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# Information Relevant to a Recovery Potential Assessment of Lake Sturgeon: Winnipeg River-English River Populations (DU5)

# Renseignements pertinents pour l'évaluation du potentiel de rétablissement de l'esturgeon jaune : populations de la rivière Winnipeg et de la rivière English (UD 5)

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## ABSTRACT

The Lake Sturgeon (*Acipenser fulvescens*) was common in nearshore waters across much of Canada in the nineteenth century, but intensive fishing, habitat loss and degraded water quality caused severe reductions in population size or extirpation across their range. Today they remain extant from the North Saskatchewan River in Alberta, to Hudson Bay in the north, and eastward to the St. Lawrence River estuary. In November 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed Lake Sturgeon in Canada. Designatable Unit (DU) 5, the Winnipeg River-English River populations, includes Lake Sturgeon in the Winnipeg River from Pine Falls upstream to Kenora and the English-Wabigoon river system. COSEWIC assessed and designated DU5 as Endangered as Lake Sturgeon in this DU declined severely over the past century and a significant portion of their habitat has been degraded or lost. Historically, over-exploitation from commercial fisheries was probably the primary threat, whereas more recently habitat degradation or loss resulting from industrial activities and dams/impoundments and other barriers, genetic contamination from stocking, fishing and population fragmentation, resulting from dams/impoundments and other barriers, have become the most important threats.

DU5 Lake Sturgeon is being considered for legal listing under the *Species at Risk Act* (SARA). In advance of making a listing decision, Fisheries and Oceans Canada (DFO) has been asked to undertake a Recovery Potential Assessment (RPA). This RPA summarizes the current understanding of the distribution, abundance and population trends of Lake Sturgeon in DU5, along with recovery targets and times. The current state of knowledge about habitat requirements, threats to both habitat and Lake Sturgeon, and measures to mitigate these impacts for DU5 are also included. This information may be used to inform both scientific and socio-economic elements of the listing decision, development of a recovery strategy and action plan, and to support decision-making with regards to the issuance of permits, agreements and related conditions, as per sections 73, 74, 75, 77 and 78 of SARA.

Nine Lake Sturgeon Management Units (MUs) have been identified for DU5. Available data and expert opinion indicate that current status is critical in MUs 3 and 4, and population trajectory is decreasing in MU3 and unknown or possibly decreasing in MU4. The status of MU7 is cautious and population trajectory is unknown. MUs 5 and 6 are both healthy and population trajectory is stable or increasing in MU5 and stable in MU6. The status and population trajectories of MUs 1, 2, 8 and 9 are unknown. Current data indicates that there are several thousand adult Lake Sturgeon in this DU and juveniles are abundant. There is evidence of population recovery in some MUs.

**RÉSUMÉ**

L’esturgeon jaune (*Acipenser fulvescens*) était abondant dans les eaux côtières de la majeure partie du Canada au dix-neuvième siècle, mais la pêche intensive, la perte d’habitat et la dégradation de la qualité de l’eau ont entraîné de graves diminutions de la taille de la population ou, encore, sa disparition dans l’ensemble de son aire de répartition. Aujourd’hui, les populations subsistent de la rivière Saskatchewan Nord en Alberta à la baie d’Hudson au nord et à l’estuaire du fleuve Saint-Laurent à l’est. En novembre 2006, le Comité sur la situation des espèces en péril au Canada (COSEPAC) a évalué l’esturgeon jaune au Canada. L’unité désignable (UD) 5, à savoir les populations de la rivière Winnipeg et de la rivière English, comprend les esturgeons jaunes présents dans la rivière Winnipeg depuis Pine Falls jusqu’à Kenora en amont ainsi que dans le réseau hydrographique English-Wabigoon. Le COSEPAC a évalué l’UD 5 et l’a désignée comme étant en voie de disparition, car l’esturgeon jaune de cette UD a connu un grave déclin au cours du siècle dernier ainsi que la dégradation ou la perte d’une partie importante de son habitat. Historiquement, la surexploitation par la pêche commerciale était probablement la menace principale, tandis que, plus récemment, la dégradation ou la perte de l’habitat causées par les activités industrielles, les barrages, les ouvrages de retenue et autres obstacles, la contamination génétique due à l’ensemencement, la pêche ainsi que la fragmentation de la population causée par les barrages, ouvrages de retenue et autres obstacles sont devenues les menaces les plus importantes.

On étudie la possibilité d’inscrire l’esturgeon jaune de l’UD 5 à la liste de la *Loi sur les espèces en péril* (LEP). Avant de prendre une décision quant à l’inscription, on a demandé à Pêches et Océans Canada (MPO) d’effectuer une évaluation du potentiel de rétablissement (EPR). Cette EPR résume les connaissances actuelles associées à la répartition, à l’abondance et aux tendances relatives aux populations d’esturgeons jaunes dans l’UD 5 et propose des cibles et des délais de rétablissement. On présente également l’état actuel des connaissances sur les exigences en matière d’habitat, les menaces pesant sur l’habitat et sur l’esturgeon jaune ainsi que les mesures d’atténuation à mettre en œuvre dans l’UD 5. Cette information peut être utilisée pour éclairer les volets scientifiques et socio-économiques des processus décisionnels relatifs à l’inscription ainsi que l’élaboration d’un programme de rétablissement et d’un plan d’action et, finalement, pour soutenir les processus décisionnels concernant la délivrance de permis, la conclusion d’accords et l’établissement de conditions connexes en vertu des articles 73, 74, 75, 77 et 78 de la LEP.

On a relevé neuf unités de gestion (UG) de l’esturgeon jaune pour l’UD 5. Selon les données disponibles ainsi que les opinions d’experts, l’état actuel des UG 3 et 4 est critique; la trajectoire de la population est à la baisse dans l’UG 3 et est inconnue ou peut-être à la baisse dans l’UG 4. L’état de l’UG 7 se situe dans la zone de prudence, et la trajectoire de la population est inconnue. L’état des UG 5 et 6 est sain; la trajectoire de la population est stable ou à la hausse dans l’UG 5, et elle est stable dans l’UG 6. L’état et la trajectoire des populations des UG 1, 2, 8 et 9 sont inconnus. Selon les données actuelles, plusieurs milliers d’esturgeons jaunes adultes sont présents dans cette UD et les juvéniles sont abondants. On observe des signes de rétablissement de la population dans certaines UG.

# INTRODUCTION

The Lake Sturgeon (*Acipenser fulvescens*) is part of an evolutionarily ancient, temperate freshwater fish family. They are slow-growing and long-lived, and their extended reproductive cycles make them vulnerable to human-induced population declines. The Lake Sturgeon was common in nearshore waters across much of Canada in the nineteenth century, but over the past century have undergone severe reductions in population size, or extirpation, in response to intensive fishing, habitat loss and degraded water quality. Eight Canadian designatable units (DUs) of Lake Sturgeon are recognized by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). DU5 includes Lake Sturgeon in the Winnipeg River from Pine Falls upstream to Kenora and the English-Wabigoon river system (Figure 1). COSEWIC assessed and designated this DU as Endangered in November 2006 (COSEWIC 2006). The Lake Sturgeon, called *namay* by the Anishinaabe, has cultural significance and importance for subsistence harvesting to First Nations peoples. This species is valued by recreational fishers for catch-and-release and is of value to the tourist industry. Maintaining Lake Sturgeon populations in Canada, including DU5, is important for the long-term survival and recovery of this species.

## SPECIES BIOLOGY AND ECOLOGY

The Lake Sturgeon is a bottom-dwelling freshwater fish that is heavy, cartilaginous and torpedo-shaped with an extended, hard snout and shark-like caudal fin. Larval and juvenile fish have conspicuous bony plates (scutes) in five rows along the body which become less obvious with age as they embed in the body wall. The pointed snout has four prominent barbels located ventrally and well in front of the mouth. The Lake Sturgeon is typically light to dark brown or grey in colour on the back and sides with a lighter-coloured belly. They can attain over 3 m in length and 180 kg in weight, though they mostly range about 0.9-1.5 m in length and about 5-35 kg in weight (Scott and Crossman 1973). Studies conducted in between the Pointe du Bois and Slave Falls generating stations (GSs) from 2006 to 2009 found that fork length (FL) and weight of the captured Lake Sturgeon ranged between 0.12-1.6 m and 0.23-23.5 kg, respectively (MacDougall *et al.* 2008a, b, D. MacDonell, pers. comm.). Females are usually larger than males (Harkness and Dymond 1961, Mosindy and Rusak 1991).

This species is found in large rivers and lakes. To date, most Lake Sturgeon research has been conducted in riverine rather than lacustrine systems so most of the available data presented reflect this.

The Lake Sturgeon usually occurs at depths of 5-10 m or more over mud, clay, sand or gravel substrates in water temperatures within the range of 3-24°C (COSEWIC 2006). In the Winnipeg River, juvenile Lake Sturgeon prefer deep water areas greater than 13.7 m (Barth *et al.* 2009), while most adults were captured in 4-19 m depths (D. MacDonell, pers. comm.). In the Slave Falls reservoir of Winnipeg River, juvenile and adult Lake Sturgeon range between 4-40 m and 4-27 m in depth, respectively; there was no Lake Sturgeon captured at depths < 3.5 m in summer or fall despite considerable fishing effort (D. MacDonell, pers. comm.). The Lake Sturgeon has been described as largely sedentary (Threader and Brousseau 1986, Fortin *et al.* 1993, Haxton 2003) with high site fidelity except to move over longer distances for spawning. A low proportion of adult fish migrate long distances, sometimes in excess of hundreds of km, but most make localized (1-20 km) seasonal movements between feeding areas in large rivers or lakes and spawning areas, and typically exhibit site fidelity to spawning areas and sometimes to “home” or “activity” centres for feeding and/or overwintering (Sandilands 1987, Kempinger 1988, Fortin *et al.* 1993, Auer 1996, Rusak and Mosindy 1997, Borkholder *et al.* 2002, Knights *et al.* 2002, Barth and Ambrose 2006). In the Winnipeg River, tagged Lake Sturgeon traveled 45 km in a single day (Dick, as cited in DFO

2007). Tagging studies indicate that in contiguous lake-river systems, basin-wide movement patterns may be the most prevalent during the ice-free season, especially during the spawning and post-spawning period when water temperatures increase, while fairly limited movements are typical during the winter months (Mosindy and Rusak 1991, Rusak and Mosindy 1997, Borkholder *et al.* 2002). Tagging studies also indicate that younger, smaller Lake Sturgeon do not move as far as older, larger individuals (Mosindy and Rusak 1991, Swanson *et al.* 1991, Holtgren and Auer 2004, Benson *et al.* 2005, Smith and King 2005). Tagging studies in Numao Lake on the Winnipeg River indicate that young Lake Sturgeon are relatively sedentary (Dick 2004). Further, mark-recapture and acoustic telemetry data from the reach of the Winnipeg River between Slave Falls GS and Seven Sisters Falls GS (MU5) indicate that habitat transitions, specifically areas characterized by shallow water depths (1-5 m) and fast moving (> 1.0 $m \cdot s^{-1}$) water, may limit or restrict juvenile movement (Barth, unpubl. data).

