+*		
Lac des Chats	+*	+	+	+*	
Lac Dollard des Ormeaux	-	-	+	≡	-

* P = 0.001

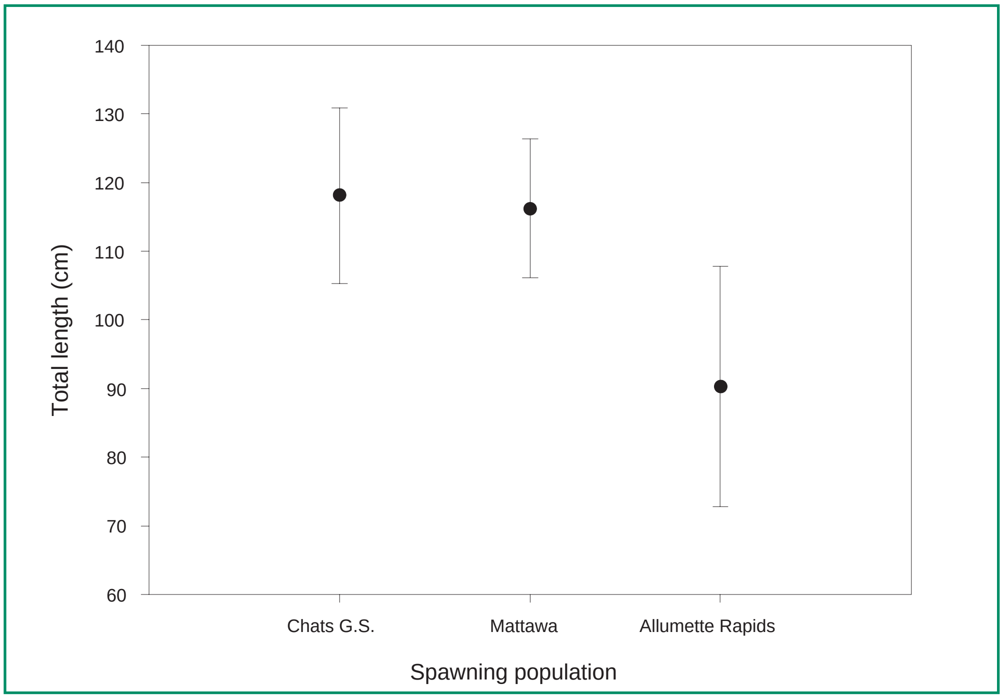


Figure 11. Mean total length (cm ± 1 standard deviation) of lake sturgeon spawning populations sampled using both trap and gill nets during 1997—2007 in the Ottawa River, ON.

Von Bertalanffy's growth parameters were estimated for each river reach except Lac la Cave, Lac du Rocher Fendu and Lac des Chats where sample sizes were too small (Table 5). The equation that best described lake sturgeon growth in the Ottawa River is

$$L_t = 133.7(1 - \exp^{-0.058(t-(-3))})$$

where t is time and L_t is length at time t. Variation (95% CIs) was determined around growth parameters (Figure 12; Table 5). The asymptotic length (L_∞) for Upper Allumette Lake, as determined by nonlinear regression, was unrealistically small (Table 5) and therefore should be interpreted with caution. The true L_∞ for Upper Allumette Lake should approximate Lower Allumette Lake (i.e., 130.2 cm). Growth varied significantly among river reaches (GLM $F_{5,562} = 11.10$ $P<0.001$). Lake sturgeon growth was slowest in Lac Coulonge and Lower Allumette Lake and greatest in Holden Lake and Lac Deschênes (Table 6; Figure 13).

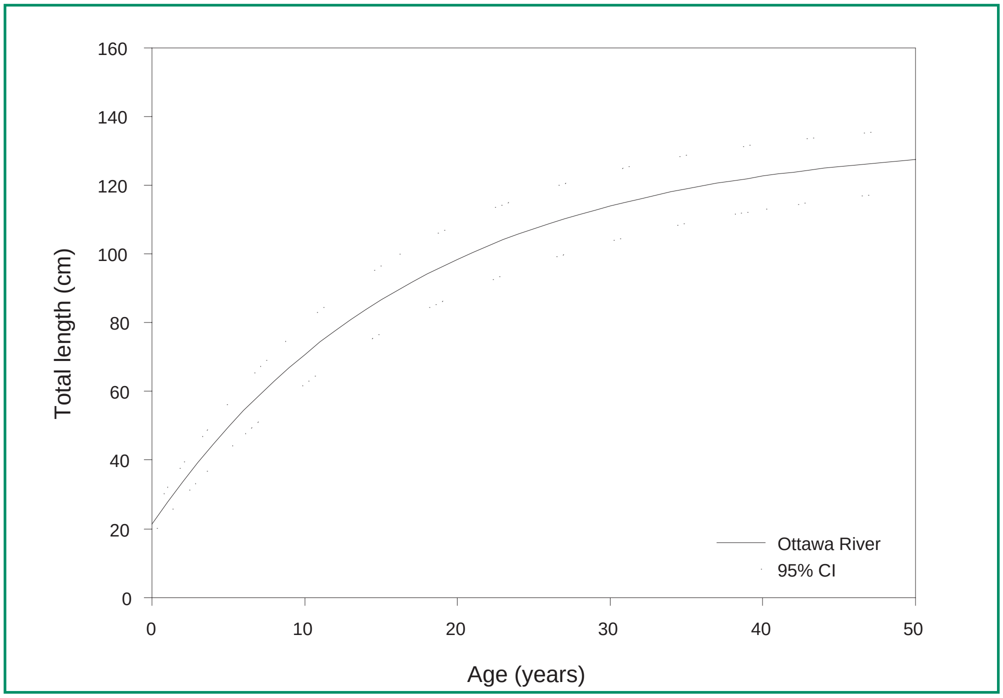


Figure 12. Von Bertalanffy growth curve with 95% confidence intervals for lake sturgeon caught in the Ottawa River, ON using various sampling methods, 1997—2007.

