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Information Relevant to a Recovery Potential Assessment of Lake Sturgeon: Nelson River Populations (DU3)

Renseignements pertinents pour l'évaluation du potentiel de rétablissement de l'esturgeon jaune : populations de la rivière Nelson (UD 3)

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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) 3, the Nelson River populations, includes Lake Sturgeon in the Nelson River in northeastern Manitoba, downstream of Lake Winnipeg (to Hudson Bay), and all related drainages. COSEWIC assessed and designated DU3 as Endangered. Historically, over-exploitation from commercial fisheries probably was the primary threat which led to depletion of Lake Sturgeon in DU3. More recently, habitat degradation or loss associated with dams/impoundments and other barriers and impacts of fishing have become the most important threats.

DU3 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 DU3, 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 DU3 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.

Six Lake Sturgeon Management Units (MUs) have been identified for DU3. Available data and expert opinion indicate that the current status of MUs 1, 4 and 5 is critical where relatively few Lake Sturgeon are known to occur. The population trajectory of MU1 is increasing, due to stocking, and unknown for MUs 4 and 5. The status of MUs 2 and 3 is deemed to be cautious with a trajectory that is stable or possibly increasing in MU2 and unknown in MU3. The status of MU6 is healthy and trajectory is unknown. Current data indicate that there are several thousand adult Lake Sturgeon in DU3. The long-term recovery goal 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) 3, à savoir les populations de la rivière Nelson, comprend les esturgeons jaunes présents dans la rivière Nelson dans le nord-est du Manitoba, en aval du lac Winnipeg (jusqu’à la baie d'Hudson) et dans tous les bassins hydrographiques connexes. Le COSEPAC a évalué l'UD 3 et l’a désignée comme étant en voie de disparition. Historiquement, la surexploitation par la pêche commerciale était probablement la principale menace ayant mené à l'épuisement du stock d'esturgeons jaunes dans l'UD 3. Plus récemment, la dégradation ou la perte d'habitat causées par les barrages, les ouvrages de retenue et autres obstacles ainsi que les impacts de la pêche sont devenus menaces les plus importantes.

On étudie la possibilité d’inscrire l’esturgeon jaune de l’UD 3 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 3 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 3. 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 six unités de gestion (UG) de l'esturgeon jaune pour l'UD 3. Les données disponibles ainsi que les opinions d’experts indiquent que l’état actuel des UG 1, 4 et 5, là où relativement peu d'esturgeons jaunes sont présents, est critique. La trajectoire de la population de l’UG 1 est à la hausse en raison de l’ensemencement et demeure inconnue pour les UG 4 et 5. On estime que l’état des UG 2 et 3 se situe dans la zone de prudence; la trajectoire est stable ou peut-être à la hausse dans l’UG 2 et est inconnue dans l’UG 3. L’état de l’UG 6 est sain et la trajectoire est inconnue. Selon les données actuelles, plusieurs milliers d'esturgeons jaunes adultes sont présents dans l'UD 3. 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). DU3 includes Lake Sturgeon in the Nelson River system in northeastern Manitoba, between Lake Winnipeg and Hudson Bay (Figure 1). COSEWIC assessed and designated this DU as Endangered in November 2006 (COSEWIC 2006). The Lake Sturgeon, called *numao* by the Cree along the Nelson River, 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 DU3, 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 the lower Nelson River in the 1990s found the largest Lake Sturgeon caught each year were 1.4-1.6 m in length and 17.3-30 kg in weight (MacDonell 1995, 1997, 1998, Barth and MacDonell 1999). Fish surveyed in the Kelsey GS to Kettle GS reach of the Nelson River from 2001-2008 ranged in length from 0.3 to 1.6 m and weighed 1.1 to 49.9 kg (Macdonald 2009). 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). Lake Sturgeon in the Nelson River can remain in small local areas for periods of up to five years (MacDonell 1992), while others have been shown to undertake movements of over 300 km (North/South Consultants Inc., unpubl. data). 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. Data collected in the Nelson River in the mid-1950s indicated that females and males in DU3 reached sexual maturity at 20-23 years (average length: 113.1 cm) and 18-20 years (97.8 cm), respectively (Sunde 1959). In the lower Nelson River, females have been found to mature at 71.5 cm (fork length (FL)) and males at 63.5 cm (FL) (North/South Consultants Inc., unpubl. data).