The importance of migration to Lake Sturgeon extends beyond feeding and spawning. It is also critical for the recolonization of areas that are subject to freezing, drought or other seasonal changes or catastrophic events (Aadland, as cited in DFO 2007).

Adult Lake Sturgeon spawn in swift current after moving upstream to suitable areas containing rapids or below barriers (e.g., falls or dams) (Harkness and Dymond 1961, Scott and Crossman 1973, Priegel and Wirth 1974, Baker 1980, Mosindy and Rusak 1991, Lyons and Kempinger 1992, Auer 1996). They return downstream following spawning (Mosindy and Rusak 1991, Lyons and Kempinger 1992) to replenish energy stores before the next spawning cycle.

Sexual maturity in Lake Sturgeon typically occurs between 14 and 33 years of age in females and between 14 and 22 years in males (Harkness and Dymond 1961). Age at first spawning may occur several years after eggs first start to develop. Historically, age at maturity was determined from egg development when fish were collected for caviar. Today, sexual maturity is based on the age at which Lake Sturgeon are first observed spawning. Therefore, comparisons between historical and current age at maturity should be made with caution as they may reflect differences in methods rather than changes in population characteristics.

Spawning generally occurs in May and/or June, once waters are free of ice. In the Winnipeg River, spawning occurs in May and/or June once water temperatures approach 11°C (Beyette, pers. comm., as cited in McDougall 2008a). Peak spawning in the Slave Falls reservoir occurred between May 10 (in 2006) and June 6 (2009). Spawning can begin at temperatures as low as 8°C if spring is delayed (M. Duda, pers. comm.). The maximum number of females and heaviest spawning activity usually occurs when water temperature reaches 11.5-16.0°C (Bruch and Binkowski 2002. Individual spawning females are surrounded by 2-8 males in fast current, often near shore though not always, and release about 1,000 eggs into a cloud of sperm during 2-4 spawning events (Bruch and Binkowski 2002, D. MacDonell, pers. comm.). Females may contain between about 50,000 and > 1,000,000 eggs with heavier females producing more eggs (Scott and Crossman 1973). A female will continue spawning for about 8-12 hours and spawning typically occurs for 2-4 days at each site depending on the number of spawning females. Spawning periodicity has been estimated to be 3-7 years for females and 2-3 years for males (Sunde 1959, Mosindy and Rusak 1991, Wallace 1991). Reproductive senescence has not been reported. Lake Sturgeon scatter their eggs and move quickly downstream after spawning, providing no parental care to the eggs or fry.

The eggs hatch in 5-10 days, depending on water temperature. Newly-hatched young are negatively phototactic, and remain burrowed in the interstitial spaces of the substrate until the yolk sac is absorbed. Typically they emerge at night within 13-19 days after hatching and disperse downstream with the current (up to 40 kilometers) before returning to a benthic habitat (Seyler 1997). By that time they resemble miniature adults and start feeding. The early age-0 stage (i.e., the transition from larvae to exogenous feeding) is a critical life history stage for Lake Sturgeon. Age-0 fish grow rapidly from 1.7-1.8 cm at emergence to approximately 11-20 cm total length (TL) by the end of the first summer (COSEWIC 2006, C. Barth, pers. comm.). Up to five years of age, they grow more rapidly in length than weight, whereas from 5-15 years of age they grow more rapidly in weight than length. In general, growth rate and body condition in Lake Sturgeon have been found to vary in relation to mean annual air temperature, latitude and region of Canada (east versus west portion of the range) and water properties such as pH and conductivity (Fortin *et al.* 1996).

The sex ratio at birth is unknown but assumed to be 1:1 based on data from populations with little or no anthropogenic mortality (Threader and Brousseau 1986, Nowak and Jessop 1987). Following maturation, the sex ratio can favour either females or males as a result of targeted exploitation. For example, in the St. Lawrence the sex ratio shifted in favour of females reaching 6:1 by age 40 (Fortin *et al.* 1993). In the Lake Winnebago system it shifted in favour of males due to targeted exploitation of females (Bruch 1999). Information about survival is limited. Survival and mortality rates in Lake Winnebago in 1936-52 were 0.946 and 0.054 for ages 16-36 years and 0.866 and 0.134 for ages older than 36 years, respectively (Priegel and Wirth 1975). The estimate of survivorship of adult and sub-adult Lake Sturgeon below the St. Lawrence FDR Power Project at Massena, New York, was 0.86 (Hayes and Werner 1997). Recruitment (i.e., the number of fish which grow into the catchable size range in a year) in populations which are self sustaining is reported to be in the range of 4.7-5.4% (Priegel and Wirth 1975, Baker 1980). Natural survival of adult Lake Sturgeon is high (Vélez-Espino and Koops 2009), but adults are particularly vulnerable to exploitation.

There are historic records of Lake Sturgeon living up to 150 years of age (Scott and Crossman 1973, Stewart and Watkinson 2004) however the typical lifespan in western Canada was about 80 years for females and 55 years for males (Choudhury and Dick 1993). Maximum ages were higher in the more northern, slower-growing populations (Scott and Crossman 1973). Lifespan today is more in the range of 25-50 years with an average generation time of about 26-30 years (Fortin *et al.* 1996, Scott and Crossman 1973), but lifespan is population specific. Shorter average lifespan today may reflect current and/or past effects of harvest rather than natural longevity.

The Lake Sturgeon follows a benthic generalist feeding strategy. Age-0 fish mostly feed on amphipods and chironomid larvae while the diet of juveniles also includes oligocheates, aquatic insects (e.g., ephemeroptera nymphs, trichoptera larvae) mollusks and fish eggs (Peterson *et al.* 2007, Randall 2008). In the Winnipeg River, the juvenile (approximately 20-70 cm TL) diet is comprised almost entirely (97%) of insect larvae from three invertebrate taxa, trichoptera, diptera and ephemeroptera (Barth, unpubl. data). A shift in diet has been reported to occur when Lake Sturgeon reach about 70-80 cm TL, from a diet comprised mainly of soft bodied insects to a wide range of benthic organisms including bivalves or crayfish (Sandilands 1987, Werner and Hayes 2005). Some pelagic feeding has also been reported (Dick 2004). The Lake Sturgeon feeds actively throughout the year, though consumption may decline in the fall and winter (DFO 2008).

## ASSESSMENT

### HISTORIC AND CURRENT DISTRIBUTION AND TRENDS

DU5 includes the Winnipeg River from Pine Falls (in southeastern Manitoba), upstream to Kenora (in northwestern Ontario), and the English-Wabigoon river system (Figure 1). The Lake Sturgeon in this region is considered a distinct designatable unit on the basis of distinguishable variation in three nuclear microsatellite loci (Robinson and Ferguson 2001, COSEWIC 2006).

Nine Lake Sturgeon MUs, separated from each other by natural or man-made barriers, have been identified in the Winnipeg River-English River system (DU5) (Figure 1): (1) the Wabigoon River (separated from the English River by falls), (2) the English River from Manitou Falls GS to Caribou Falls GS, (3) from Norman GS to Whitedog Falls GS on the Winnipeg River, (4) from Caribou Falls GS and Whitedog Falls GS to Pointe du Bois GS, (5) from Pointe du Bois GS to Slave Falls GS, (6) from Slave Falls GS to Seven Sisters GS, (7) from Seven Sisters GS to McArthur GS, (8) from McArthur GS to Great Falls GS and (9) from Great Falls GS to Pine Falls GS. Within each of these MUs there may be one or more spawning stocks.

MUs 1-6 are situated in the Canadian Shield surrounded by boreal forest. MUs 7-9 are located in the transition zone between the Canadian Shield and Interior Plain geological regions with a mix of moderate- to gently-sloping shorelines lined with scrub brush, farmland and boreal forest. The Winnipeg River (MUs 3-9) extends 260 km from Lake of the Woods to Lake Winnipeg and drains a watershed of over 150,000 $km^2$ (St. George 2006). Historically, the river consisted of a series of low gradient areas interspersed by short stretches of high gradient series (e.g., waterfalls and rapids) as it descended 105 m along its course. By the beginning of the 1900s, the river was seen as a valuable source of energy and the first hydroelectric GS was constructed at Pinawa in 1908, followed by six more in Manitoba and two in Ontario. The are two Ontario GSs (Caribou Falls and Manitou Falls) on the English River over 142 km of river.

In the mid-1920s, Lake Winnipeg and its tributary rivers including the Winnipeg River were considered prime Lake Sturgeon fishing areas and Manitoba waters were recognized as the last important stronghold for Lake Sturgeon on the continent (Skaptason 1926). In the Winnipeg River, Lake Sturgeon were isolated from Lake Winnipeg by the Lower Pine and Great Falls. The construction of hydroelectric GSs, beginning in 1906, further fragmented the distribution of this species and restricted upstream movement (Figure 2). Upstream fish passage was not provided at any of the GSs on the Winnipeg or English rivers and few Lake Sturgeon are thought to move downstream between MUs. Only two (< 0.2%) of over 1,800 Lake Sturgeon tagged in the Slave Falls reservoir (MU5) from 2006 to 2009 were captured downstream of the Slave Falls GS during the same time period (Manitoba Hydro, unpubl. data). Similar limited downstream movements have been demonstrated in other tagging studies conducted in the Winnipeg River, though some tagged fish moved downstream through several GSs (Manitoba Fisheries Branch (MFB), unpubl. data). This indicates that Lake Sturgeon are able to move downstream, but not upstream, past barriers thus it is likely that over the past several decades, mixing has become increasingly restricted the farther upstream one goes. The Lake Sturgeon is currently known to occur in at least eight of the nine MUs in DU5 and their area of occupancy is estimated to be < 1,000 $km^2$ (COSEWIC 2006). The trend in habitat availability in DU5 has been stable for more than fifty years.

#### Wabigoon River (MU1)

The Wabigoon River is 150 river km in length and a major tributary of the English River. It flows in a northwesterly direction from Wabigoon Lake at Dryden, Ontario, into the English River at Ball

Lake. It is not known whether the Lake Sturgeon was historically present in the Wabigoon River or occurs there now.

**English River: Manitou Falls GS – Caribou Falls GS (MU2)**

The English River from the Manitou Falls GS to Caribou Falls GS is about 142 river km in length and descends through a chain of seven lakes. Shorelines range from gradual to steep, primarily comprised of bedrock.

There are no documented records of Lake Sturgeon in the English River above Manitou Falls GS (M. Schillemoore, pers. comm., as cited in DFO 2007). According to the Atlas of Lake Sturgeon Waters in Ontario (Kerr 2002), there is past documented Lake Sturgeon presence in Lake St. Joseph and numerous other waterbodies and river systems to the north of Lake St. Joseph. Over the past century, potential barriers to Lake Sturgeon migration have been constructed on the English River system. No substantive efforts at detecting Lake Sturgeon have been undertaken. It is possible that unknown populations exist in the upper English River system (D. Berube, pers. comm.).

The Lake Sturgeon was known to occur historically below Manitou Falls GS. Recent anecdotal information indicates this species still persists in the lower English River system, including Umfreville and Oneman lakes, Kettle Falls and Separation Lake (Ontario Ministry of Natural Resources (OMNR), unpubl. data).