Table 5. Estimated von Bertalanffy's growth parameters with 95% confidence interval (parentheses) for lake sturgeon caught during assessment netting, 1997—2007, in different reaches of the Ottawa River, ON. n equals sample size, L_α represents asymptotic length, k represents intrinsic growth rate and t_0 represents the time at which the length is 0.

River reach	*n*	L_a	k	t_0
All reaches	585	133.7 (126.4/141.1)	0.058 (0.052/0.064)	-3
Lac la Cave	1			
Holden Lake	25	131.3 (123.5/144.2)	0.084 (0.061/0.117)	-2.68 (-3/0)
Upper Allumette Lake	263	104.2 (100/115.4)	0.101 (0.076/0.119)	-3
Lower Allumette Lake	124	130.2 (115.2/148.2)	0.054 (0.043/0.068)	-3
Lac Coulonge	52	126.4 (105.1/150)	0.056 (0.043/0.076)	-3
Lac du Rocher Fendu	4			
Lac des Chats	6			
Lac Deschênes	56	135.8 (125.9/146.7)	0.088 (0.067/0.124)	-2.21 (-3/0)
Lac Dollard des Ormeaux	54	119.6 (100.1/143.8)	0.085 (0.053/ 0.128)	-1.65 (-3/0)

Table 6. Significance of lake sturgeon growth analyses based on Tukey's pairwise comparison (P<0.001) for lake sturgeon caught during assessment netting, 1997—2007, in different reaches of the Ottawa River, ON. "+" signifies significantly greater; "-" signifies significantly less; "≡" signifies not significantly different.

	Holden Lake	Upper Allumette Lake	Lower Allumentte Lake	Lac Coulonge	Lac Deschênes
Upper Allumette Lake	-				
Lower Allumentte Lake	-	-			
Lac Coulonge	-	-	≡		
Lac Deschênes	≡	+	+	+	
Lac Dollard des Ormeaux	-*	≡	+	+	-

* P = 0.018

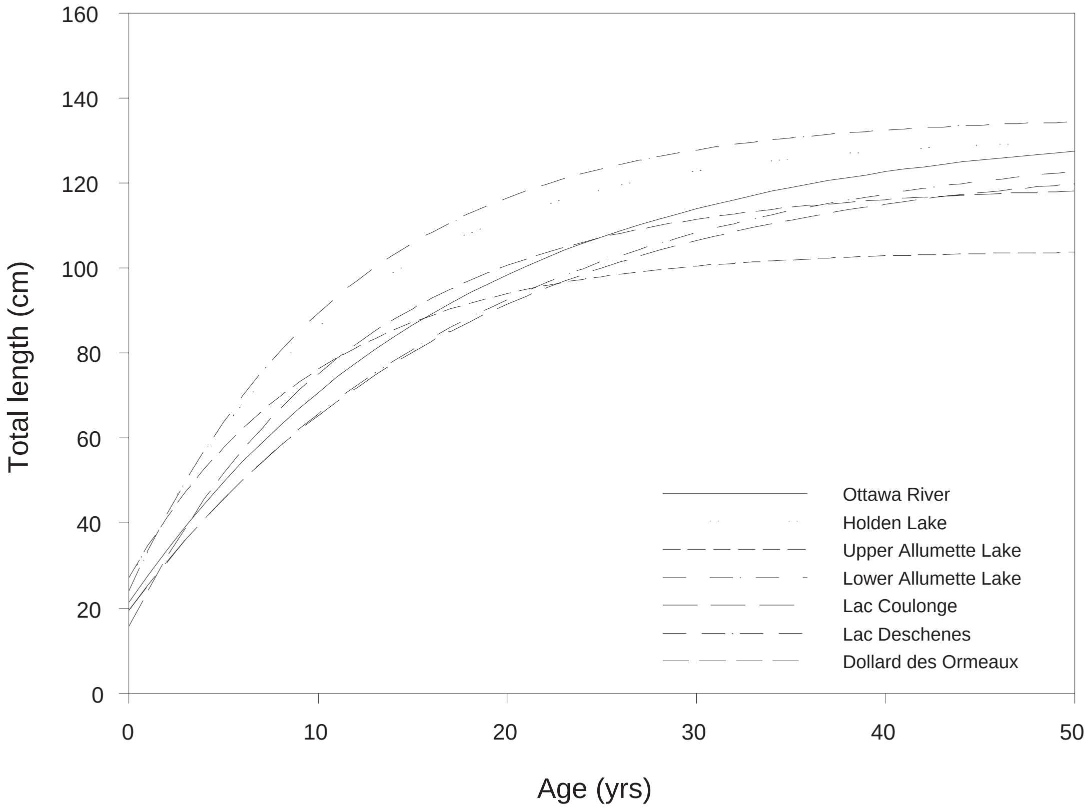


Figure 13. Von Bertalanffy growth curves for lake sturgeon caught using various sampling methods from different reaches of the Ottawa River, ON, 1997—2007.