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). In the Lower Nelson River, spawning occurs when water temperatures are in the range of 11-17°C (MacDonell 1998, Barth and MacDonell 1999). 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. The annual estimate of survival, taking into account natural and fishing mortality, in the Gull Lake area of the Nelson River is currently thought to be about 0.85 (North/South Consultants Inc., unpubl. data).

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. Out of a small sample of Lake Sturgeon caught and aged from the lower Nelson River in the 1990s, the oldest was 43 years of age (MacDonell 1995, 1997, 1998, Barth and MacDonell 1999). The oldest Lake Sturgeon from the upper Nelson River was a 90 year old fish caught at Bladder Rapids in the 1990s. These data likely underestimate the oldest ages present as older fish may have been caught but not aged and very large Lake Sturgeon can escape gill nets so they are rarely caught.

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

DU3 includes the Nelson River, between Lake Winnipeg and the coast of Hudson Bay, and its immediate drainages in northeastern Manitoba (Figure 1). The Nelson River flows from the north end of Lake Winnipeg to Hudson Bay for a distance of about 660 km, descending approximately 217 m in elevation. It lies entirely within the boreal forest zone of the Precambrian Shield. 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). Recent tagging data indicate that Lake Sturgeon from the Nelson River (DU3) move into the Hayes River (DU7) from Hudson Bay (Ambrose *et al.* 2009, North/South Consultants Inc., unpubl. data) which brings into question the boundaries of these two DUs.

Five hydroelectric generating stations (GSs) currently exist on the Nelson River, resulting in a series of lake-like impoundments interspersed with unimpounded river sections. Six Lake Sturgeon MUs, separated from each other by natural or man-made barriers, have been identified in the Nelson River (DU3) (Figure 1): (1) from Playgreen Lake to Whitemud Falls, (2) from Whitemud Falls to the Kelsey GS, (3) from Kelsey GS to Kettle GS, (4) from Kettle GS to Long Spruce GS, (5) from Long Spruce GS to Limestone GS and (6) below Limestone GS to Hudson Bay. Within each of these MUs there may be one or more spawning stocks.

Scientific knowledge of the historic distribution of Lake Sturgeon in DU3 is limited. The construction of hydroelectric dams, beginning in 1960, fragmented the distribution of this species and isolated Lake Sturgeon into a series of reservoirs (Figure 2). The Lake Sturgeon currently occurs in all six MUs. Their area of occupancy in DU3 is estimated to be < 40,000 km^2 and the trend in area, extent or quality of habitat is declining in response to dam construction (COSEWIC 2006). Stocks within the DU are fragmented, particularly between Kettle and Limestone GSs (MUs 4 and 5).

<u>Playgreen Lake – Whitemud Falls (MU1)</u>

This MU extends approximately 160 km between Warren Landing and Whitemud Falls. There are no barriers to movement where Lake Winnipeg drains into the Nelson River. In addition to the natural channel of the river there are three man-made channels designed to improve the hydraulic efficiency of the river: Two Mile Channel which opens another outlet on Lake Winnipeg, Eight Mile Channel which adds another outlet from Playgreen lake and Ominiwin Bypass Channel which improves flows in the original West Channel of the Nelson River as it flows out of Playgreen Lake. These channels change current patterns on Playgreen Lake, and also have a role in sediment transport, with material eroded from the north basin of Lake Winnipeg being transported into Playgreen Lake. The two major lakes in this MU (Playgreen and Cross) are large, shallow waterbodies with extensive rock islands and reefs.

The Nelson River is divided into two channels as it flows between Playgreen and Cross lakes. The West Channel flows towards Jenpeg GS, which is a barrier to upstream movement from Cross Lake. The outlet weir on Cross Lake limits fluctuations in Cross Lake water levels caused by the operation of Jenpeg GS for Lake Winnipeg Regulation. The East Channel is unregulated and flows over Sea River Falls (also referred as Sea Falls) as it exits Little Playgreen Lake. Sea River Falls may not be a complete barrier to fish movement during all flow conditions. The East Channel downstream of Sea River Falls is a high gradient, rock controlled, riverine reach with numerous rapids. It is relatively unimpacted by development. Both channels rejoin in Cross Lake.