**Norman GS – Whitedog Falls GS (MU3)**

The Winnipeg River between the Norman GS, at Kenora, and Whitedog Falls GS is about 45 river km in length. The river contains fast-moving riverine and vast sections of lake habitats. Depths in this reach vary from shallow fast-moving rapids to deeper lakes such as Sand Lake which has a maximum depth of 62 m. The shoreline is mostly composed of bedrock. No historic scientific information about Lake Sturgeon distribution is available for MU3. Recent netting efforts throughout the MU produced only two Lake Sturgeon at Norman Dam (OMNR, unpubl. data)

**Caribou Falls GS and Whitedog Falls GS – Pointe du Bois GS (MU4)**

MU4 is 81 river km in length, of which 45.9 km is located in Manitoba between the border with Ontario and the Pointe du Bois GS. In Ontario, the Winnipeg River is 27.5 km from the border to Whitedog Falls GS and 7.6 km from the mainstem to the Caribou Falls GS. Flows in MU4, and farther downstream (i.e., in MUs 5-9), are controlled by dams in Ontario. The Winnipeg River flows through several large lakes and riverine stretches in MU4 before reaching the Pointe du Bois GS. The lacustrine areas are characterized by numerous reefs, islands and bays while the riverine areas are characterized by faster-flowing water and smaller rapids in high-water years. Shorelines range from gradual to steep and are primarily comprised of bedrock. Depth ranges considerably throughout the entire MU from shallow water areas (e.g., shorelines, shallow bays, reefs) to deep areas in excess of 40 m (e.g., near Mattson Island) in the old river channel (Canadian Hydrographic Service 2000a). Pointe du Bois GS is typically operated as a run-of-the-river facility[1]. Most of MU4 contains undeveloped shorelines.

No historic scientific information about Lake Sturgeon distribution is available for MU4. In recent years, the Lake Sturgeon has been found in both the Ontario and Manitoba portions of this MU.

[1] Run-of-river hydroelectric facilities use the natural flow and elevation drop of a river to generate electricity.

Adult Lake Sturgeon spawn at Caribou Falls and South Boundary Falls (near the Ontario-Manitoba border) and are suspected to spawn at Whitedog GS (M. Duda, pers. comm.).

**Pointe du Bois GS – Slave Falls GS (MU5)**

MU5 is 10.5 river km in length. On the Pointe du Bois spillway shelf are two large, bedrock-lined pools through which some water continuously passes during the open-water season and extreme water flow occurs during high-water years. Throughout the rest of the MU, shorelines are characterized by moderate to steep scoured bedrock. Depths in the reach above Eight Foot Falls are shallower than below the falls and depths range up to 25 m (Canadian Hydrographic Service 2000a). Downstream of Eight Foot Falls there is an abundance of deep water, up to a maximum depth of 64 m (Canadian Hydrographic Service 2000a), in the main channel and in several small, narrow bays. The lower reach also contains islands and reefs. Slave Falls GS is typically operated as a run-of-the-river facility. A town site and some cottages are located primarily along the western shoreline of the MU. The Lake Sturgeon likely occurred in MU5 historically though scientific information dates back only several decades. Today, this species is found throughout much of the MU (D. MacDonell, pers. comm.).

**Slave Falls GS – Seven Sisters GS (MU6)**

MU6 is 39.5 river km in length and flows through a series of lakes and swift riverine sections. The upper 35 km of the MU is located in the Canadian Shield, with moderate- to steeply-sloping shorelines and many islands, reefs and shoals. Depths reach up to 40 m in some locations (Canadian Hydrographic Service 2000b). Rapids occur at Scots Rapids, Sturgeon Falls and Otter Falls. The lower 8 km of MU6 is located in the transition zone between the Shield and Interior Plain, and has gently-sloping shorelines with few islands, reefs and shoals. Seven Sisters GS is typically operated as a run-of-the-river facility thus water levels do not vary greatly on a daily basis. The Pinawa Control Dam, located at the upstream end of the Pinawa Channel, affects how water flows through MU6. A town site and homes/cottages are located along the shorelines of this MU. The Lake Sturgeon likely occurred in MU6 historically though scientific information dates back only several decades. Today, this species is found in at least some reaches of the MU (Barth, unpubl. data).

**Seven Sisters GS – McArthur GS (MU7)**

MU7 is 34.9 river km in length with a mix of moderate- to gently-sloping shorelines lined with scrub brush, farmland and boreal forest. The upper 20 km of the MU is characterized as riverine, slowing in velocity and getting deeper as it flows downstream, before it widens into Lac du Bonnet. Most of the reservoir ranges from 2 to 12 m with a maximum depth of 22 m (Canadian Hydrographic Service 2000c). It covers a total area of 11,500 ha. The Winnipeg River flows downstream from Lac du Bonnet through McArthur GS, which is typically operated as a run-of-the-river facility, and operates in unison with Great Falls GS downstream. Two town sites and homes/cottages are located along the shorelines of this MU. The Lake Sturgeon was historically present in MU7. Angler reports, as well as results from experimental netting programs in recent years indicate that the Lake Sturgeon is present in MU7 (MFB, unpubl. data).

**McArthur GS – Great Falls GS (MU8)**

MU8 is 8.6 river km in length with a mix of moderate- to gently-sloping shorelines lined with scrub brush, farmland and boreal forest. This MU is characterized as wide with moderate flow, becoming more lacustrine as water depth increases with proximity to Great Falls GS. The highest waterfall on the Winnipeg River (10.7 m) is the site of the Great Falls GS which is typically operated as a run-of-the-river facility. The Lake Sturgeon is reported to occur in MU8 (MFB, unpubl. data) but no historic scientific information is available.

**Great Falls GS – Pine Falls GS (MU9)**

MU9 is 22.5 river km in length situated in the transition zone between the Canadian Shield and Interior Plain. Moderate- to gently-sloping shorelines are lined with scrub brush, farmland and boreal forest. This MU is characterized as wide with moderate flow, except at Silver and Whitemud falls where the river narrows and rapids form. Pine Falls GS is typically operated as a run-of-the-river facility. A town site and homes/cottages are located along the shorelines of this MU. The Lake Sturgeon is reported to occur in MU9 (Stantec Consulting Ltd 2007, MFB, unpubl. data) but no historic scientific information is available.

## HISTORIC AND CURRENT ABUNDANCE AND TRENDS

Over the past century, a history of commercial over-exploitation, combined with the construction of hydroelectric dams, resulted in significant population declines in DU5 until the 1990s or 2000s. Since 1996, stocking is known to have occurred in MUs 3 and 5-9. At least some MUs are now showing positive signs of recovery. Today, the Lake Sturgeon is relatively common in the Pointe du Bois-Seven Sisters area (MUs 5 and 6) and their population trajectory is stable or increasing. The number of mature individuals in the DU is unknown but MUs 5 and 6 combined may support at least 2,200 mature individuals.

The current conservation status (Figure 2), based on the precautionary framework (DFO 2005), of each of the MUs in DU5 was evaluated on the basis of available information and expert opinion (Table 1).

**Wabigoon River (MU1)**

There appear to be no confirmed current or historical records of Lake Sturgeon occurrences in the Wabigoon River (J. Van Walleghem, pers. comm.). The current population status and trajectory of Lake Sturgeon in MU1 are unknown (Table 1).

**English River: Manitou Falls GS – Caribou Falls GS (MU2)**

Below Manitou Falls GS, the Lake Sturgeon was known to occur historically, but now likely remain only as remnant populations in the lower reaches of the English River. Netting records from July 1987 documented 58 Lake Sturgeon ranging from 10 to 32 years old. There was no Lake Sturgeon caught incidentally in index nets set between Ball and Separation lakes in 1997 and 1998 (McAughey, cited in DFO 2007). Recent interviews with lodge operators and anglers indicate that Lake Sturgeon are often seen at and above Kettle Falls, though rarely in Umfreville and Oneman lakes, and that recruitment is taking place (OMNR, unpubl. data). Given the limited information available, current population status and trend of Lake Sturgeon in MU2 are unknown (Table 1).

**Winnipeg River: Norman GS – Whitedog Falls GS (MU3)**

There was no Lake Sturgeon caught incidentally in nets in MU3 over a six-year period in the early 2000s (McAughey, cited in DFO 2007). Over 100,000 Lake Sturgeon fry were recently stocked in this portion of the Winnipeg River from DU6 in an effort to recover the remnant Lake Sturgeon population. In 2008 and 2009, intensive netting for adult and juvenile Lake Sturgeon throughout the entire MU resulted in the tagging and release of two adults at Norman Dam (OMNR, unpubl. data). The current status and trend of Lake Sturgeon in MU3 is critical and decreasing, respectively (Table 1).

**Caribou Falls GS and Whitedog Falls GS – Pointe du Bois GS (MU4)**

Hundreds of juvenile and adult Lake Sturgeon have been tagged in the Ontario portion of this MU in recent years. Most age classes are represented though adult fish are relatively uncommon, and there is evidence of recruitment but it is relatively low and sporadic (M. Duda, pers. comm.). The potential for recovery exists if conditions that support recruitment can be improved.

In the Manitoba portion of MU4, the Lake Sturgeon occurs at lower densities than in MUs 5 and 6 (Manitoba Hydro, unpubl. data). Netting data from the early 1990s between the Manitoba border and Pointe du Bois GS yielded only two adult Lake Sturgeon from 27 set locations over a two-year period with a catch per unit effort CPUE of 0.07 (MFB, unpubl. data). Anglers using this reach of the Winnipeg River have reported both visual observations and occasional catches of Lake Sturgeon. Between Lamprey Rapids and the Pointe du Bois GS during 2006-2009, spring gillnetting caught only two adult fish (CPUE 0.13 fish/100m net/24h) and additional netting efforts captured 14 juvenile fish (30-80 cm FL) during summer and fall and four adult fish during spring (Manitoba Hydro, unpubl. data).

At present, the current status of Lake Sturgeon in MU4 is thought to be critical and population trend to be unknown or possibly decreasing (Table 1).

**Pointe du Bois GS – Slave Falls GS (MU5)**

Ageing data collected in MU5 from 1991 to 1999 shows a population comprised of strong cohorts from the 1960s to the late 1970s and a significant decline in cohort strength from 1979 to 1984 (MFB, unpubl. data). This pattern mirrors the results of the data collected in the Nutimik-Namao reach in MU6. Annual population estimates were developed for MU5 between 1994 and 1997 which ranged between 360 (95% CI: 186-2,903) and 1,100 (95% CI: 498-7,154) (Block 2001). A recent Manitoba Hydro study in MU5, starting in 2006, produced CPUEs based on spring gillnetting ranging between 7.8 and 18.7 and a population estimate in 2007 of 2,205 (95% CI: 921-4,095) Lake Sturgeon greater than 80 cm in length. Fall gillnetting in 2007 found that approximately 80% of captured Lake Sturgeon were juveniles (i.e., < 80 cm in length). This MU contains a relatively high density of Lake Sturgeon, indicating that the population could be near the carrying capacity of the habitat. Stocking for research and management purposes has occurred at least once in MU5 (in 2009), using broodstock from MU5 (MFB, unpubl. data). The current status of Lake Sturgeon in MU5 is healthy and population trajectory is stable or increasing (Table 1).