5.5 Condition

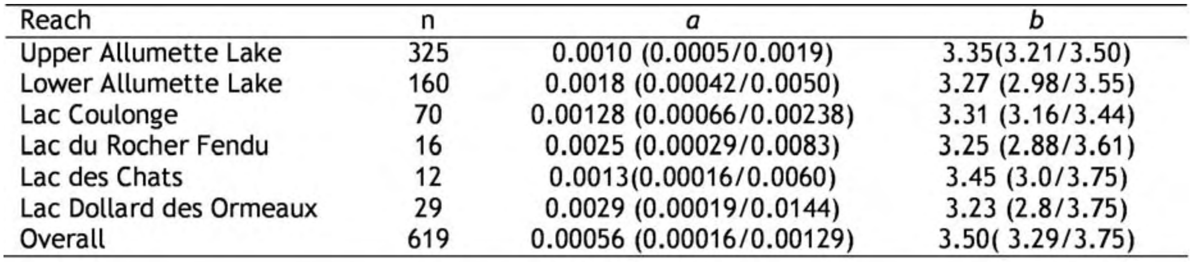
Condition parameters (*a* and *b*) were determined by a least squares nonlinear regression using Solver in Microsoft Excel where $2.25 \leq b \leq 3.75$ and no constraints were placed on a to ensure convergence. Bootstrapped CIs on estimated condition parameters were obtained by sampling with replacement n individuals (where n is the actual sample size), estimating growth parameters, and estimating the CIs based on the parameter distribution over the 250[1] trials. Condition parameters were determined for river reaches with a sample size of lake sturgeon greater than 20 from standard index netting assessment and for the overall Ottawa River with all lake sturgeon from various river reaches pooled. Generalized linear model was used to assess variation in condition among river reaches. Total length and weight were $\log_{10}$ transformed to meet the assumptions of the linear model. Tukey's pairwise comparison was conducted when a significance difference was noted at $P = 0.05$.

The equation that best described lake sturgeon condition in the Ottawa River is

$$w = 5.6x10^{-4} l^{3.50}$$

where w is weight (g) and l is total length (cm). Condition parameters varied for the aforementioned equation and among river reaches (Table 7). There was a significant difference in condition among river reaches (GLM: $F_{5,607} = 16.8$ $P<0.001$). Lake sturgeon condition was significantly lower in Lac Dollard des Ormeaux than Upper Allumette Lake, Lower Allumette Lake and Lac Coulonge ($P<0.001$). No other significant differences were detected.

Table 7. Condition parameters with 95% confidence intervals (in parentheses) for lake sturgeon caught during assessment netting from different reaches of the Ottawa River, ON, 1997-2007.



Reach	n	*a*	*b*
Upper Allumette Lake	325	0.0010 (0.0005/0.0019)	3.35(3.21/3.50)
Lower Allumette Lake	160	0.0018 (0.00042/0.0050)	3.27 (2.98/3.55)
Lac Coulonge	70	0.00128 (0.00066/0.00238)	3.31 (3.16/3.44)
Lac du Rocher Fendu	16	0.0025 (0.00029/0.0083)	3.25 (2.88/3.61)
Lac des Chats	12	0.0013(0.00016/0.0060)	3.45 (3.0/3.75)
Lac Dollard des Ormeaux	29	0.0029 (0.00019/0.0144)	3.23 (2.8/3.75)
Overall	619	0.00056 (0.00016/0.00129)	3.50(3.29/3.75)

5.6 Maturity

Maturity was assessed for 78 individuals, 40 male and 38 females, which were sampled from various Ottawa River reaches over the past several years (2002–2006). A maximum likelihood estimator was used to assess size and age at 25% maturity (i.e., size and age at which you would expect to find 25% of the lake sturgeon mature), 50% and 75% maturity. Size and age at 50% maturity for males was 106.7 cm total length and 20.4 yrs and for females was 112.2 cm total length and 25.4 yrs (Table 8).

5.7 Fecundity

Fecundity was assessed for three mature females varying in length from 112 cm to 136 cm (7.5 kg–14.9 kg). The number of eggs per female increased with size. Mean fecundity was 12 170 ± 2 010 eggs•kg^{-1}.

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[1] Bootstraps pertaining to condition took excessively long therefore the number of bootstraps was reduced to 250 (still required approximately 2 hours to run each bootstrap).

Table 8. Size and age of lake sturgeon at 25%, 50% and 75% maturity with 95% confidence intervals, caught during assessment netting during 1997-2007, from the Ottawa River, ON.

Sex	% mature	Total length (cm)	Age (yrs)
male	25	103.0 (87.6/107.4)	17.6 (12.8/19.9)
	50	106.7 (98.5/111.7)	20.4 (17.7/23.4)
	75	110.5 (105.8/119.7)	23.2 (20.8/28.7)
female	25	105.3 (93.8/113.9)	21.7 (16.7/26.8)
	50	112.2 (105.1/129.8)	25.4 (21.8/35.8)
	75	119.0 (111.4/150.9)	29.2 (24.9/46.7)

5.8 Tagging

Lake sturgeon were tagged with a numbered, aluminum Monel tag on the dorsal fin. commencing in August 2001. Since then, 843 lake sturgeon were tagged in seven Ottawa River reaches during index netting, spawning assessment or other netting projects (Table 9). Only nine lake sturgeon have been recaptured (Table 9). The longest period between recaptures was three years while the shortest was three months (Table 10). All lake sturgeon were recaptured within the reach where they were tagged and most were recaptured in the general vicinity where they were originally caught. Tag retention may be an issue however, very few lake sturgeon displayed signs of having previously been tagged (e.g., section of pectoral ray removed for aging or tissue sample from pectoral fin). Previous tagging projects on the Ottawa River also experienced low recapture rates (Easton 1968).

Table 9. Number of lake sturgeon tagged and subsequently recaptured by various methods during 2001-2007, from different reaches of the Ottawa River, ON.

Reach	Number of lake sturgeon tagged	Standard index netting recaptures	Spawning assessment recaptures	Commercial harvest recaptures
Holden Lake	30	0	0	
Upper Allumette Lake	411	1		2
Lower Allumette Lake	197	0	2	0
Lac Coulonge	52	0		0
Lac des Chats	24	0	0	0
Lac Deschênes	69	0	3	1

5.9 Mortality

Annual mortality (A) was estimated for Ottawa River lake sturgeon using the Robson and Chapman estimator of survival (Van den Avyle 1993) where $A = 1 - S$ (survival). Only aged lake sturgeon from Upper Allumette Lake, Lower Allumette Lake and Lac Coulonge were used to avoid any potential bias by fish from river reaches under waterpower management (i.e., recruitment is limited (Haxton and Findlay 2008)

Table 10. Summary of dates, locations, size of lake sturgeon at original tagging and recapture, and method of recapture during 2001-2007, Ottawa River, ON.

