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Information Relevant to a Recovery Potential Assessment of Lake Sturgeon: Western Hudson Bay Populations (DU1)

Renseignements pertinents pour l'évaluation du potentiel de rétablissement de l'esturgeon jaune : populations de l'ouest de la baie d'Hudson (UD 1)

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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) 1, the Western Hudson Bay populations, includes Lake Sturgeon in the Churchill River system of northern Manitoba and Saskatchewan. COSEWIC assessed and designated DU1 as Endangered, as Lake Sturgeon in this DU declined severely over the past century. Historically, over-exploitation from commercial fisheries was the primary threat, whereas more recently habitat degradation or loss associated with dams/impoundments and other barriers, and domestic/subsistence fisheries, have become the most important threats.

DU1 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 DU1, 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 DU1 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.

Three Lake Sturgeon Management Units (MUs) have been identified for DU1. The current conservation status of MU1 is unknown, MU2 is likely critical and MU3 is cautious. Population trajectories of all three MUs are unknown. MU2 is thought to have moderate potential for recovery, while MU3 is thought to have low potential for recovery as a result of habitat limitations. The recovery potential of MU1 is unknown. There are estimated to be at least 1,300 adults in the lower Churchill River. The long-term recovery goal for DU1 is to protect and maintain healthy, viable populations of Lake Sturgeon in all 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) 1, à savoir les populations de l’ouest de la baie d’Hudson, comprend les esturgeons jaunes présent dans le réseau hydrographique de la rivière Churchill du nord du Manitoba et de la Saskatchewan. Le COSEPAC a évalué l’UD 1 et l’a désignée comme étant en voie de disparition, car l’esturgeon jaune a connu un grave déclin au cours du siècle dernier. Historiquement, la surexploitation par la pêche commerciale était la principale menace; toutefois, plus récemment, la dégradation ou la perte d’habitat causée par les barrages, les ouvrages de retenue et autres obstacles ainsi que les pêches canadiennes et de subsistance sont devenues les menaces les plus importantes.

On étudie la possibilité d’inscrire l’esturgeon jaune de l’UD 1 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 1 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 1. 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 trois unités de gestion (UG) de l’esturgeon jaune pour l’UD 1. L’état de conservation actuel de l’UG 1 demeure inconnu, tandis qu’il est vraisemblablement critique pour l’UG 2 et se situe dans la zone de prudence pour l’UG 3. Les trajectoires des populations des trois UG demeurent elles aussi inconnues. On estime que l’UG 2 affiche un potentiel de rétablissement modéré, mais que l’UG 3 a un faible potentiel de rétablissement en raison de limites relatives à l’habitat. Le potentiel de rétablissement de l’UG1 demeure, quant à lui, inconnu. Selon les estimations, il y aurait au moins 1300 adultes dans le cours inférieur de la rivière Churchill. Dans l’UD 1, le but du rétablissement à long terme est de protéger et de maintenir des populations d’esturgeons jaunes en santé et viables dans l’ensemble des 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). DU1 includes Lake Sturgeon in the Churchill River system of northern Manitoba and Saskatchewan (Figure 1). COSEWIC assessed and designated this DU as Endangered in November 2006 (COSEWIC 2006). The Lake Sturgeon 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 DU1, 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). 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.). 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). 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). Further, some mark-recapture and acoustic telemetry data from DU5 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 occurs in May and/or June, once waters are free of ice. 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). 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

From its headwaters near the eastern edge of central Alberta to where it empties into Hudson Bay in northeastern Manitoba, the Churchill River is 1,609 river km in length. DU1 includes the Churchill River system of northern Manitoba and Saskatchewan (Figure 1). Lake Sturgeon may also occur in the river systems north along the western Hudson Bay coast but there are no published reports to substantiate this. The Lake Sturgeon in this region is considered a distinct designatable unit on the basis of their presence in the Western Hudson Bay ecozone, a biogeographically distinct region (COSEWIC 2006).