**Slave Falls GS – Seven Sisters GS (MU6)**

Ageing data collected in MU6 from 1991 to 1999 shows a population comprised of strong cohorts from the 1960s to the late 1970s and a significant decline in cohort strength from 1979 to 1984. Since that time, cohort strength has continually improved and the early cohorts in this group have now reached sexual maturity (MFB, unpubl. data). Block (2001) produced annual population estimates for MU6 between 1992 and 1997 which ranged between 2,998 (95% CI: 1,143-13,101) and 27,374 (95% CI: 5,317-326,827). In the late 1990s, Lysack (unpubl. data, cited in COSEWIC 2006) estimated 2,352 Lake Sturgeon were present between Pointe du Bois and Seven Sisters GSs (MUs 5 and 6), of which about 660 (28%) were sexually mature (i.e., > 26 years). This population estimate may be positively biased as some assumptions used to derive the estimate may not be valid. CPUE data collected in this MU between 1983 and 2003 showed a downward trend; CPUE decreased by 54.9% between 1989 and 2003 (Lysack, unpubl. data, as cited in COSEWIC 2006). The majority of the decrease likely occurred from 1989 to 1990 with CPUE remaining relatively stable to the present (MFB, unpubl. data). Since 2003, CPUE data shows an upward trend primarily due to significant increases in catches from the 14 cm (5.5. inch) mesh. Recent research indicates that several thousands of juveniles (25-70 cm FL) exist in certain river reaches of MU6 (Barth *et al.* 2009; Barth, unpubl. data) as a result of natural reproduction. Stocking for research and management purposes has occurred in MU6 at least eleven times (between 1998 and 2005), using broodstock likely from, in most cases, MUs 5 and/or 6 (MFB, unpubl. data). The current status of Lake Sturgeon in MU6 is healthy and population trajectory is stable (Table 1).

**Seven Sisters GS – McArthur GS (MU7)**

Before construction of the Seven Sisters GS, there was an important Lake Sturgeon spawning and nursery area located below the GS site (Letander, pers. comm., cited in COSEWIC 2006). Fewer Lake Sturgeon may occur in this MU now than did historically, though a current study indicates that the Lake Sturgeon is relatively common, at least within several km downstream of the Seven Sisters GS, they still spawn below the GS and recruitment is occurring (C. Hrenchuk, pers. comm.). Angler reports, as well as results from experimental netting programs, indicate that various size classes of Lake Sturgeon are represented (MFB, unpubl. data). Stocking for research and management purposes has occurred in MU7 at least six times between 1997 and 2008), using broodstock likely from MUs 5 and/or 6 (MFB, unpubl. data). The current status of Lake Sturgeon in MU7 is thought to be cautious although population trend is unknown (Table 1)

**McArthur GS – Great Falls GS (MU8)**

Anglers are known to target Lake Sturgeon below McArthur GS. Experimental netting in 2003 yielded two Lake Sturgeon (1.0 m and 1.5 m in length) from five set locations with a CPUE of 0.4 (MFB, unpubl. data). Stocking for research and management purposes has occurred in MU7 at least three times (between 1996 and 2002), using broodstock likely from, in most cases, MUs 5 and/or 6 (MFB, unpubl. data). The current status and trend of Lake Sturgeon in MU8 are unknown (Table 1).

**Great Falls GS – Pine Falls GS (MU9)**

Experimental netting conducted in 2003 yielded 54 Lake Sturgeon ranging in size between 0.4 m and 1.6 m from nine set locations with a CPUE of 6.0 (MFB, unpubl. data). Environmental monitoring studies conducted within an area extending nine kilometers upstream of Pine Falls GS in 2006 yielded a CPUE of 1.36 for Lake Sturgeon (Stantec Consulting Ltd 2007). Stocking for research and management purposes has occurred in MU9 at least once (in 2002), using broodstock likely from, in most cases, MUs 5 and/or 6 (MFB, unpubl. data). The current status and trend of Lake Sturgeon in MU9 are unknown (Table 1).

## INFORMATION TO SUPPORT IDENTIFICATION OF CRITICAL HABITAT

Survival and recovery of Lake Sturgeon depend on the availability of habitat for key components of the life cycle: spawning, rearing, summer feeding, overwintering and migration. In general, the Lake Sturgeon is found in water depths of at least 5 m except during spawning. They are thought to move to deeper waters during warmer periods and return to shallower waters when temperatures decline. This may reflect seasonal or diel changes in distribution and also may vary by waterbody. Movements appear to be limited, except for spawning migrations (Fortin *et al.* 1993). Research indicates that habitat preferences may vary between waterbodies.

The earliest age-0 stage, from hatch to first feeding (about 7-10 days), is assumed to be critical for survival and recovery of Lake Sturgeon but research on this life stage is only now underway. Age-0 fish have been captured in a variety of habitat types. In small tributaries of the Great Lakes, age-0 fish use shallow riverine areas with low current velocity, sand substrates and an abundance of dipteran larvae (Benson *et al.* 2005). In large rivers, they have been captured in habitat characterized by depths > 10 m, water velocities ranging from 0.1-0.3 $m{\cdot}s^{-1}$ and substrates comprised of clay, sand and gravel/cobble (Barth, unpubl. data). In MU5 of the Winnipeg River, deep sandy environments are preferred for nursery habitat (D. MacDonell, pers. comm.).

Finer substrate types, like clay and sand, are reported to be preferred habitat for juvenile Lake Sturgeon as they contain larger amounts of small benthic prey (see review by Barth *et al*. 2009), however juvenile rearing habitat has also been reported to include areas of coarse-sand and pea-sized gravel (Smith 2003). In the St. Lawrence River, juveniles were most abundant in areas with water depths of 3-6 m, currents of 0.25-0.50 $m{\cdot}s^{-1}$ and silt/sand substrates (Hayes and Werner 2002, Randall 2008). In the Winnipeg River, juvenile Lake Sturgeon preferred deep water areas greater than 13.7 m with detectable currents (i.e., greater than 0.2 $m{\cdot}s^{-1}$) over a variety of substrate types between June and November (Barth *et al.* 2009). Depth was shown to be the primary abiotic factor influencing habitat selection in juvenile Lake Sturgeon from the Winnipeg River (Barth *et al.* 2009). In the Winnipeg River, from spring to fall, juveniles were found congregating in deep water (depths > 13.7 m), with detectable water velocities (> 0.20 $m{\cdot}s^{-1}$) over a variety of substrate types, and were rarely located in shallow, low water velocity habitats (Barth *et al.* 2009).

Some evidence indicates that after their first year, juveniles are found in the same habitats as adults (Priegel and Wirth 1974). Other evidence indicates that age-0 and juvenile Lake Sturgeon may occupy habitats different than those of adults to avoid competition and that younger fish use individual areas of activity rather than the core areas used by adult groups in riverine environments (Smith and King 2005). The habitat requirements of young Lake Sturgeon appear to be more restricted (Chiasson *et al.* 1997) and, thus, availability of suitable habitat may be more limiting for age-0 and early juvenile life stages than for adults. Adult life stages tend to be more plastic, adapting to various habitat conditions (Werner and Hayes 2005).

Migration of adult Lake Sturgeon is functionally linked to movement between the adult feeding and spawning habitat. Open connections between these habitats are necessary, as adults may be required to migrate considerable distances to find suitable spawning habitat (Randall 2008).

Adults typically spawn in late spring, in water temperatures of 11.5-16°C in high-gradient reaches of large rivers, often below rapids or dams, with current velocities of 0.5-1.3 $m{\cdot}s^{-1}$, water depths of 0.5-10 m, and over substrates of cobble, boulders, coarse gravel, hardpan, or sand (McKinley *et al*. 1998, Peterson *et al.* 2007, Randall 2008, R. Wallace, pers. comm.). Cascades and/or suitable water flows are necessary to keep the eggs healthy by ensuring strong oxygenation and cleaning action preventing sediment deposition while eggs incubate. Conditions necessary for successful spawning are typically found below dams and other barriers. During the incubation period, eggs adhere to the substrate. Spawning success is dependent on the availability of prime substrates, as sub-optimal substrates can significantly reduce spawning success if flushing flows occur during the incubation period and carry eggs downstream. Spawning habitat is also used for hatching and by the newly-hatched young for a period of about one month before larval drift occurs (Randall 2008). Fidelity to spawning sites is known in Lake Sturgeon though these may vary among years in response to flow conditions (Barth and MacDonell 1999). A number of historical spawning sites likely existed in DU5. For example, before the construction of the Seven Sisters GS, Pinawa Channel may have been an important Lake Sturgeon spawning area (Dick, as cited in DFO 2007). More recently, spawning occurred below the Seven Sisters GS in 2008 and 2009 in MU7 (C. Hrenchuk, pers. comm.). Other Lake Sturgeon studies conducted farther upstream in recent years indicate that spawning occurs below the Slave Falls GS in MU6 and the Pointe du Bois GS in MU5 (McDougall *et al.* 2008b), and are believed to spawn at Sturgeon Falls (J. Beyette, pers. comm.). There is no recent evidence of Lake Sturgeon spawning between Lamprey Falls and Pointe du Bois GSs in MU4 (MacDougall *et al.* 2008a, b). Other spawning sites likely exist given the multiple age/size classes present in other MUs within DU5.

Tagging studies have documented that Lake Sturgeon movements are complex. Some individuals may move substantial distances away from core areas and then return weeks or months later, while others will remain in the core area or leave and not return. Regardless, many or most Lake Sturgeon groups demonstrate a preference for certain areas, at least in riverine environments (Fortin *et al.* 1993, Rusak and Mosindy 1997, Knights *et al.* 2002, Barth and Ambrose 2006).These areas appear to contain hydraulic features characterized by transition from high-current velocities to slower velocities (e.g., the confluence of the main river channel with a tributary). These local changes in size and shape of the river result in depositional substrates where silt accumulates, providing good habitat for invertebrates which, in turn, provides good feeding habitat for Lake Sturgeon. Core areas of activity for groups of Lake Sturgeon may be more important in flowing (i.e., lotic) than lake (i.e., lentic) environments (Smith and King 2005).

Current velocity also appears to be an important variable in determining preferred habitat of Lake Sturgeon throughout the year (Rusak and Mosindy 1997). Juveniles are reported to use areas with detectable currents (i.e., greater than 0.2 $m \cdot s^{-1}$) (Barth *et al.* 2009). Adults prefer habitats with moderate water flow (< 0.6 $m \cdot s^{-1}$) (Benson *et al.* 2005). They appear to avoid areas with high current velocity, except during spawning, which are typically associated with increased energy costs and diminished food resources (Knights *et al.* 2002). Seasonal and annual changes in flow may affect fidelity to specific spawning and feeding areas.

Not as much is known about habitat preferences during winter. Burton *et al.* (2004) and Environnement Illimité inc. (2007) found that during winter, adult Lake Sturgeon tended to gather at water depths of 6-8 m (max. depth 20 m), and water velocities of 0.2 $m \cdot s^{-1}$ or less (max. velocity: 0.4 $m \cdot s^{-1}$) (Burton *et al.* 2004, Environnement Illimité inc. 2007). Overwintering substrate was typically silt and sand (Environnement Illimité inc. 2007). Juvenile Lake Sturgeon tended to congregate at the same depths as adults (max. depth 12 m). They also appeared to prefer the same flow velocities although some juveniles were observed at flow velocities as high as 0.4-0.6 $m \cdot s^{-1}$ (Environnement Illimité inc. 2007). Juveniles often spend the winter over silt and sand substrates and less so over gravel (Environnement Illimité inc. 2007).