	Originally tagged			Recaptured		
Tag #	Date	Total length (cm)	Section	Date	Total length (cm)	Method of recapture
110	23/08/2001	115.0	Upper Allumette Lake	22/10/2004	117	commercial
185	11/09/2001	110.0	Upper Allumette Lake	09/10/2003		angling
333	05/06/2003	110.0	Lac Deschênes	08/06/2004	115.0	gillnet
385	10/06/2003	104.0	Lac Deschênes	02/06/2004	108.0	gillnet
399	09/06.2003	131.0	Lac Deschênes	10/06/2004	131.0	gillnet
435	11/08/2004	93.0	Upper Allumette Lake	19/07/2006	94.0	gillnet
526	12/06/2003	107.0	Lac Deschênes	15/09/2003	109.0	commercial
531	08/06/2004	130.0	Lower Allumette Lake	07/06/2007	133.5	gillnet
595	04/06/2004	104.0	Lower Allumette Lake	12/06/2007	110	gillnet

therefore assumption of constant recruitment may be violated). Lake sturgeon were assumed to be fully vulnerable to sampling gear at 80 cm or 12 years old.

Lake sturgeon survival was determined to be 85% for fish aged 12–30 years old and therefore total annual mortality was 15%.

5.10 Contaminants

Forty-eight lake sturgeon from five reaches were collected for contaminant analysis. A 500 g sample of epaxial muscle from each sturgeon was sent to the Ontario Ministry of Environment for contaminant analysis. Samples were tested for: mercury; PCBs; heptachlor; aldrin; mirex; photomirex; hexachlorocyclohane (α-BHC, β-BHC, γ-BHC); α-chlordane; γ-chlordane; toxaphene; hexachlorobenzene; octachlorostyrene; trans-nonachlor; cis-nonachlor; oxychlordane; o,p'-DDT; p,p'-DDD; p,p'-DDT; p,p'-DDE. Generalized linear model with $\log_{10}[Hg]$ as the dependent variable, $\log_{10}$ total length and sex as factors was used to determine if Hg body burden differed among sexes.

Of 21 contaminants assayed, only three had at least one sample above detection limit: total PCB ranged from 20–120 ng•g^{-1}; DDT and metabolites ranged from 2–170 ng•g^{-1}; and total mercury ranged from 0.06–0.68 µg•g^{-1} (Table 11). Mercury was the most commonly detected contaminant. Total mercury concentration increased with total length ($r^2 = 0.17$; d.f. = 47 $P = 0.002$; Figure 14) with no detectable difference between sexes with respect to either the intercept ($F_{1,41} = 0.04$, $P = 0.84$) or the slope ($F_{1,41} = 0.04$, $P = 0.84$) of this relationship.

5.11 Movement

Sturgeon are renowned for their migrations. Lake sturgeon, a potamodromous species, will migrate in excess of 200 km (Kempinger 1988; Rusak and Mosindy 1997;

Table 11. Detection limits (Ministry of Environment 2005) and levels of selected contaminants (ng/g) detected in 48 lake sturgeon caught by various methods during 1997-2007 from the Ottawa River, ON.

Compound	Detection Limit (ng/g)	N (number samples > DL)	Average concentration (SD)	Range
polychlorinated biphenyls (total)	20	36	52.9 (29.7)	20 - 120
Heptachlor	1	0		
Aldrin	1	0		
Mirex	5	0		
Photomirex	4	0		
α-BHC	1	0		
β-BHC	1	0		
γ-BHC	1	0		
α-chlordane	2	0		
γ-chlordane	2	0		
toxaphene	50	0		
hexachlorobenzene	1	0		
octachlorostyrene	1	0		
trans-nonachlor	2	0		
cis-nonachlor	2	0		
oxychlordane	2	0		
o,p'-DDT	5	0		
p,p'-DDD	5	0		
p,p'-DDT	5	0		
p,p'-DDE	1	35	27.8(35.4)	2 - 170
Hg*		48	0.29 (0.15)	0.06 - 0.68

*µg/g

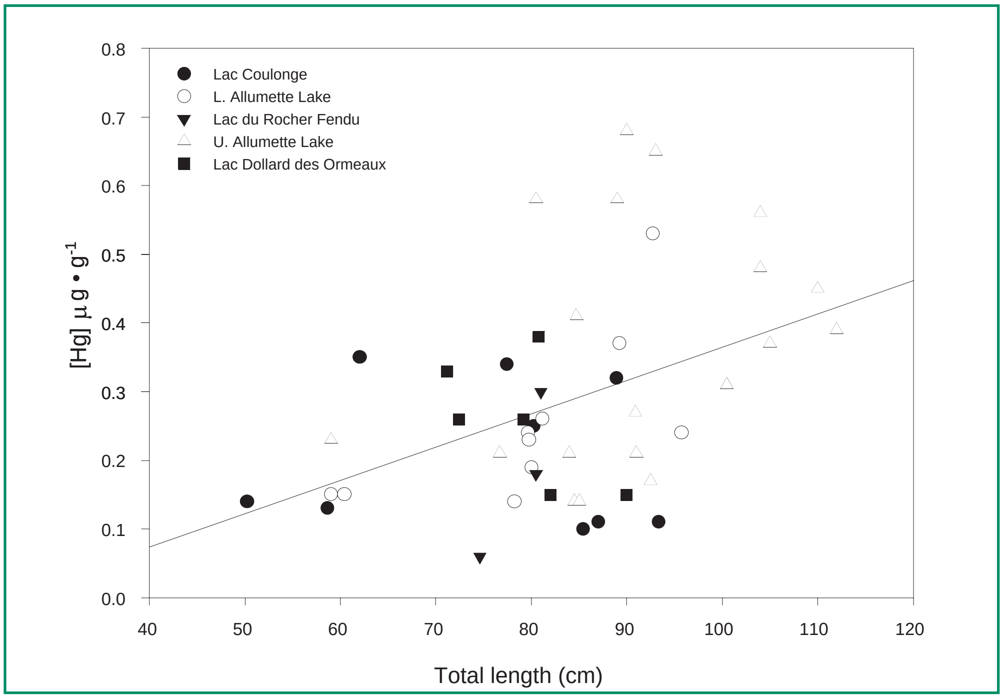

Figure 14. Mercury concentration in relationship to total length of lake sturgeon from various Ottawa River reaches.