Lake Sturgeon were present in Playgreen and Cross lakes between the 1890s and 1920s (Skaptason 1926), but had then largely disappeared due to over-exploitation by commercial fisheries (Manitoba Department of Natural Resources 1994). Stocking was undertaken in MU1 starting in the mid-1990s.

Whitemud Falls – Kelsey GS (MU2)

This reach extends approximately 220 km starting below Whitemud Falls and Eves Falls, each of which is situated on a channel of the Nelson River exiting Cross Lake. Whitemud Falls is a total barrier to upstream fish movement. Eves Falls is likely a barrier to upstream movement in most flow conditions but under some flows, passage may be possible. The Nelson River between Cross and Sipiwesk lakes is frequently in paired channels. This reach is high gradient and predominantly bedrock substrate not vulnerable to erosion. Flows are altered by the operation of Jenpeg GS and its role in the regulation of Lake Winnipeg, which tends to result in seasonal flow reversal with peak flows during the winter and reduced flows in summer. This can result in significant dewatering of shallow habitats in the river between Cross and Sipiwesk lakes during summer, though relatively constant flows are maintained during the spawning period.

Sipiwesk Lake is flooded by Kelsey GS, with significant changes in water level annually though the operation of Jenpeg GS. This is a large, complex lake with many reefs and islands. It is principally riverine, with significant current in narrow channels throughout the lake. There can be significant differences in water elevation and flow during wet and dry years.

Downstream of Sipiwesk Lake there is a 150 km reach of river until Kelsey GS. The river is flooded by Kelsey GS through this stretch and is deep (20 m) with significant flows. Any rapids that existed prior to the construction of Kelsey GS are inundated, although they remain areas of fast water and turbulent flow. Kelsey GS operates primarily as a run-of-the-river system[1].

In areas with clay shorelines, elevated water levels have caused widespread bank collapse and shoreline erosion on both Sipiwesk Lake and the Nelson River downstream.

Sipiwesk Lake was the center of the Nelson River commercial Lake Sturgeon fishery during the 1950s and again during the fishery from 1970-1991. Lake Sturgeon are still found in MU2 and known to spawn upstream of Sipiwesk Lake at Bladder Rapids and downstream at the mouth of the Landing River (Macdonald 1998).

Kelsey GS – Kettle GS (MU3)

MU3 is 150 river km in length and contains Split, Clark, Gull and Stephens lakes. A number of tributaries enter the Nelson River system in this MU. Split Lake, which is immediately downstream of the Kelsey GS at the confluence of the Burntwood and Nelson rivers, is the second largest waterbody in this MU. Due to the large inflows from the Nelson and Burntwood rivers, the lake has detectable current in several locations. Split Lake is 26,100 ha (excluding islands) in area with maximum and mean depths of 28.0 m and 3.9 m, respectively (Lawrence *et al*. 1999). The reach of the Nelson River between Split Lake and Stephens Lake is characterized by narrow sections with swiftly flowing water (including Birthday and Gull rapids) and wider more lacustrine sections, including Clark and Gull lakes. Mean winter flow in the reach is 3,006 $m^3 \cdot s^{-1}$ and mean summer flow is 2,812 $m^3 \cdot s^{-1}$ (Manitoba Hydro 1996). Stephens Lake, the largest lake in MU3, is located downstream of Gull Rapids and was created through the development of the Kettle GS. It is 29,930

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

ha (excluding islands) in area. There is no detectable current throughout most of this large lake, except for the old Nelson River channel.

Commercial fishing of Lake Sturgeon on the Nelson River in the vicinity of Split Lake (MU3) began around 1915, when the Hudson Bay Railway was constructed and fish could be shipped south to markets (Skaptason 1926). Today, the Lake Sturgeon occurs throughout the MU (North/South Consultants Inc., unpubl. data).

Kettle GS – Long Spruce GS (MU4)

MU4 is 16 river km in length and consists largely of the forebay area above Long Spruce GS. The upstream portion of the MU is riverine while the downstream portion is more lacustrine. About 13 km of dikes border the downstream section. During winter, a stable ice sheet forms over the forebay to within 1 km of Kettle GS. Prior to construction of the Long Spruce GS there was a set of rapids at what is now Long Spruce GS. Bedrock in the lower Nelson River region (MUs 4-6) consists of granite and gneiss overlain with fine-grained and granular glacio-lacustrine deposits (Bodaly *et al*. 1984). On a daily basis, water levels are typically drawn down during the day with partial recovery by evening. On a weekly basis, water levels progressively decrease from Monday through Friday with recovery during the weekend. Water fluctuations generally remain within a 1 m range. Historically there were rapids at the Kettle railway bridge.