In summary, maintaining the functional attributes of habitat, including the ecologically-based flow regimes, needed for spawning, egg incubation, juvenile rearing, summer feeding and overwintering, as well as migration routes between these habitats, is critical to the survival and recovery of Lake Sturgeon. The current distribution of Lake Sturgeon in DU5 is fragmented by nine GSs which may negatively affect the spawning habitat. It is essential that conditions that optimize the survival and recovery of Lake Sturgeon be maintained in DU5, especially during the spawning and incubation periods.

## RESIDENCE

SARA defines a *residence* as “a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating”. Residence is interpreted by DFO as being a *constructed* place (e.g., a spawning redd). The Lake Sturgeon does not change its physical environment or invest in a structure during any part of its life cycle, therefore no biological feature of this species meets the SARA definition of residence as interpreted by DFO.

## RECOVERY TARGETS

DFO has determined that Population Viability Analysis (e.g., minimum viable population (MVP)) is a good approach for setting recovery targets for species at risk (DFO 2010) and meets the SARA requirement for demographic sustainability. MVP size has often been used as the abundance target. Using Minimum Viable Population (MVP) analysis of stage-structure demographic matrices, Vélez-Espino and Koops (in prep.) used MVP analysis of stage-structure demographic matrices to calculate recovery targets for Lake Sturgeon in DUs 1-5. They calculated that each MU in DU5 would need at least 413 spawning females per year (i.e., 4,130 adults) to achieve a 99% probability of persistence of Lake Sturgeon over 250 years, given a probability of catastrophe (50% decrease in the abundance of all life stages in one year) of 14% per generation, and assuming a balanced sex ratio and 5-year spawning periodicity and a sufficient number of juveniles to support the adult population goal. They used annual number of spawning females as it is the most tractable to sampling. Using MVP combined with information on area per individual and stable stage distributions, Vélez-Espino and Koops (in prep.) calculated that at least 1,886 ha of Lake Sturgeon habitat for lotic (riverine) environments, or approximately twice as much for lentic (lake) environments, is needed to support all life stages of a viable MU in DU5 at the recommended recovery target. On average, age-0 individuals would require 2.3% of the total area of required habitat, juveniles 45.3% and adults 52.3%.

The MVP modelling uses vital rates as inputs, and it is important to note that there are uncertainties associated with these vital rates. For example, the vital rates data may not have been specific to the DU being modelled, recent unpublished data may not be available or assumptions used in the model (e.g., a balanced sex ratio) may not accurately represent current conditions for that DU. Additionally, the recovery target may not reflect historic Lake Sturgeon abundance before over-exploitation and habitat degradation or loss began. In spite of uncertainty around the model output, its results are still useful and provide a recovery target to work towards. The model can be updated once new information comes available.

On the basis of this information, a recovery goal and population and distribution objectives were developed. The long-term recovery goal for DU5 is to protect and maintain healthy, viable populations of Lake Sturgeon in the lower English River (MU2) and Winnipeg River (MUs 3-9). To reach this recovery target, each MU must have at least 413 spawning females each year (i.e., 4,130 adults) and at least 1,886 ha of suitable riverine habitat or 3,772 ha of suitable lake habitat. The aim is to reach these population and distribution objectives within three generations (i.e., about 108 years). If the Lake Sturgeon is found in the Wabigoon River, then recovery efforts should be undertaken.

Vélez-Espino and Koops (in prep.) chose a recovery target that, if undertaken, would achieve a significant reduction in the probability of extinction of Lake Sturgeon in DU5. If a less precautionary recovery target is chosen, the number of spawning females per year would be reduced and years to recovery increased accordingly.

Vélez-Espino and Koops (2009) modeled recovery efforts combined with recovery targets to project recovery timeframes as a stochastic process under a number of management scenarios targeting different combinations of Lake Sturgeon vital rates. They estimated MVP as the number of adults required for a 99% chance of persistence over 40 generations (> 1,000 years). Vélez-Espino and Koops (in prep.) re-calculated MVP as the number of adults required for a 99% chance of persistence over 250 years. Regardless of the change in some parameters, the long-term projections and timeframes for recovery reported by Vélez-Espino and Koops in 2009 do not change given that initial population sizes used in the model simulations are relative (1-10%) to the recovery target (M. Koops, pers. comm.). When current abundances are assumed to be 10% of the recovery target, the times-to-recovery range from about 20 years to around 95 years (i.e., about 1-3 generations), depending on the recovery actions implemented (Vélez-Espino and Koops 2009) (Figure 3). Recovery timeframes diminish if Lake Sturgeon spawning periodicity is shorter or reproductive effort is higher than expected and, conversely, will lengthen if spawning periodicity is longer or reproductive effort is lower than expected (Vélez-Espino and Koops 2009).

The recovery potential and importance to recovery of each of the nine Lake Sturgeon MUs in DU5 was evaluated on the basis of available information (e.g., quantitative population data) and expert opinion (Table 1). The recovery potential of MUs 1 (Wabigoon River) and 2 (Manitou Falls GS – Caribou Falls GS) and their importance to recovery of DU5 are unknown. In MUs 7 (Seven Sisters Gs – McArthur GS), 8 (McArthur GS – Great Falls GS) and 9 (Great Falls GS – Pine Falls GS), the potential for recovery is also unknown but their importance to recovery is moderate or, in the case of MU7, moderate or high. The potential for recovery of Lake Sturgeon in MU3 (Norman GS – Whitedog Falls GS) is low but the importance of this MU to species recovery in DU5 is moderate due to recent stocking efforts. In MU4 (Caribou Falls GS and Whitedog Falls GS – Pointe du Bois GS), recovery potential is moderate but importance to DU recovery is considered to be high. MUs 5 (Pointe du Bois GS – Slave Falls GS) and 6 (Slave Falls GS – Seven Sisters GS) are both healthy. Both MUs have high potential for recovery and high importance for recovery of Lake Sturgeon in DU5.

Some stretches of the Winnipeg River between GSs are relatively short and narrow (e.g. MUs 5 and 8). While these MUs may provide sufficient habitat to meet all life history requirements of Lake Sturgeon, they do not provide sufficient total area to support the population and distribution objectives recommended by the MVP modelling analysis. Thus, for these MUs the recovery goal is to maintain or increase Lake Sturgeon abundance, recognizing that the full recommended population target may not be attainable, and to maintain or enhance habitat required to support the population. Lake Sturgeon abundance in MU5 may be close to carrying capacity. If so, MU5 has high recovery potential relative to the carrying capacity of available habitat but low recovery potential with respect to the recommended modelling recovery target (Table 1).

Insufficient information is available for MUs 1, 2, 8 and 9 to evaluate times to recovery. Recent information for MU3 suggests that Lake Sturgeon numbers are low so recovery may be, at best, very protracted. It may be possible to attain recovery in MUs 4 and 7 with appropriate management and/or recovery efforts. Based on recent population estimates and catch-effort data, MUs 5 and 6 contain a healthy number of adult fish, thus potential to reach carrying capacity, if not recovery, within the recommended timeframe would seem highly probable.

In order to meet the recovery goal and recommended population and habitat objectives, within the suggested timeline, threats must be identified and removed or mitigated.

## THREATS TO SURVIVAL AND RECOVERY

The life history traits of Lake Sturgeon, including large size, delayed maturation, low natural adult mortality and high fecundity, allow this species to be successful when facing extremes in environmental conditions and consequently have contributed to the long-term success of the species. Unfortunately, many of these traits became disadvantageous when faced with human-induced mortality and habitat changes (Beamesderfer and Farr 1997).

An historical commercial fishery in the Winnipeg River harvested significant amounts of Lake Sturgeon: 79,000 kg in 1910; 145,437 kg between 1939 and 1947; and 28,800 kg between 1957 and 1959 (D. MacDonell, pers. comm.). The commercial harvest in DU5 ended in the 1960s in Manitoba and the 1970s in Ontario. A species conservation closure, which prohibited all harvest including recreational and First Nations domestic harvest, was implemented on the Winnipeg River in 1993, upstream of Pine Falls to the Ontario border. A catch-and-release recreational fishery continues. In Ontario, recreational anglers had a catch limit of one Lake Sturgeon of greater than 190 cm up until 2008 when the Lake Sturgeon fishery was closed (OMNR 2009). Since 2009, any Lake Sturgeon caught while recreational fishing for other species must be released. Aboriginal harvest of Lake Sturgeon by First Nations for subsistence, cultural and ceremonial purposes continues in Ontario, but not in Manitoba. Poaching is a concern in DU5. Although the current levels of legal harvesting through the subsistence fishery (Ontario only) and illegal harvesting are low, the removal of juveniles and adults affects recovery (Vélez-Espino and Koops 2009).

Annual rates of harvest for Lake Sturgeon are not available for this DU. Regardless, it is worth noting that annual harvest rates that are thought to be sustainable for Lake Sturgeon are typically 5% or less (Threader and Brousseau 1986, Beamesderfer and Farr 1997, Secor *et al.* 2002, Auer 2003, Bruch 2008). A guideline developed for rehabilitation of Lake Sturgeon in the State of Michigan, for populations that currently exist, specifies maintaining fishing mortality below 3% for an expanding population and below 6% to maintain Lake Sturgeon abundance (Hay-Chmielewski and Whelan 1997).

Nine hydroelectric GSs were developed on the Winnipeg River over the past century (Figure 1). Dams and control structures elsewhere have been shown to alter the natural flow regime and fragment habitat resulting in degradation and/or loss of Lake Sturgeon habitat, loss of genetic diversity, reduced spawning success, reduced prey availability (through removal of prey items by flushing flows and entrainment or exposure during low flows) and mortality (e.g., excessive siltation leading to loss of critical age-0 fish) (see review in Pratt 2008). Dam construction can extirpate local Lake Sturgeon populations (Dumont *et al.* 1987) by preventing fish from accessing spawning areas and stranding fish between impassable barriers. Larger structures, like hydroelectric dams, can also cause injury or direct mortality from exposure to rapid and extreme water pressure changes, cavitation, shear, turbulence and/or mechanical injuries (Cada 1998) through entrainment[2], impingement[3] and fish passing downstream through the turbines (Hay-Chmielewski and Whelan 1997, McKinley *et al.* 1998). However, the intakes of most hydroelectric GSs are covered by bars or grates spaced such that they that would prevent passage of adult Lake Sturgeon through turbines.

Other human activities likely have also contributed to the degradation of Lake Sturgeon habitat in DU5. Water quality deteriorated due to industrial activities, specifically pulp and paper processing.

[2] Entrainment occurs when fish eggs and larvae are taken into a facility's water-intake systems, pass through and back to the water body.
[3] Impingement occurs when fish are trapped or pinned by the force of the intake flow against the intake.

During the 1960s, the mill in Dryden, Ontario, released significant amounts of mercury into the Wabigoon River as part of its paper bleaching process. Even though mercury dumping was discontinued in 1970, MU1 is still likely affected by flushing of residual discharge. The mill in Kenora, Ontario, closed in 2005 but residual effects from its historic discharge probably still affect water quality in MU3. Mining and forestry exploration and extraction, agricultural activities and urban development, particularly cottage developments, occur in various MUs within DU5. Their effects on Lake Sturgeon habitat are nil, low or unknown.