Auer 1999) primarily for spawning purposes (Dumont et al. 1987; Auer 1996; McKinley et al. 1998). Outside of spawning migrations, lake sturgeon can be relatively sedentary (Fortin et al. 1993). Telemetry of juvenile lake sturgeon in Upper Allumette Lake did not show extensive movement (i.e., > 10 km) but fish displayed site fidelity (Haxton 2003) which has been previously observed for lake sturgeon (Threader and Brousseau 1986; Fortin et al. 1993; Rusak and Mosindy 1997; Auer 1999; Borkholder et al. 2002; Caswell et al. 2004). Tagging information corroborated telemetry observations since all recaptures were within the same reach, and the same vicinity of where they were initially captured. An extensive tagging project conducted in Lac des Deux Montagnes (Ottawa River reach downstream of Carillon) also found lake sturgeon to be relatively sedentary with very few recaptured in the St. Lawrence River despite the absence of barriers to prevent movement (Fortin et al. 1993). Likewise, only one St. Lawrence tagged lake sturgeon was recaptured in Lac des Deux Montagnes (Fortin et al. 1993).

5.12 Genetics

Despite advances in the genetic field, standardization of genetic markers for lake sturgeon North America wide, and seemingly annual collection of tissue samples, little analysis has been conducted on the Ottawa River lake sturgeon genetics. There is evidence to suggest Ottawa River sturgeon are similar throughout the river, but genetically unique from the St. Lawrence population (Guénette et al. 1993). More emphasis has been placed on assessing lake sturgeon across Canada with the delineation of designated units and the recommended listing, as threatened, for DU8, which includes the Ottawa River. Therefore, further genetic analysis for the Ottawa River population will be forthcoming.

6.0 Current demands

6.1 Sport harvest

Angler harvest has, in recent years, been incidental although there used to be outfitters who targeted lake sturgeon (Figure 15). The occasional angler fishes for lake sturgeon in the river, specifically downstream of Hull/Ottawa but effort directed at this species is largely unknown however believed to be low. Lake sturgeon are targeted by anglers downstream of the dam at the confluence of Muskrat River (Pembroke). It is believed that lake sturgeon spawn at Pansy Patch (first set of rapids upstream in the Muskrat River). Stop logs were installed in early June in 1998 and as a consequence, lake sturgeon congregated at the base of the dam for about a week. Lake sturgeon as large as 16 kg were purportedly harvested during this period. During a two day winter fishing tournament (Shiver on the River) near Pembroke in 1992, 27 lake sturgeon were sampled with a mean total length of 86.6 ± 5.4 cm (S.D.) and a mean weight of 3.1 ± 0.7 kg. All but six lake sturgeon were purportedly released. More recently, the incidence of lake sturgeon caught in winter has increased near Petrie Island (Lac Dollard des Ormeaux). Current regulations allow for a harvest of one lake sturgeon a day from the Ottawa River, from June 15th through October 31st. More stringent regulations are probably pending.

The harvest of a large lake sturgeon from the Ottawa River, and other waterbodies, has traditionally made headlines in a local or national media (Szabo 2004). The largest