Lake Sturgeon are currently present in MU4. No historic information is available.

Long Spruce GS – Limestone GS (MU5)

MU5 is 23 river km in length, about 15 km of which is the flooded forebay area above Limestone GS. The upstream portion of the MU is riverine while the downstream portion is more lacustrine. The forebay area is contained within the existing riverbank with a minimal dike system. The water level operating regime is similar to MU4. Prior to construction of the Limestone GS there was a set of rapids at what is now the site of the GS.

Lake Sturgeon are currently present in MU5. No historic information is available.

Limestone GS – Hudson Bay (MU6)

This MU encompasses the unimpounded portion of the lower Nelson River between the Limestone GS and the Nelson River estuary, a distance of approximately 130 river km. The lower Nelson River lies within the Hudson Bay Lowlands physiographic region; an area characterized by emergent plains of clay, silt and sand sediments overlain by poorly drained bogs and fens supporting open coniferous forests dominated by black spruce (Penner *et al.* 1975). The banks of the Nelson River downstream of the Limestone GS rise up to 40 m above the river channel and are composed of the same fine sediments. Banks generally are unstable, and slump regularly due to the overall high gradient of the banks, the small grain size of the bank materials, intermittent permafrost, constant water level fluctuations, and moderate to high river velocities. MU6 is subject to the most extreme flow fluctuations in the DU. The upper end of MU6 is bounded by the Limestone GS which first came into service in 1990. Upstream of Gillam Island channel widths vary from 450 to more than 1,100 m. Depths are generally less than 6 m but can reach approximately 20 m in the vicinity of Jackfish Island. Substrates are primarily cobbles which are subject to heavy ice scour on an annual basis. Two sets of rapids occur in the reach: Sundance Rapids approximately 3 km downstream of Limestone GS and Lower Limestone Rapids approximately 15 km downstream. There are three major fifth order perennial tributaries (Limestone, Angling and

Weir rivers) and numerous smaller tributaries draining into the reach.

No historic information about Lake Sturgeon distribution is available for MU6.

Three spawning locations are currently known in MU6: the Lower Limestone Rapids, mouth of the Angling River and mouth of the Weir River. Recent tagging studies have shown that Lake Sturgeon tagged near the mouth of the Weir River are being recaptured in the Hayes River (DU7- Southern Hudson Bay and James Bay populations) demonstrating they can move between the mouth of the Nelson and Hayes rivers (D. MacDonell, pers. comm.). A spawning location on the Gods River has been identified by the residents of Shamattawa and there are likely others.

It appears Lake Sturgeon can make extensive movements up the Hayes River and its tributaries which raises questions about whether these areas warrant consideration as separate DUs. Recent genetics research indicated the Hayes River Lake Sturgeon were more closely related to Lake Sturgeon from the Gull Lake reach (MU3) than the lower Nelson River (MU6) (D. MacDonell, pers. comm.). Additional analyses are underway with increased sample sizes which may provide further insight into the relationship between these populations. Consideration should be given as to whether the Hayes-Gods river system is included in DU3 or whether MU6 (in DU3) is included in DU7.

HISTORIC AND CURRENT ABUNDANCE AND TRENDS

The Lake Sturgeon was historically abundant in DU3. Commercial fisheries in the Nelson River were established by 1902 (Stewart 2009) and the last fishery closed in 1991 (COSEWIC 2006). Overfishing, combined with the construction of hydroelectric dams that blocked migration routes, resulted in population declines in DU3 over the past 50 years. Today, there are several Lake Sturgeon populations in the Nelson River, all of which have, and continue to be, affected by exploitation and hydroelectric development. Spawning populations have been reduced, though successful spawning and recruitment are known to be occurring in the Sipiwesk Lake to Kelsey GS reach (in MU2), Kelsey GS to Gull Rapids reach (in MU3), and Limestone GS to Nelson River estuary reach (MU6). There is much less certainty about recruitment in Stephens Lake (in MU3), Long Spruce and Limestone forebays (in MUs 4 and 5, respectively), and upstream of Whitemud Falls (MU1). The overall number of mature individuals in DU3 is unknown but based on the most recent population estimates available, could be in the range of several thousand adult Lake Sturgeon.