Operation of the Island Falls Generating Station (GS) in Saskatchewan beginning in 1930 and the Missi Falls Control Structure (CS), and associated Churchill River Diversion, in 1976 potentially fragmented the distribution of Lake Sturgeon in DU1. However, it is not known if this is the case, as there were natural barriers at the dam locations that may have restricted Lake Sturgeon movements, and the Churchill River Diversion allowed Lake Sturgeon to move into the Burntwood and Nelson rivers thereby potentially opening up new habitat.

Three Lake Sturgeon MUs, separated from each other by man-made barriers, have been identified in DU1 (Figure 1): (1) from Kettle Falls to Island Falls GS, (2) from Island Falls GS to Missi Falls CS and (3) the lower Churchill River below Missi Falls CS. The man-made barrier at the start (i.e., upstream end) of an MU is included in the MU. For example, Island Falls GS is included in MU2. Within each of these MUs there may be one or more spawning stocks.

Scientific knowledge of the historic and current distribution of Lake Sturgeon within DU1 is, at best, limited. The Lake Sturgeon currently occurs in all three MUs and the area of occupancy is estimated to be < 300,000 km^2, though the trend in area, extent or quality of habitat is unknown (COSEWIC 2006).

Kettle Falls – Island Falls GS (MU1)

The Churchill River between Kettle Falls and the Island Falls GS is about 112 river km in length and consists of a series of lakes interconnected by riverine sections containing numerous sets of rapids. The Reindeer River is a large tributary of the Churchill River which drains Wollaston and Reindeer lakes and empties into the Churchill River just downstream of Kettle Falls. About 4.5 km upstream of the confluence of the Reindeer and Churchill rivers is Atik Falls which may be a barrier to Lake Sturgeon movement. Little or no historic scientific information is available for Lake Sturgeon in MU1. In recent decades, there have been reports of Lake Sturgeon as far upstream as Kettle Falls on the Churchill River and Atik Falls on the Reindeer River (Sawchyn 1975, R. Wallace, pers. comm.).

Island Falls GS – Missi Falls CS (MU2)

The Churchill River between the Island Falls GS and the Missi Falls CS (MU2) is about 430 river km in length and has similar environmental features to those described for MU1. The Missi Falls CS is located at the eastern end of Southern Indian Lake. Historically, Lake Sturgeon were reported near the community of Sandy Bay (Saskatchewan), which is located near a trading post called “Sturgeon House” that was in operation around 1800 (R. Wallace, pers. comm.). In the Manitoba portion of MU2, Lake Sturgeon were fished between Duck and Pukatawagan Lakes in the 1920s and later in the Churchill-Granville-Opachuanoa region (Skaptason 1926). In the past decade, two Lake Sturgeon were caught in test nets at Sandy Bay (M. Duffy, pers. comm.).

Lower Churchill River below Missi Falls CS (MU3)

The Churchill River below the Missi Falls CS (MU3) is about 440 river km in length and mostly riverine with numerous sets of rapids. Several tributaries, including the Little Churchill River, flow into the lower Churchill River. Lake Sturgeon are known to occur in the vicinity of the confluence of the Churchill and Little Churchill rivers (Cleator *et al.* 2010), but no historic scientific information is available.

HISTORIC AND CURRENT ABUNDANCE AND TRENDS

Little historic or recent abundance information is available for the Churchill River system (DU1). Lake Sturgeon in this DU declined severely over the past century as a result of over-exploitation. The historic landings data indicate that Lake Sturgeon throughout the Churchill River declined by over 90%, possibly by more than 98%, between the 1920s and 1939 (COSEWIC 2006). The life history traits of Lake Sturgeon recently harvested indicate a population that has been subject to over-exploitation and not recovered.

The current conservation status (Figure 2), based on the precautionary framework (DFO 2005), of each of the MUs in DU1 was evaluated on the basis of available information and expert opinion (Table 1).

Kettle Falls – Island Falls GS (MU1)

An historical harvest record of 14,425 kg Lake Sturgeon (marketed weight) from 1937 is reported for the Churchill River in Saskatchewan (Stewart 2009), but the harvest location is unknown. In recent decades, there has been no record of Lake Sturgeon farther upstream than Kettle Falls on the Churchill River or upstream of Atik Falls on the Reindeer River, and very small numbers have been caught by local fishers in MU1 (Sawchyn 1975, R. Wallace, pers. comm.). The current status and population trajectory of Lake Sturgeon in MU1 are both unknown (Table 1).