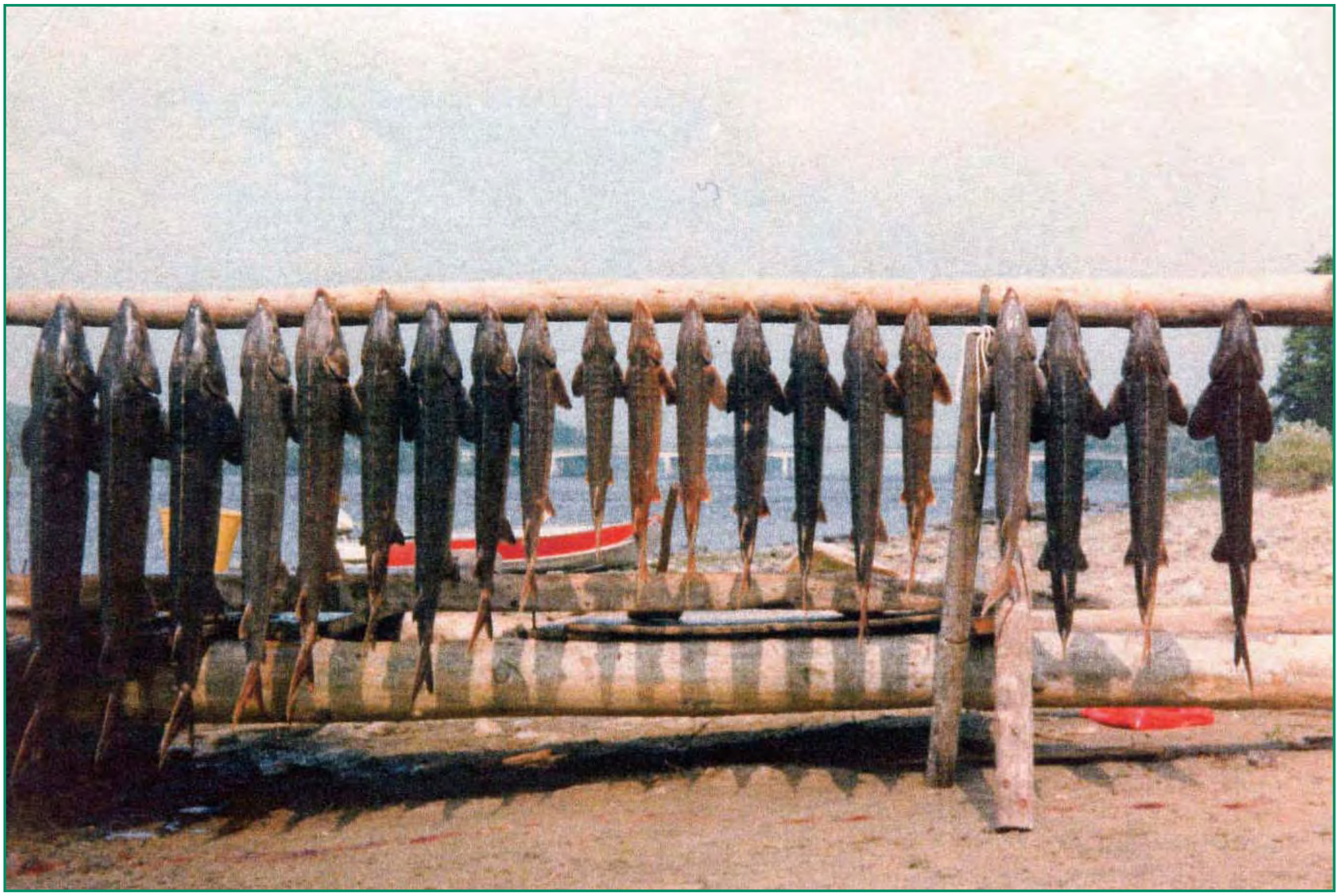

Figure 15. Lake sturgeon harvested by anglers from Lower Allumette Lake, Ottawa River, ON in the early 1970s. The bridge in the background is highway 148 near Allumette Rapids. The top of the hanging rack is approximately 1.5 m. Photo was provided by Phillip McGuire (taken September 4, 1974).

lake sturgeon ever reported from the Ottawa River was caught at Montebello in 1931 and weighted 98.4 kg (Toronto Globe and Mail, March 26, 1931). The most recent large lake sturgeon was caught at the Deschênes Rapids in Lac Deschênes in 1972, measured 1.8 m and weighed 48.5 kg (Ottawa Citizen, July 7, 1972).

6.2 Commercial harvest

A commercial lake sturgeon fishery in the Ottawa River became established in 1881 and peaked at a harvest of 28 780 kg in 1898 (Dymond 1939). Harvest declined in the early 1900s and never attained the levels historically recorded (Figure 2). Another peak occurred in the 1960s at approximately 13 000 kg. Currently, with three commercial licenses for the Ottawa River operating out of Quebec for the portion of the river between Fort William and Quyon, harvests average 1 300 kg•yr^{-1}. Current quotas are set at 0.1 kg•ha^{-1} in Quebec waters with harvests permitted between June 15 to July 15 and September 15 to October 31.

The actual number of lake sturgeon harvested historically was not well documented and therefore it is unknown if the absolute population in the Ottawa River ever recovered. It could be assumed that the harvest in the late 1800s was comprised of predominately large, mature fish that were previously unexploited. Mean size in subsequent years was probably much lower. The mean size of lake sturgeon commercially harvested in the mid 1980s near Pembroke was 110.2 cm; sex ratio of the catch was 1 male: 4.3 females.

Although historical commercial harvests inarguably initiated lake sturgeon decline in the Ottawa River, a review of existing potential stressors suggested that current commercial harvest is no limiting population recovery (Haxton 2007; Haxton and Findlay 2008). However, commercial fisheries exist in several river reaches where recruitment is limited (e.g. Lac Deschênes, Lac des Chats, and Lac du Rocher Fendu). Commercial harvests cannot be considered “sustainable” when recruitment is impaired or populations are depleted.

6.3 Illegal harvest

The extent of illegal harvest of lake sturgeon from the Ottawa River is unknown. There are instances where anglers have been charged and fish confiscated for catching and keeping lake sturgeon out of season. More recently, a gillnet was found in February 2007 that contained seven lake sturgeon—four dead and decomposing and the other three live and subsequently released.

6.4 Current management

Management of lake sturgeon in the Ottawa River is essentially passive. Sport fish regulations limit the possession of lake sturgeon from the river, but the actual annual fishing effort directed at them or harvest levels are unknown. The commercial harvest is controlled by the Quebec Ministry of Agriculture under the auspices of the Quebec Ministry of Natural Resources and Wildlife. While quotas are set (section 6.2), and considered sustainable, the effect on the population is unknown. Although current commercial harvest does not appear to be limiting lake sturgeon populations (Haxton 2007; Haxton and Findlay 2008), the impact and proportion of population harvested annually is unknown.

6.5 Current stressors

There are numerous stressors that can impact lake sturgeon populations (e.g. commercial harvest; water power management; fragmentation; isolation; habitat deterioration and loss; contaminants; pollution; deterioration of water quality; climate change; exotic and invasive species; parasites and diseases). Some of these stressors can be controlled or mitigated, while others (e.g., climate change) will be harder to offset. Historical commercial harvests inarguably had the greatest impact on populations within the Ottawa River. Species with life history traits such as lake sturgeon are unable to compensate for an increase in adult mortality (Vélez-Espino et al. 2006). Coinciding with the uncontrolled harvest was development along the river shore (industrial and residential) and the subsequent deterioration of water quality from the dumping of refuse (i.e., pollution). In addition, log drives on the Ottawa River were instrumental in the movement of timber downstream to markets and mills. The loss of logs and the deposition of bark from logs altered the river bed and most likely water chemistry. Crib dams were constructed in the 1870s along the river to facilitate log drives, forming the first true barriers to upstream movement of lake sturgeon.