Stocking was undertaken in MU3 using fish from the Rainy River stock (DU5) thus the risk of genetic contamination in the remnant population is relatively high. Over the past fifteen years or more, stocking has also been undertaken in MUs 5-9 using broodstock from the same general region of the river thus the likelihood of genetic contamination there is lower.

In summary, the most important current threats to survival and recovery of Lake Sturgeon in DU5 are habitat degradation or loss resulting from industrial activities and dams/impoundments and other barriers, genetic contamination resulting from stocking, mortality, injury or reduced survival resulting from fishing, and population fragmentation resulting from dams/impoundments and other barriers (Table 2). The likelihood and severity of individual threats may vary by MU. All other threats that have been identified for other DUs in Canada are relatively unimportant or their impacts are unknown in DU5. The timeframe and impacts of climate change are unknown.

## LIMITING FACTORS FOR POPULATION RECOVERY

The Lake Sturgeon possesses several intrinsic or evolved biological characteristics that make this species susceptible to over-exploitation and habitat changes and may naturally influence or limit potential for recovery: (1) slow growth and late maturation, (2) intermittent spawning intervals, (3) specific temperature, flow velocities and substrate requirements to ensure uniform hatching and high survival of eggs and (4) high fidelity to spawning areas. The early age-0 stage (transition from larvae to exogenous feeding) is a critical life stage for Lake Sturgeon.

## MITIGATION, ALTERNATIVES AND ENHANCEMENTS

As with the impacts of threats, suggested mitigations and alternatives can also differentially affect survival or productivity of certain life stages. Vélez-Espino and Koops (2009) examined the effects of five hypothetical recovery scenarios that represented positive and increasing impacts on the Lake Sturgeon vital rates derived from habitat rehabilitation, stocking, modified fishing regulations, and improved fish passage at barriers. They used a stage-structured projection matrix with five life stages. Young-of-the-year, referred to as age-0 in this document, was the stage from eggs to age-1. The juvenile stage was defined as the period from the end of the first year to the mean age at first maturity, with the early and late juvenile stages being the first and second half of this period. The early and late adult stages referred to the first and second half of the adult period, respectively, and covered the period from mean age at first maturity to maximum reproductive age where TL is 95% of asymptotic length. Their modelling results indicated that even if the main causes of population decline are removed from Lake Sturgeon in DU5, geometric mean population growth rates will continue to show declining abundances. The Lake Sturgeon in this DU is highly sensitive to harm with early adults most sensitive, followed by late juveniles, late adults, early juveniles and age-0 (in decreasing order).

Fishing mortality, one of the main causes of population decline in DU5, has been largely eliminated over the past few decades. Contrary to the modelling results, recent research in DU5 suggests that the Lake Sturgeon is showing signs of recovery in at least two MUs (i.e., 5 and 6). While this is encouraging, the modelling results highlight the importance of reducing mortality on adults and late juveniles (e.g., from fishing) as the key to recovering this DU, and indicate that any recovery measures that maximize survival of these stages will increase the likelihood of, or shorten the time to, recovery (Vélez-Espino and Koops 2009). While elimination of mortality to early adults and late juveniles can produce significant improvements in recovery timeframes, the potential for improving survival of early adults is low relative to the potential in age-0 and young juveniles (Table 3) (Vélez-Espino and Koops 2009). Therefore, the possibility of implementing recovery strategies that improve age-0 and juvenile survival (e.g., habitat rehabilitation) should also be considered. For example, in some circumstances it may be possible and desirable to improve age-0 and young juvenile survival by capturing pre-spawn adult Lake Sturgeon, stripping them of their eggs and sperm, fertilizing and hatching the eggs, and raising the larvae to fingerlings before releasing them back into their natal waters. Conservation stocking programs must address potential impacts on genetic variability, artificial selection and transmission of disease from cultured to native fish (LaPatra *et al.* 1999). In an effort to conserve genetic variability in the native population, a better alternative would be to capture drifting larval fish or fertilized eggs and raise them in onsite facilities prior to release. While conservation stocking using fish from the same genetic stock has the potential to improve survival of age-0 and young juvenile fish, it should be undertaken only after careful consideration and as part of a comprehensive conservation stocking strategy for the DU, not a substitute for other effective mitigation measures or alternates outlined in this document.

Fertility rates in both early and late adult stages are less sensitive to perturbation. Although eliminating or mitigating threats to adult mortality would have a substantially greater impact on recovery than threats that cause impacts on reproduction (e.g., denial of access to spawning through dams and barriers) (Vélez-Espino and Koops 2009), continuous and intense recruitment failure caused by blocking spawning migration by dams and barriers or habitat degradation can still produce more apparent population constraints than adult mortality (Jager *et al.* 2007). Complete blockage of spawners at barriers can eradicate a population in a generation from continuous reproductive failure and strong site fidelity for spawning (Swanson *et al.* 1991, Rusak and Mosindy 1997).

Table 4 provides an inventory of possible mitigation measures, alternatives and enhancements to anthropogenic activities that pose threats to Lake Sturgeon survival and recovery. The mitigations/alternatives/enhancements for the most important threats for DU5, as identified in Table 2, are explained more fully below.

**<u>Mitigations and alternatives</u>**

<u>Habitat degradation or loss: industrial activities</u>

- Prevent significant sedimentation, especially during winter or spring.
- Minimize release of contaminants.
- Prevent significant changes in water temperature, total gas pressure, salinity or nutrient concentrations.
- Prevent removal of substrates of coarse gravel, cobble, boulders, hardpan or sand in known or suspected spawning areas.
- Prevent significant changes in water flow, especially during spring (when spawning and rearing occur).
- Rehabilitate habitat in key areas to mitigate habitat degradation or loss of important habitat (e.g., spawning sites) and to improve age-0 and juvenile survival.
- Protect spawning and rearing habitat.

Habitat degradation or loss: dams/impoundments and other barriers

- Adjust water management operating conditions of dams/impoundments and other barriers for those currently in place and those planned in the future to optimize the survival and recovery of Lake Sturgeon, especially during the spawning and incubation periods.
- Rehabilitate habitat in key areas to mitigate habitat degradation or loss of important habitat (e.g., spawning sites) and to improve age-0 and juvenile survival.
- Ensure design of new dams and modernization of existing dams does not jeopardize the survival and recovery of Lake Sturgeon (e.g., consider possible need for fish passage).
- Protect spawning and rearing habitat.

Sturgeon culture: genetic contamination

- Develop an effective and controlled stocking policy/plan (for the entire DU) before any stocking is undertaken.
- In areas where stocking of Lake Sturgeon is undertaken, ensure the broodstock, eggs and/or larval fish are from the local population (i.e., same genetic stock).

Mortality, injury or reduced survival: fishing

- Educate the public about the importance of Lake Sturgeon and what measures they can take to prevent over-exploitation.
- Ensure effective enforcement of regulations.
- Immediate release of bycatch to promote survivability.
- Regulate or encourage fishing practices that improve fish survival for catch-and-release fisheries, such as cutting lines of deeply-hooked fish, tight-line fishing, and minimizing “playing” and handling of hooked fish.
- Consider closure (e.g., conservation closures, closed seasons and areas), or at least reduce mortality, for adults through the use of legal size limits.

Mortality, injury or reduced survival: population fragmentation

- Prevent any additional fragmentation.
- Provide effective upstream and downstream fish passage for Lake Sturgeon at new dams and modernization of existing dams if necessary.
- Remove barriers that prevent Lake Sturgeon from migrating to known historical spawning sites, or provide effective upstream and downstream fish passage at current barriers if necessary.
- Rehabilitate habitat in key areas to mitigate habitat degradation or loss of important habitat (e.g., spawning sites) and to improve age-0 and juvenile survival.
- Select the most appropriate design option for new dams and modernization of existing dams to ensure Lake Sturgeon survival and recovery is not jeopardized.

## Enhancements

The following population enhancements could be considered supplementary measures to the mitigations and alternatives indicated above.

- Enhance age-0 and young juvenile survival through a conservation stocking program that does not introduce disease or reduce the genetic fitness of naturally-reproducing Lake Sturgeon.

## ALLOWABLE HARM

Decisions about whether harm from human-induced mortality and habitat modifications is allowable are informed by the potential for recovery and the impact of human activities as well as alternate and mitigation measures to those activities. Vélez-Espino and Koops (2009) modelled allowable harm for DU5. They reported that even if the main causes of population decline are removed, the minimum recovery efforts for individual vital rates that would be necessary to reverse declines in abundance would be approximately 4.7-27.2% increments in adult survival, 18.2-35.8% in juvenile survival, 39.7% in age-0 survival and 62.4-136.1% in fertility rates (Table 3). It is not feasible to increase survival rates sufficiently for late adults and fertility rates for early and late adults to achieve recovery (Table 3).

Negative impacts associated with habitat degradation or loss resulting from industrial activities and dams/impoundments and other barriers, genetic contamination from stocking, fishing and population fragmentation, resulting from dams/impoundments and other barriers, currently pose the most significant threats to the long-term survival and recovery of Lake Sturgeon in DU5, although their importance varies by MU. Dams and other barriers, and habitat degradation, have the potential to negatively impact all three life stages while fishing focuses on juveniles and adults. It may be possible to estimate harm resulting from threats such as entrainment, impingement, turbine mortality and fishing but assessing the levels of harm resulting from threats such as changes in flow regime, and habitat fragmentation and degradation, are more difficult to quantify.

While modelling allowable harm at the DU level provides useful information, careful examination of conditions within an MU is necessary to fully assess the level of risk posed by harm from human-induced mortality and habitat modifications. Current status and trend of MUs 1, 2, 8 and 9 (Table 1) is unknown thus harmful activities may pose a high to very high risk to survival or recovery of Lake Sturgeon. Available data and expert opinion indicate that the current status of MUs 3 and 4 is critical (Table 1), so activities that damage or destroy functional components of habitat or key life components of the life cycle (e.g., spawning, recruitment and survival) pose a very high risk to survival or recovery of any remaining populations in those MUs, at least in the case of MU3 until there is evidence that the stocked fish have become successfully established (e.g., successful reproduction). In MU7, current status is thought to be cautious but trend is unknown, thus harmful activities pose a high risk to populations. In MU6, current status and trend are thought to be healthy and stable, so harmful activities may pose a moderate risk to survival or recovery. In MU5, current status and trend are healthy and stable or increasing, and the population could be near carrying capacity, but spawning and overall habitat is limited thus harmful activities may pose a moderate risk to survival or recovery. Allowable harm in DU5 should be assessed on a case-by-case basis, keeping in mind the cumulative effects of all threats to the DU, to ensure that survival and recovery of Lake Sturgeon are not jeopardized.

Research activities should be allowed if they are beneficial to the species and would not jeopardize the survival or recovery of an MU.