Island Falls GS – Missi Falls CS (MU2)

Historical and recent records for Lake Sturgeon are more common below Island Falls GS (in MU2), including the community of Sandy Bay, than above (in MU1) (R. Wallace, pers. comm.). In Manitoba, fishing in the Churchill River began in the winter of 1924/25, between Duck and Pukatawagan Lakes, with a limit (i.e., quota) of 100,000 lbs (45,359 kg) and later moved downstream to the Churchill-Granville-Opachuanoa region where Lake Sturgeon were reported to be larger and more abundant (Skaptason 1926).

In the 1980s, it was believed that Lake Sturgeon in this MU belonged to a remnant population (R. Wallace, pers. comm.). The most recent information available shows the few Lake Sturgeon reported were very large and probably very old; two were caught in test nets over a five-year period around 2003 from the upper Churchill River at Sandy Bay (M. Duffy, pers. comm.). The current status of Lake Sturgeon in MU2 is critical and population trend is unknown (Table 1).

Lower Churchill River below Missi Falls CS (MU3)

A population estimate of 1,812 ± 508 adults is available, based on a mark-recapture study conducted within a 28 km reach, at the confluence of the Churchill and Little Churchill rivers, in 2003 (MacLean and Nelson 2005). The estimate may be positively biased because some juveniles may have been included in the estimate. A few Cree Nation communities in the region harvest Lake Sturgeon for subsistence from this MU. There are estimated to be at least 1,300 mature individuals in the lower Churchill River, thus the current status of Lake Sturgeon in MU3 is thought to be cautious but the population trajectory is 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 (C. Barth, unpubl. data).

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).

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). Spawning is known to occur in the Little Churchill River.

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 $m \cdot s^{-1}$). 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 distribution of Lake Sturgeon in DU1 was almost certainly affected by the construction and operation of the Missi Falls CS and associated Diversion. While access to Lake Sturgeon habitat may have increased in MU2, MU3 underwent significant dewatering in 1976-77 which almost certainly caused a decline in the quantity and quality of Lake Sturgeon habitat there. It is essential that conditions that optimize the survival and recovery of Lake Sturgeon be maintained in DU1, 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. 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 DU1 would need at least 586 spawning females per year (i.e., 5,860 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 974 ha of suitable 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 DU1 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 DU1 is to protect and maintain healthy, viable populations of Lake Sturgeon in all MUs within the Churchill River system. To reach this goal, each MU must have at least 586 spawning females each year and at least 974 ha of suitable riverine habitat or 1,948 ha of suitable lake habitat. The aim is to reach these population and distribution objectives within three generations (i.e., 3 x 36 years = about 108 years).

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 DU1. 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) modelled 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). Without recovery actions, time to recovery would be significantly longer.

The recovery potential and importance to recovery of each of the three Lake Sturgeon MUs in DU1 was evaluated on the basis of available information (e.g., quantitative population data) and expert opinion (Table 1). In MU1, the potential for recovery of Lake Sturgeon and the importance of the MU to recovery in DU1 are both unknown as there is no scientific knowledge currently available (Table 1). No population estimate is available for MU2 but local knowledge and test netting indicates that it currently contains only a few Lake Sturgeon, thus recovery should be possible albeit slow. The potential for recovery is thought to be moderate and importance of MU2 to recovery high. MU3 likely contains at least 1,300 adult Lake Sturgeon but the population trajectory is unknown. The lower Churchill River below Missi Falls CS underwent significant dewatering since 1976-77 as a result of the Diversion. Recovery of Lake Sturgeon in MU3 may not be possible due to low flows, thus recovery potential is low, but the importance of MU3 to recovery in DU1 is thought to be high (Table 1).

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).