Hydroelectric dams were first constructed in the 1880s at Chaudière Falls, Bryson in 1925 and then Chats Falls in 1932. Large scale hydroelectric construction commenced in 1948 and probably had the greatest impact on sturgeon habitat with flooding of natural rapids and shore lands. The last dam to be constructed on the Ottawa River was at Carillon in 1964, which replaced the crib dam constructed in 1870s and flooded a traditional lake sturgeon spawning grounds at Hawkesbury (Easton 1968). Since then, strict quotas on commercial harvest have been instituted (section 6.2) in Quebec, and all commercial lake sturgeon licensees in Ontario were bought out in the late 1980s. Water quality has also improved dramatically since the 1970s with primary, and sometimes secondary or tertiary treatment, occurring on all waste water destined for the Ottawa River. Log drives ceased in the 1990s as roads became a more efficient means of transport.

Water power management has been identified as a limiting factor to recruitment and lake sturgeon population recovery (Haxton 2007; Haxton and Findlay 2008). Although commercial harvest has the potential to limit population recovery, there is no evidence that this is occurring (Haxton 2007). An elevated mercury burden in Ottawa River sturgeon is not considered to be excessive when compared to other North American populations, and has had no noticeable effect on growth or condition (Haxton 2007).

7.0 Future of lake sturgeon in the river

The future of lake sturgeon appears promising in the Ottawa River, however, several inauspicious clouds loom. With the apparent worldwide collapse of sturgeon stocks (Billard and Lecointre 2001; Pikitch et al. 2005), specifically the caviar producing Caspian Sea stock, other sturgeon species have experienced increased pressure. Although attempts to thwart international trade in sturgeon are ongoing (e.g. listing on CITES), the demand may drive up prices that attract black market activity and increase both legal and illegal activity on lake sturgeon.

The Ottawa River has yet to be affected by invasive species (e.g., zebra mussels, quaga mussel, round goby). Future invasions could subsequently affect lake sturgeon populations through shifts in the food web or alterations to habitat (e.g. spawning areas). Impacts of invasive species on lake sturgeon are relatively unknown and difficult to predict. Zebra mussels may affect the feeding efficiency of lake sturgeon (McCabe et al. 2006) but have also been found to form an important component of the diet of sturgeon greater than 70 cm (Jackson et al. 2002). Since round gobies are a preferred species when baited on setlines for sturgeon (Thomas and Haas 1999), they may inadvertently benefit sturgeon when introduced. Lake sturgeon, being benthivores, may be able to offset the negative ecological impacts of exotic introductions or prevent large scale colonization if their populations were of adequate size.

Lake sturgeon are a cool-water species generally preferring temperatures less than 25°C (Cech and Doroshov 2004). There has been a gradual increase in growing degree days in the vicinity of the Ottawa River over the past 100 years (Figure 16), however, mean annual water temperatures at the intake at Lemieux Filtration Plant have not increased (Figure 17). Higher water temperatures may cause acute mortality, increase stress and thereby affect condition, growth and mortality rates of lake sturgeon. They

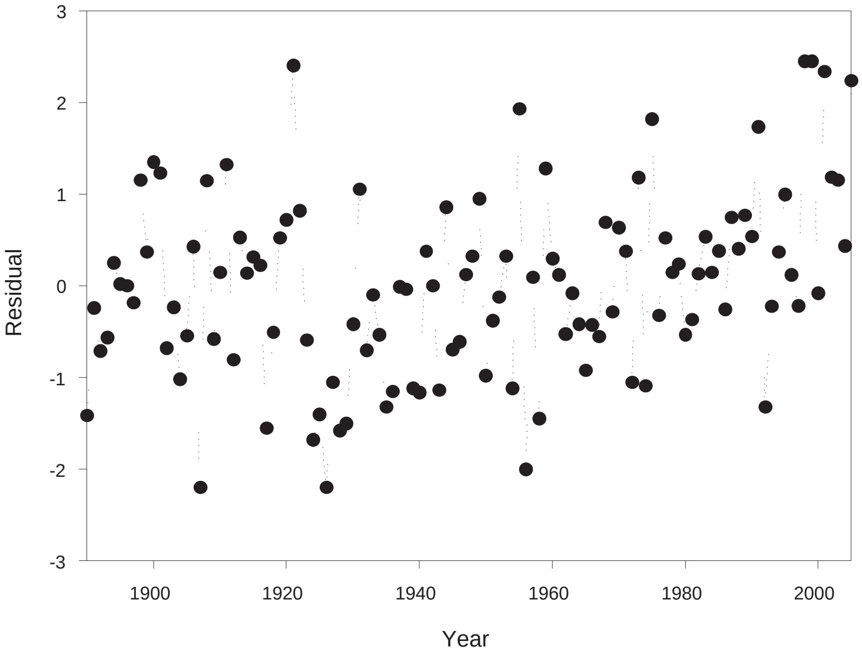

Figure 16. Residual around mean GDD (>5° C; mean GDD = 2 075) in the vicinity of Ottawa River. Note the gradual increase from about 1925 to current day temperatures.