## DATA AND KNOWLEDGE GAPS

The relationship between key life history stages and habitat in DU5 needs to be better understood. Obtaining reliable estimates of population size, population growth rate and harvest in each MU is a high priority. Surveys are needed to identify where spawning and feeding occur and whether access to, and the quantity and quality of spawning habitat, for individual MUs is sufficient. The habitat needs of age-0 and juvenile Lake Sturgeon should be better understood. Determination of the impact of altered flow regimes and other environmental factors on egg, larval and juvenile survival, and corresponding mitigation measures would be useful. The additive or cumulative effects of multiple dams/impoundments and barriers on Lake Sturgeon populations also should be investigated. MVP modelling needs to be updated as new knowledge about vital rates is obtained for each MU.

**SOURCES OF UNCERTAINTY**

For almost a century, Lake Sturgeon ages have been estimated by counting annuli in transverse sections of pectoral fin rays. Recently the accuracy of this ageing technique and others were tested using bomb radiocarbon ($^{14}C$) assays (Bruch *et al.* 2009). Age estimates made using growth increments on pectoral fin spine cross sections were found to underestimate the true age of fish older than 14 years and error increased with age; the average difference was -4.96 ± 4.57 years, and ranged from +2 to -17 years (Bruch *et al.* 2009). A correction factor has been developed to correct existing age estimates obtained using this method, though validation studies are needed to determine whether there are differences among populations.

Some uncertainties may exist regarding the Lake Sturgeon vital rates used in the MVP modelling. For example, the vital rates data may not have been specific to the DU being modelled, recent unpublished data may not be available or assumptions used in the model (e.g., a balanced sex ratio) may not accurately represent current conditions for that DU.

Assessing population size for Lake Sturgeon is difficult given the behaviour and ecology of the species. This makes it difficult to determine whether recovery targets are being met.

## CONCLUSIONS

Nine Lake Sturgeon MUs have been identified in DU5: MU1 is the Wabigoon River, MU2 is the English River downstream of Manitou Falls, MU3 is the Winnipeg River between Norman GS and Whitedog Falls GS, MU4 is between Caribou Falls GS and Whitedog Falls GS and Pointe du Bois GS, MU5 between Pointe du Bois GS and Slave Falls GS, MU6 between Slave Falls GS and Seven Sisters GS, MU7 between Seven Sisters GS and McArthur GS, MU8 between McArthur GS and Great Falls GS and MU9 between Great Falls GS and Pine Falls GS

Over the past century, Lake Sturgeon in DU5 declined as a result of over-exploitation from commercial fisheries and, more recently, from degradation or loss of a significant portion of their habitat. Current data indicate that there are several thousand adult Lake Sturgeon in this DU and that juveniles are abundant in some areas. There is evidence of population recovery in some MUs.

Available data and expert opinion indicate that current status is critical in MUs 3 and 4 and population trajectory is decreasing in MU3 and unknown or possibly decreasing in MU4. The status of MU7 is cautious and population trajectory is unknown. MUs 5 and 6 are both healthy and population trajectory is stable or increasing in MU5 and stable in MU6. The status and population trajectories of MUs 1, 2, 8 and 9 are unknown.

Survival and recovery of Lake Sturgeon in DU5 depends on maintaining the functional attributes of habitat, including the ecologically-based flow regimes, needed for spawning, egg incubation, juvenile rearing, summer feeding and overwintering, as well as migration routes between these habitats. It is essential that conditions that optimize the survival and recovery of Lake Sturgeon be maintained, especially during the spawning and incubation periods.

The long-term recovery goal for DU5 is to protect and maintain healthy, viable populations of Lake Sturgeon in the English River (MU2) and the Winnipeg River (MUs 3-9). To reach this goal, each MU must have at least 413 spawning females each year (i.e., 4,130 adults) and at least 1,886 ha of suitable riverine habitat or 3,772 ha of suitable lake habitat. The aim is to reach these population and distribution objectives within three generations (i.e., about 108 years). If a less precautionary recovery target is chosen, the number of spawning females per year would be reduced and years to recovery increased accordingly. If the Lake Sturgeon is found in the Wabigoon River, then recovery efforts should be undertaken.

The most important current threats to survival and recovery of Lake Sturgeon in DU5 are habitat degradation or loss resulting from industrial activities and dams/impoundments and other barriers, genetic contamination resulting from stocking, mortality, injury or reduced survival resulting from fishing, and population fragmentation resulting from dams/impoundments and other barriers. The likelihood and severity of individual threats may vary by MU. The timeframe and impacts of climate change are unknown.

A variety of mitigation measures and alternatives could be implemented to aid in the survival and recovery of Lake Sturgeon in DU5 including protecting spawning and rearing habitat, minimizing activities that cause habitat degradation or loss, rehabilitating habitat in key areas, reducing impacts of the catch-and-release recreational fishery and poaching in Manitoba through education and effective enforcement and ensuring no genetic contamination. Conservation stocking using fish from the same genetic stock may be a useful enhancement tool as part of a comprehensive conservation stocking strategy for the DU and when combined with mitigation measures and alternatives.

Activities that damage or destroy functional components of habitat or key life components of the life cycle pose a very high risk to the survival or recovery of Lake Sturgeon in MUs 3 and 4, high to very high risk in MUs 1, 2, 8 and 9, high risk in MU7 and moderate risk in MUs 5 and 6. Research activities should be allowed in DU5 if they are beneficial to the species and would not jeopardize the survival or recovery of a Lake Sturgeon MU.

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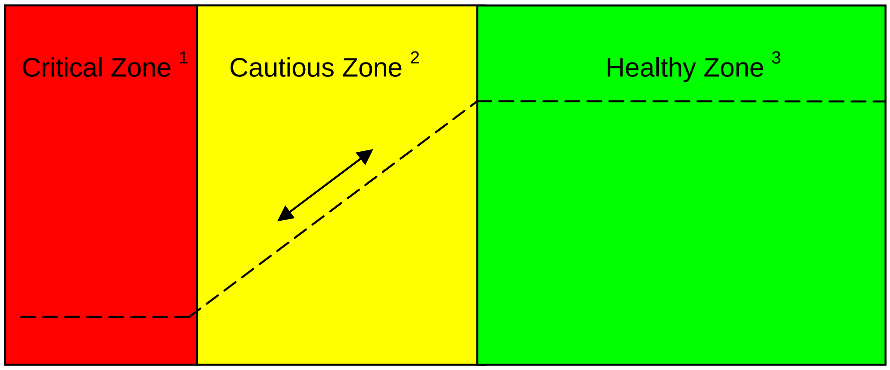
*Figure 1. DU5 showing locations of MUs and place names mentioned in text.*




**STOCK STATUS**

[1] The Critical zone is where stock biomass is evaluated as being at or below a level where there is a high risk of serious or irreversible harm to stock productivity.

[2] The Cautious zone reflects uncertainty about the estimation of annual stock status and the biomasses at which stock productivity begins to decline and becomes at risk of serious or irreversible harm.

[3] The Healthy zone is where stock biomass is evaluated as being within the historical range of the stock when it was healthy.

*Figure 2. Conservation status of a stock or population based on the framework for the application of the precautionary approach (adapted from DFO 2005).*

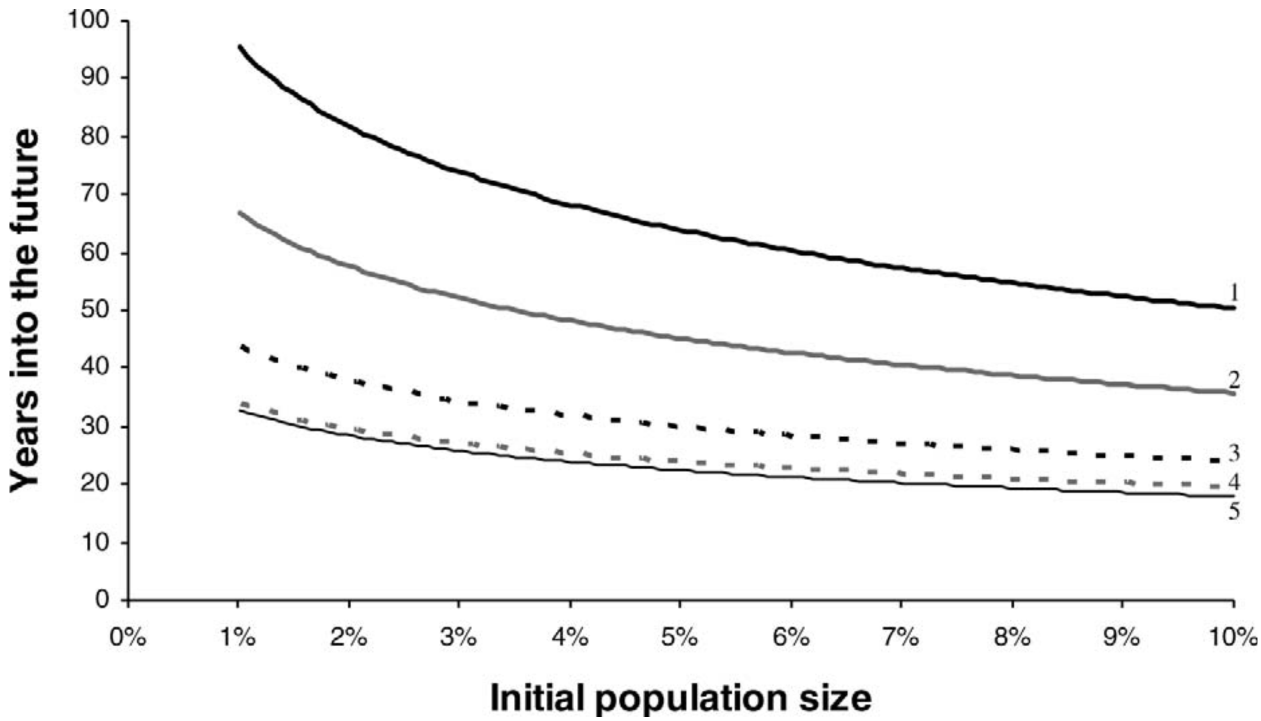



*Figure 3. Stochastic projections of times to recovery for Lake Sturgeon based on initial population size (i.e., percentage of MVP) under five different recovery scenarios. Strategy 1 (solid black line) was the maximization of the survival rates of early adults, strategy 2 (solid grey line) added a 10% increase in the survival rates of late juveniles, strategy 3 (black dotted line) added a 20% increase in the survival rates of age-0 and early juveniles, strategy 4 (dotted grey line) added the maximization of the survival rate of late adults, while strategy 5 (black dashed line) added a 20% increase in fertility. Initial population size is expressed as a percentage of the recovery target (from Figure 8 in Vèlez-Espino and Koops 2009)*

*Table 1. Assessment of the current conservation status, population trajectory, overall importance to species recovery and recovery potential of the nine Lake Sturgeon Management Units (MUs) in the Winnipeg River-English River system. Conservation status (Figure 2) was based on the best available information and Precautionary Framework (DFO 2005); population trajectory was rated as Unknown, Stable, Increasing or Decreasing; importance to species recovery evaluates the importance of the MU to the overall recovery of Lake Sturgeon within DU5. For example, if a DU contained only one Lake Sturgeon MU whose conservation status was considered to be Healthy, then its importance to species recovery would be rated high as catastrophic loss of that MU would result in extirpation of the DU. Recovery potential is based on a combination of current conservation status and current threats status. Importance to species recovery and Recovery potential were rated as Nil, Low, Moderate, High or Unknown.*

| MU | Location | Conservation status | Population trajectory | Importance to DU recovery | Recovery potential |
|---|---|---|---|---|---|
| 1 | Wabigoon River | Unknown | Unknown | Unknown | Unknown |
| 2 | Manitou Falls GS – Caribou Falls GS | Unknown | Unknown | Unknown | Unknown |
| 3 | Norman GS – Whitedog Falls GS | Critical[1] | Decreasing | Moderate[2] | Low |
| 4 | Caribou Falls GS and Whitedog Falls GS – Pointe du Bois GS | Critical | Unknown or Possibly Decreasing[3] | High | Moderate |
| 5 | Pointe du Bois GS – Slave Falls GS | Healthy | Stable or Increasing | High | Low/High[4] |
| 6 | Slave Falls GS – Seven Sisters GS | Healthy | Stable | High | High |
| 7 | Seven Sisters GS – McArthur GS | Cautious | Unknown | Moderate or High | Unknown |
| 8 | McArthur GS – Great Falls GS | Unknown | Unknown | Moderate | Unknown |
| 9 | Great Falls GS – Pine Falls GS | Unknown | Unknown | Moderate | Unknown |

[1] Remnant population remains and the stocked fish have not yet reached reproductive age.
[2] Stocking occurs and has value to species recovery in DU5.
[3] There is evidence of recruitment.
[4] Low in terms of the recommended modelling recovery targets and high relative to the carrying capacity of the available habitat.