Mortality, injury or reduced survival resulting from fishing activities can pose a threat to Lake Sturgeon. In DU1, the Lake Sturgeon was commercially fished intermittently during the first half of the twentieth century, after which catches declined and only sporadic catches were reported despite continued fishing effort (SERM 1996). The high market value and vulnerability of Lake Sturgeon to the fishery led to over-exploitation from which they have not recovered. Aboriginal subsistence fishing may still occur throughout most of the DU but harvest records are not available. Sport fisheries also continue but any captured individuals must be released. Although the current levels of harvesting may be low, Lake Sturgeon populations are sensitive to the removal of juveniles and adults (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).

The Island Falls GS and Missi Falls CS have been in operation in DU1 for decades. Island Falls GS, located near Sandy Bay, began operation in 1930. The Missi Falls CS, at the eastern end of Southern Indian Lake (Manitoba), went into operation in 1976 causing the lake to increase about 3 m in depth and about 85% of the water that normally flowed into Southern Indian Lake and out through the Churchill River to be diverted into the Burntwood and Nelson rivers system (Federal Ecological Monitoring Program 1992) (Figure 1). The Churchill River Diversion resulted in significant dewatering of MU3, below the Missi Falls CS. The proposed Wintego Dam project in Saskatchewan, which would impound the Churchill River upstream of its confluence with Reindeer River (MU1), may still be under consideration. A proposed GS at Granville Falls (MU2), on the upper Churchill River above Granville Lake, may also be considered in the future.

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[1], impingement[2] 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 prevent passage of adult Lake Sturgeon through turbines.

In summary, the most important current threats to survival and recovery of Lake Sturgeon in DU1 are habitat degradation or loss, resulting from dams/impoundments and other barriers, and mortality, injury or reduced survival resulting from domestic/subsistence fisheries (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 DU1. 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 total length is 95% of asymptotic length. Their modelling results indicated that the Lake Sturgeon in DU1 is most sensitive to harm on early adults, followed by late adults, late juveniles, early juveniles and age-0 (in decreasing order).

These 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-

[1] Entrainment occurs when fish eggs and larvae are taken into a facility's water-intake systems, pass through and back to the water body.

[2] Impingement occurs when fish are trapped or pinned by the force of the intake flow against the intake.

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 and enhancements for the most important threats for DU1, as identified in Table 2, are explained more fully below.

Mitigations and alternatives

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.

Mortality, injury or reduced survival: fishing

- Immediate release of bycatch to promote survivability.
- Consider closure (e.g., conservation closures, closed seasons and areas), or at least reduce mortality, for adults through the use of legal size limits.

- Educate the public about the importance of Lake Sturgeon and what measures they can take to prevent over-exploitation.
- Ensure effective enforcement of regulations.

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 DU1. They reported that once the main causes of population decline are removed, maximum allowable harm should not exceed reductions of 1.0-1.3% in adult survival, 1.8-3.3% in juvenile survival, 6.1% in age-0 survival or 7.4-23.7% in fertility rates (Table 3).

Negative impacts associated with habitat degradation or loss from dams /impoundments and other barriers as well as domestic/subsistence fisheries, currently pose the most significant threats to the long-term survival and recovery of Lake Sturgeon in DU1, 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. There is no known published scientific information about the distribution or abundance of Lake Sturgeon in MU1 thus activities that damage or destroy functional components of habitat or negatively affect key life components of the life cycle (e.g., spawning, recruitment and survival) could pose a high to very high risk to survival or recovery of any remaining Lake Sturgeon populations. Available data and expert opinion for MU2 indicate the current status of Lake Sturgeon is critical and population trajectory is unknown, thus harmful activities pose a very high risk to survival or recovery. In MU3, the current conservation status is cautious as dewatering may limit the availability of habitat. The population trajectory and levels of harvest are unknown, so it is unknown whether the present harvest is sustainable. Given the paucity of data, harmful activities could pose a high level of risk to survival or recovery in MU3. Allowable harm in DU1 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 DU1 needs to be better understood as does the current level of domestic harvest. 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 of 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

Three MUs have been identified for DU1: MU1 is located between Kettle Falls and Island Falls GS, MU2 between the Island Falls GS and Missi Falls CS and MU3 between the Missi Falls CS and Hudson Bay.