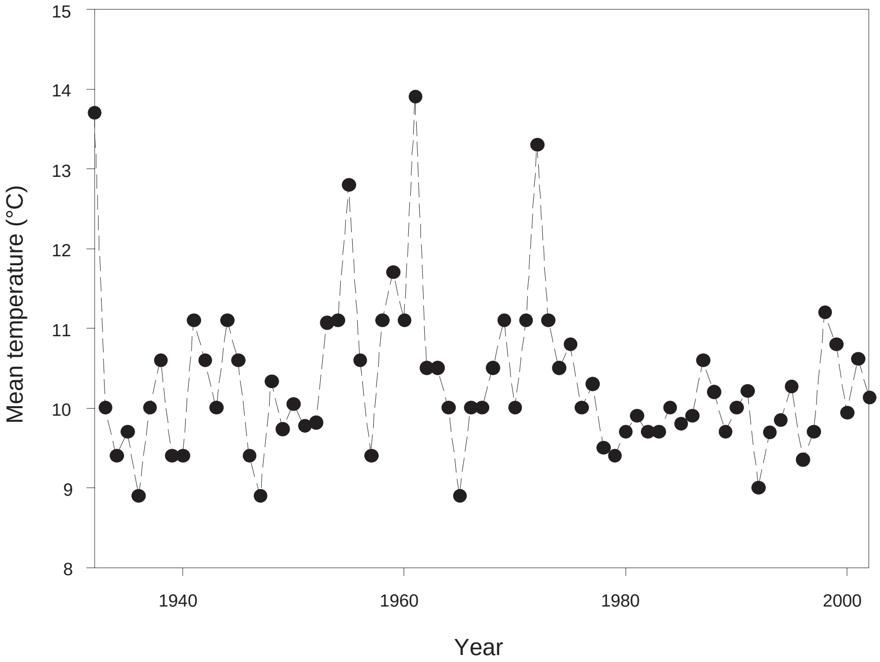

Figure 17. Mean annual water temperatures obtained at the intake of the Lemieux Filtration Plant, Ottawa River, ON. Overall mean water temperature for the period is 10.4°C.

may also affect benthos productivity, specifically of cool water invertebrates and increase the incidence of parasites and diseases of sturgeon.

Ottawa River lake sturgeon are in DU8 and are recommended to be listed as threatened by the committee on the Status of Endangered Wildlife in Canada (final decision pending). As a result, recovery strategies will be required to facilitate rebuilding populations. This could mean that commercial and sport fish harvests may have to be reduced or eliminated. Since lake sturgeon are sensitive to increased adult mortality (Gross et al. 2002; Vélez-Espino et al. 2006), management efforts would be required to ensure that mortality remained low. Currently, survival rates are estimated at 85% in the Ottawa River. When survival is already high (i.e., > 85%), little can be done to improve survival rates and facilitate population recovery (Gross et al. 2002). Instead, elasticity analysis suggests that increased juvenile survival could have the greatest impact on population recovery (Gross et al. 2002). Therefore, management efforts could be directed towards ensuring that adequate spawning conditions (e.g. substrate, flows and temperatures) are available during spawning runs. However, since the Ottawa River is so fragmented by natural and artificial barriers, lake sturgeon may be restricted to reaches that do not provide suitable conditions for all life stages (Beamesderfer 1998). Short reaches, such as Lac des Chats, may actually be sinks for lake sturgeon production in the river, while longer, unimpounded reaches may be sources. Increased recruitment within short, impounded river reaches may not benefit recovery in these areas, if progeny are lost through dispersal downstream (Jager et al. 2002; Jager 2006). The extent of larval drift within and among river reaches, unimpounded and impounded, is a research need when considering recovery strategies.

Contaminant analysis was conducted on lake sturgeon throughout the Ottawa River (section 5.10), however, the contaminants assessed were mainly common pesticides and only somatic tissue was assayed. Since lake sturgeon are long lived, they may bioaccumulate contaminants specifically in internal organs (e.g. liver; Rousseaux et al. 1995; Feist et al. 2005; Webb et al. 2006) and may display disruption of gonadal development in the presence of endocrine disrupting chemicals (Feist et al. 2005) or other contaminants (e.g. methlymercury: Webb et al. 2006).

7.1 Further research required

Despite the extensive work that has been conducted on lake sturgeon, numerous research needs remain for the Ottawa River populations. As evident from assessment work, lake sturgeon populations vary among river reaches (Haxton 2002; Haxton 2007). Waterpower management has been implicated as the primary cause of this variation (Haxton 2007; Haxton and Findlay 2008). The specific cause of this variation is unknown, whether recruitment is impaired in managed reaches because of poor spawning habitat quality and quantity; variations in flow intensity and duration on spawning areas immediately downstream of dams; abrupt changes in water temperatures from hypolimnetic draws and subsequent effects on spawning behaviour, egg and larval survival; duration of larval drift and whether larvae remain within the river reach or drift over the next barrier; and suitability of river reaches as nursery areas for juvenile sturgeon.

Lake sturgeon spawning areas need to be located and mapped, particularly in river reaches where populations are depressed. These areas can then be assessed for substrate, flows, thermal suitability and water level fluctuations during spawning and incubation periods to ensure that they are conducive for successful spawning. These areas should also be identified to enforcement staff for protection during vulnerable periods (i.e., spawning) from illegal harvest.

Changes in community structure, productivity, along with the effects of higher water temperatures and altered flows as a result of climate change may have dramatic effects on lake sturgeon.

There has been some suggestion that contaminants can affect reproductive capacity of lake sturgeon (Feist et al. 2005; Webb et al. 2006). The effects of estradiols and other hormone disrupting chemicals need to be assessed on lake sturgeon in the Ottawa River. More specifically, contaminant analysis should be conducted on fatty tissues and internal organs, especially gonadal tissue.

Despite extensive netting and tagging programs in all river reaches, we currently only have a measure of relative abundance. Low recapture rates preclude population estimates without huge confidence intervals. This may partially be due to the sedentary nature of lake sturgeon and relatively low intensity of our netting programs. An extensive mark-recapture project should be conducted to obtain absolute abundance (density) estimates.

Finally, while commercial harvest does not appear to be limiting lake sturgeon recovery (Haxton 2007; Haxton and Findlay 2008), a commercial harvest on a depressed population with limited recruitment may not be sustainable, no matter how low quotas are set. The effects of the current commercial harvest needs to be assessed. This could be conducted by examining exploitation rates through a mark-recapture program with full co-operation from commercial fishermen. Since annual mortality is relative low (section 5.9), commercial harvests may be compensatory (i.e., not increase mortality rates) and therefore not actually affect lake sturgeon abundance/recovery. This would suggest that commercial fisheries could exist within the allowable harm limits while permitting the populations to recover. However, it may alternatively be determined that mortality resulting from commercial fisheries is additive. Therefore, harvests would not be sustainable due to low recruitment observed in some river reaches.

8.0 References

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