*Table 2. Current status of threats to Lake Sturgeon in DU5 by Management Unit (MU), defined in terms of the likelihood of occurrence followed by level of severity, based on current knowledge of the MUs and the areas in which they occur. (0=Nil, L=Low, M=Moderate, H=High, U=Unknown). Status in Manitoba (MB) and Ontario (ON) were noted if different. The most important threats are highlighted. Note: In cases where a man-made barrier occurs at the start (upstream end) of an MU, it is included in the MU. For example, Pointe du Bois GS is included in MU5.*

| THREATS | Wabigoon River | Manitou Falls GS – Caribou Falls GS | Norman GS – Whitedog Falls GS | Caribou Falls and Whitedog Falls GSs – Pointe du Bois GS | Pointe du Bois GS – Slave Falls GS | Slave Falls GS – Seven Sisters GS | Seven Sisters GS – McArthur GS | McArthur GS – Great Falls GS | Great Falls GS – Pine Falls GS |
|---|---|---|---|---|---|---|---|---|---|
| | MU1 | MU2 | MU3 | MU4 | MU5 | MU6 | MU7 | MU8 | MU9 |
| **Mortality, injury or reduced survival** | | | | | | | | | |
| Entrainment, impingement and turbine mortality (e.g., from hydroelectric dams and other barriers, urban or irrigation intakes) | L,L | L,L | L,L | L,L | L,L | L,L | L,L | L,U | L,U |
| Population fragmentation (e.g., from dams/impoundments and other barriers) | U,U | 0,0 | L,L | L,L | M,M | M,L | M,L | U,U | U,U |
| Fishing: commercial net (bycatch) | U,U | L,L | L,L | L,L (ON) 0,0 (MB) | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| Fishing: domestic / subsistence | U,U | L,L | M,M[1] | M,M[1] | L,0[1] | L,0[1] | L,0[1] | L,0[1] | L,0[1] |
| Fishing: recreational / commercial tourism | 0,0 | 0,0 | 0,0 | 0,0 (ON) L,0 (MB)[1] | H,L | H,L | H,L | H,L | M,L |
| Fishing: illegal harvest | L,L | L,L | L,L | L,L | L,L | H,M | L,L | L,L | L,L |
| **Habitat degradation or loss[2]** | | | | | | | | | |
| Dams/impoundments and other barriers (e.g., hydroelectric dams or water control structures) | H,M | H,M | H,M | H,M | H,L | H,L | H,L | H,L | H,L |
| Industrial activities (including oil and gas, and pulp and paper) | H,H | 0,0 | H,H | L,L[3] | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| Forestry exploration/ extraction | H,L | H,L | H,L | H,L (ON) 0,0 (MB) | 0,0 | 0,0 | L,L | L,U | L,U |
| Mining exploration/extraction | M,U | M,U | M,U | M,U | M,U | M,U | H,U | M,U | M,U |
| Agricultural activities | M,U | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | H,L | H,L | H,L |
| Urban development | M,U | 0,0 | M,U | 0,0 | L,L | M,L | M,L | M,L | M,L |
| **Sturgeon culture** | | | | | | | | | |
| Genetic contamination | 0,0 | 0,0 | H,M | 0,0 | L,L | M,M | M,M | L,L | L,L |
| Disease | U | U | U | U | U | U | U | U | U |
| **Non-indigenous and invasive species** | H,L | H,L | H,L | H,L | H,L | H,L | H,L | H,L | H,L |
| **Climate change[4]** | U | U,U | U,U | U,U | U,U | U,U | U,U | U,U | U,U |

[1] Fishery does not target Lake Sturgeon.
[2] Examples: changes in flow regime, water temperature, concentrations of sediments, nutrients and contaminants, habitat structure and cover, food supply and migration/access to habitat, surface hardening and pollution.
[3] Caribou Falls GS to the mainstem is 0,0.
[4] Examples: changes in water temperature, patterns of precipitation, river morphology and hydrology.

*Table 3. Minimum recovery effort and maximum allowable harm with respect to annual survival and fertility of Lake Sturgeon in DU5 based on results of modelling (Vélez-Espino and Koops 2009). Minimum recovery effort indicates the minimum increase in vital rates necessary to stabilize or stimulate population growth. Maximum allowable harm indicates the maximum reduction in survival or fertility rates in a population that can occur while still allowing the population to recover, once the main causes of population decline are removed. These percentages are not additive.*

| Vital Rates | Minimum Recovery Effort | Maximum Allowable Harm |
|---|---|---|
| Age-0 survival | 39.7%[1] | 0% |
| Early juvenile survival | 35.8%[1] | 0% |
| Late juvenile survival | 18.2%[1] | 0% |
| Early adult survival | 4.7%[1] | 0% |
| Late adult survival | 27.2%[2] (12.0%[3]) | 0% |
| Early adult fertility | 136.1%[1] (18.3%[3]) | 0% |
| Late adult fertility | 62.4%[1] (7.2%[3]) | 0% |

[1] Value generated by the stochastic DU5 model.

[2] Value generated by the stochastic-generic model, which incorporated values for DUs 2, 4 and 5, resulting in a more precautionary value than was produced by the stochastic DU5 model.

[3] Maximum proportional increase possible, thus it is not feasible to increase this vital rate sufficiently for recovery.

*Table 4. Possible mitigations and alternatives to threats to ensure that activities (including structures) do not jeopardize the survival and recovery of Lake Sturgeon.*

| Threats | Mitigations and Alternatives | Life stage enhanced |
|---|---|---|
| **Habitat degradation or loss[1]** | | |
| Dams/impoundments and other barriers | Follow ecologically-based flow regimes for key life stages to optimize conditions especially during spawning, incubation and larval drift periods | Age-0[2], eggs |
| | Protect spawning and rearing habitat at new and existing dams and other barriers | Age-0[2], eggs |
| | Select the most appropriate design option for new structures, or those being modernized, to enhance survival and recovery | All |
| | Rehabilitate habitat in key areas | All |
| Industrial activities (including oil and gas), forestry and mining exploration/extraction | Prohibit activities that cause significant sedimentation especially during winter or spring | Age-0[2], eggs |
| | Prohibit activities that cause removal of substrates in known or suspected spawning areas | Age-0[2], eggs |
| | Prohibit activities that cause significant changes in water flows especially during spring | Age-0[2], eggs |
| | Prohibit activities that cause significant changes in water temperature, total gas pressure, salinity or nutrient concentrations | All |
| Agricultural activities | Prohibit activities that cause significant sedimentation especially during winter or spring | Age-0[2], eggs |
| | Prohibit activities that cause removal of substrates in known or suspected spawning areas | Age-0[2], eggs |
| | Prohibit activities that cause significant changes in water flows especially during spring | Age-0[2], eggs |
| | Prohibit activities that cause significant changes in water temperature, total gas pressure, salinity or nutrient concentrations | All |
| | Minimize release of contaminants | All |
| Urbanization | Enforce discharge limits on potential pollutants | All |
| | Improve effluent from water treatment plants | All |
| | Increase protection during work permit reviews | All |
| | Protect spawning and rearing habitat | Age-0[2], eggs |
| | Rehabilitate habitat in key areas | All |

[1] Examples: changes in flow regime, water temperature, concentrations of sediments, nutrients and contaminants, habitat structure and cover, food supply and migration/access to habitat, surface hardening and pollution.
[2] Age-0 survival could also be enhanced through conservation stocking (see Mitigation, Alternatives and Enhancements section for explanation).

*Table 4. (Continued)*

| Threats | Mitigations and Alternatives | Life stage enhanced |
|---|---|---|
| **Mortality, injury or reduced survival** | | |
| Entrainment, impingement and turbine mortality (e.g., from hydroelectric dams and other barriers, urban or irrigation intakes) | Provide protection measures to exclude Lake Sturgeon from passing through facility intakes | All |
| | Provide effective upstream and downstream passage[3] | All |
| | Select the most appropriate design option for new structures, or those being modernized, to enhance survival and recovery | All |
| Population fragmentation (e.g., from dams/impoundments and other barriers) | Prevent any additional fragmentation | All |
| | Provide effective upstream and downstream passage[3] at new dams and modernization of existing dams if necessary | Age-0[2], eggs |
| | Remove barriers to migration to known historical spawning sites or provide effective upstream or downstream fish passage at current barriers if necessary | Age-0[2], eggs |
| | Rehabilitate habitat in key areas | All |
| Fishing[4] | Regulate or encourage practices that improve fish survival | Late juvenile, both adult stages |
| | Ensure immediate release of bycatch | All juvenile and adult stages |
| | Close fishing by season and/or area, or modify fishing practises | All juvenile and adult stages |
| | Improve public education | Late juvenile, both adult stages |
| | Ensure effective enforcement of regulations | Late juvenile, both adult stages |
| **Sturgeon culture** | | |
| Genetic contamination | Develop effective and controlled stocking policy/plan | All |
| | Ensure broodstock, fertilized eggs and/or larval fish are from the same genetic stock | All |
| Disease | Monitor for bacteria and viruses | All |
| **Non-indigenous and invasive species[5]** | | |
| | Monitor non-indigenous and invasive species | All |
| | Ban use of live bait | All |
| | Establish measures to prevent introduction or spread | All |
| **Climate change[6]** | | |
| | Monitor environmental changes | All |

[3] Examples: construction of a fishway, partial dismantling or removal of barriers.
[4] Commercial net (bycatch), domestic/subsistence, recreational/commercial tourism and illegal harvest.
[5] Examples: Common Carp (*Cyprinus carpio*), Zebra Mussels (*Dreissena polymorpha*), Rainbow Smelt (*Osmerus mordax*) and Rusty Crayfish (*Orconectes rusticus*).
[6] Examples: changes in water temperature, concentrations of sediments, nutrients and contaminants, habitat structure and cover, food supply and migration/access to habitat, surface hardening and pollution.