Over the past century, Lake Sturgeon in DU1 declined primarily as a result of over-exploitation from commercial fisheries and degradation or loss of a significant portion of their habitat, especially in the lower Churchill River, as a result of dams/impoundments and other barriers. Limited data indicate there are very low numbers of Lake Sturgeon now present in MU2, and possibly MU1. There are estimated to be at least 1,300 adults in MU3.

Available data and expert opinion indicate the current conservation status of MU1 is unknown, MU2 is critical and MU3 is cautious. Population trajectories of all three MUs are unknown. The potential for recovery in MU1 is not known while MU2 is thought be moderate and MU3 is low as a result of habitat limitations.

Survival and recovery of Lake Sturgeon in DU1 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 DU1 is to protect and maintain healthy, viable populations of Lake Sturgeon in all MUs within the Churchill River system. To reach this goal, each MU must have at least 586 spawning females each year (i.e., 5,860 adults) and at least 974 ha of suitable riverine habitat or 1,948 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.

The most important current threats to survival and recovery of Lake Sturgeon in DU1 are habitat degradation or loss resulting from dams/impoundments and other barriers, and mortality, injury or reduced survival resulting from domestic/subsistence fisheries. 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 DU1 including protection of spawning and rearing habitat, minimizing activities that cause habitat degradation or loss, rehabilitating habitat in key areas and reducing impacts of the domestic/subsistence fishery to Lake Sturgeon. 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 negatively affect key life components of the life cycle pose a very high risk to the survival or recovery of Lake Sturgeon in MU2, high to very high risk in MU1 and a high risk in MU3. Research activities should be allowed in DU1 if they are beneficial to the species and would not jeopardize the survival or recovery of an MU.

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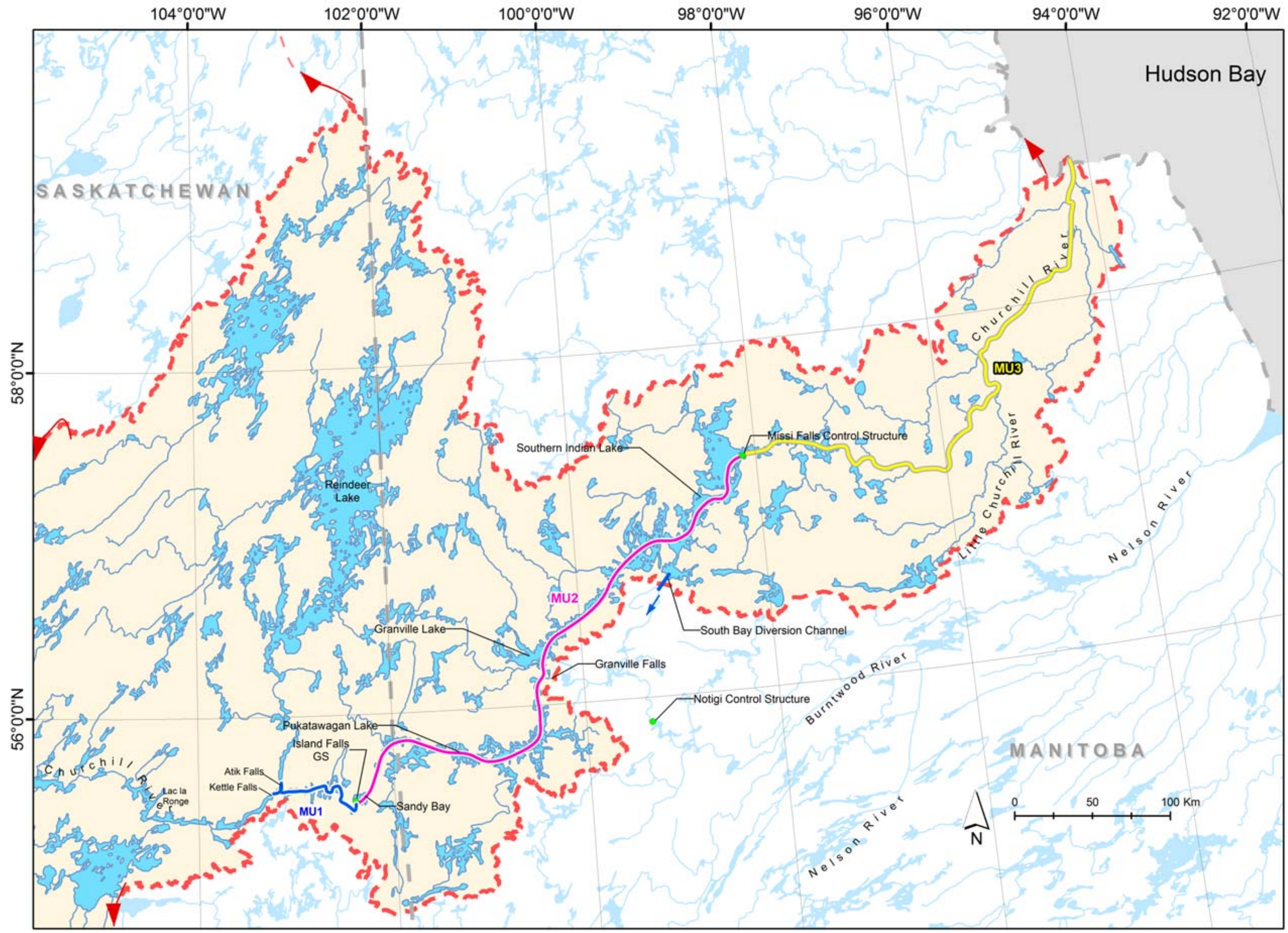
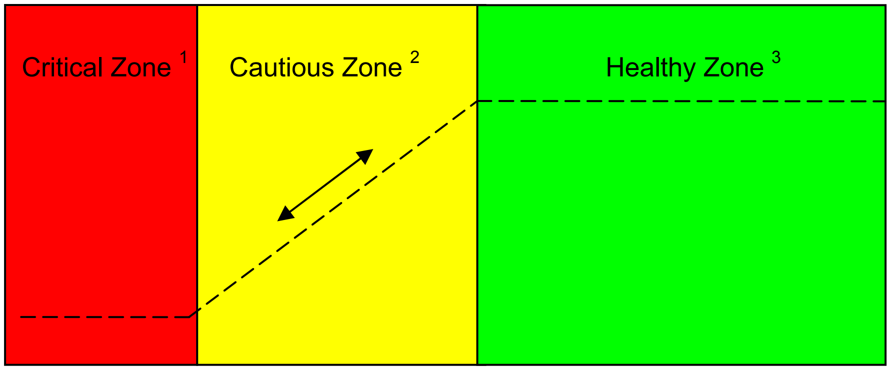


Figure 1. Churchill River system (shaded) within DU1 showing locations of MUs and place names mentioned in the text.



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).

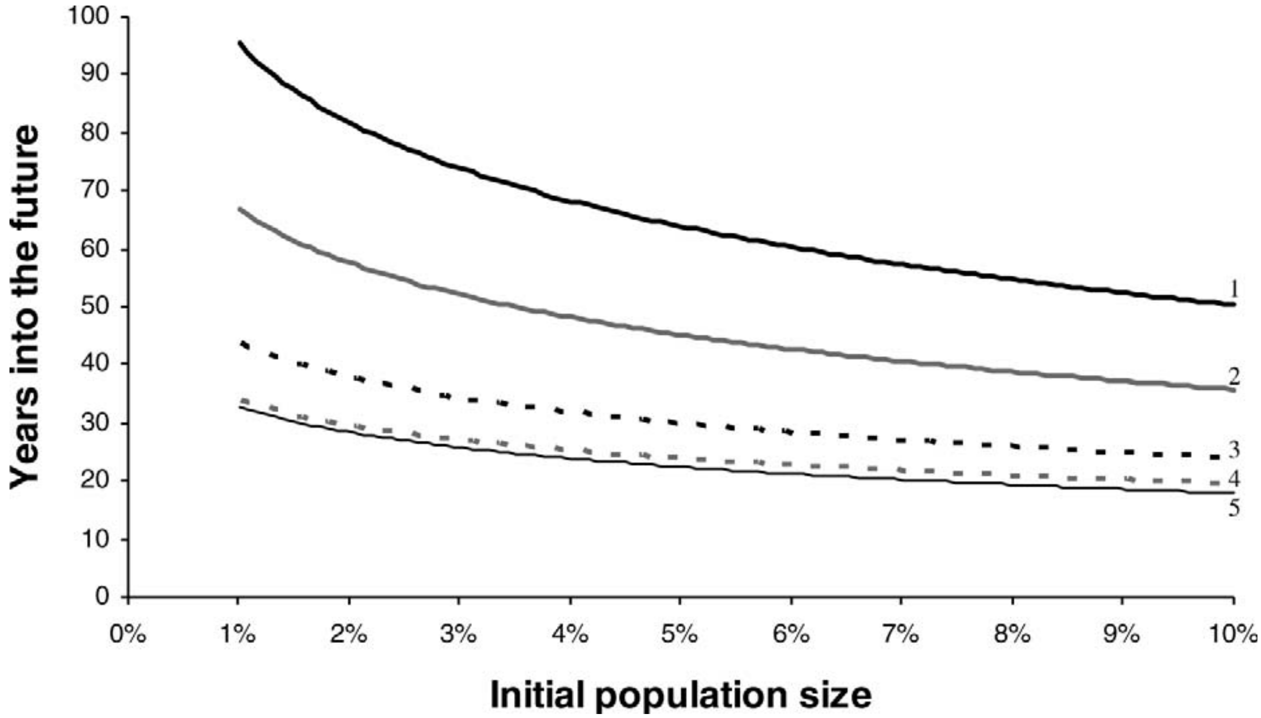


Figure 3. Stochastic projections of times to recovery for Lake Sturgeon based on initial population size (i.e., percentage of MVP) under five different recovery scenarios. Strategy 1 (solid black line) was the maximization of the survival rates of early adults, strategy 2 (solid grey line) added a 10% 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 three Lake Sturgeon Management Units (MUs) in the Churchill 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 DU1. 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	Kettle Falls – Island Falls GS	Unknown	Unknown	Unknown	Unknown
2	Island Falls GS – Missi Falls CS	Critical	Unknown	High	Moderate
3	Lower Churchill River below Missi Falls CS	Cautious	Unknown	High	Low

Table 2. Current status of threats to Lake Sturgeon in DU1 by Management Unit (MU), defined in terms of the likelihood of occurrence followed by the 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). 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, Island Falls GS is included in MU2.

THREATS	Kettle Falls – Island Falls GS	Island Falls GS – Missi Falls CS	Lower Churchill River below Missi Falls CS
	MU1	MU2	MU3
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
Population fragmentation (e.g., from dams/impoundments and other barriers)	L,L	L,L	L,L
Fishing: commercial net (bycatch)	0,0	0,0	0,0
Fishing: domestic / subsistence	L,M	L,M	H,M
Fishing: recreational / commercial tourism	0,L	L,L	L,L
Fishing: illegal harvest	U,L	L,L	L,L
Habitat degradation or loss[1]			
Dams/impoundments and other barriers (e.g., hydroelectric dams or water control structures)	L,L	H,M	H,H
Industrial activities (including oil and gas, and pulp and paper)	0,0	L,L	L,L
Forestry exploration/ extraction	L,L	L,L	L,L
Mining exploration/extraction	L,L	L,L	L,L
Agricultural activities	0,0	L,L	L,L
Urban development	0,0	L,L	L,L
Sturgeon culture			
Genetic contamination	L,L	L,L	L,L
Disease	L,L	L,L	L,L
Non-indigenous and invasive species	L,L	L,L	L,L
Climate change[2]	U,U	U,U	U,U

[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]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 DU1 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	29.6%	6.1%
Early juvenile survival	27.3%	3.3%
Late juvenile survival	11.3%	1.8%
Early adult survival	4.3%	1%
Late adult survival		1.3%
Early adult fertility		7.4%
Late adult fertility		23.7%

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.