The current conservation status (Figure 2), based on the precautionary framework (DFO 2005), of each of the MUs in DU3 was evaluated on the basis of available information and expert opinion (Table 1).

Playgreen Lake – Whitemud Falls (MU1)

Playgreen Lake was fished extensively for Lake Sturgeon starting around the end of the 1890s (Skaptason 1926). In 1925, the annual limit for Lake Sturgeon was 40,000 lbs (18,144 kg) in Playgreen and Cross lakes (Skaptason 1926). Little information on Lake Sturgeon abundance is currently available above Sipiwesk Lake, but the Cross Lake and Playgreen Lake stocks are considered to be nearly extirpated (Manitoba Department of Natural Resources 1994) (Table 1). Any Lake Sturgeon remaining in this reach would be part of a remnant population. Until 1994, this population was either stable at a very low level or declining. Stocking was considered the only useful tool to recover this area. Since 1994, approximately 25,000 fingerlings reared from eggs harvested from spawners captured in MU2 have been stocked in this area and local fishers from

Norway House have reported increasing numbers of small Lake Sturgeon caught incidentally in the area. The status of Lake Sturgeon in MU1 is critical and its trajectory is increasing as a result of stocking (Table 1).

Whitemud Falls – Kelsey GS (MU2)

Prior to the 1960s, at least 80% of the Lake Sturgeon production in DU3 was taken from this MU (Sunde 1960). The initial population estimates of 12,000 adult Lake Sturgeon in the early 1960s (Sunde 1961) and corrected estimates of 6,000 in 1987 (Sopuck 1987) had declined by 90% and 80%, respectively, to about 1,200 adults in 2000, most of which were males (COSEWIC 2006). Juveniles and pre-spawners constituted 87% of the fish harvested during the last commercial harvest in Sipiwesk Lake in the early 1990s (Choudhury and Dick 1993). The current number of mature individuals in Sipiwesk Lake may be about 150 fish (COSEWIC 2006).

Hundreds of Lake Sturgeon used to spawn in the rapids at the mouth of the Landing River, a tributary to the Nelson River downstream of Sipiwesk Lake (Macdonald 1998). This spawning run was heavily harvested from 1991 until 1993 (Macdonald 1998). Since 1994 only small numbers of spawning Lake Sturgeon are observed at this location, typically as few as a single female and up to four males (Macdonald 1998). Upstream of Sipiwesk Lake, Bladder Rapids is also an important area for Lake Sturgeon spawning (Macdonald 1998).

Growth rates in Lake Sturgeon were similar in the 1990s to those recorded in the 1950s, prior to hydro development (Macdonald 1998), suggesting that food resources are not limiting the current Lake Sturgeon population. This MU likely contains fewer than 1,300 adult Lake Sturgeon, however the harvest has declined and the current population trajectory is thought to be stable (Table 1). Current population estimates available for the Sipiwesk Lake to Kelsey GS reach of MU2 suggest both adult and, especially, juvenile Lake Sturgeon are increasing in number and showing signs of recovery (D. Macdonald, pers. comm.). As younger fish reach sexual maturity, the population trajectory may improve. The current population status and trend of MU2 are cautious and stable or possible increasing, respectively (Table 1).

Kelsey GS – Kettle GS (MU3)

Between 1998 and 2004, 875 Lake Sturgeon were tagged from Kelsey GS to Kettle GS. The 2007 population estimate for mature Lake Sturgeon in the Kelsey GS/Burntwood River area of the MU was 473 adults. The 2008 population estimate for mature Lake Sturgeon in the Birthday Rapids to Gull Rapids reach was 360 (North/South Consultants Inc., unpubl. data). There have been too few mature Lake Sturgeon captured in Stephens Lake to generate a population estimate. Subadult and adult Lake Sturgeon are captured throughout the MU. Concentrations of age-0 Lake Sturgeon have been found in the north channel of Gull Lake and below Gull Rapids. Most recaptures of tagged fish have occurred in the same waterbodies in which they were applied. However, Lake Sturgeon move between Kelsey GS and the Burntwood, Grass and Odei rivers and Split Lake. Of 573 Lake Sturgeon tagged in the Birthday-Gull Rapids reach two were captured in Stephens Lake and seven in Split Lake. Seven percent of Lake Sturgeon tagged in Stephens Lake (n=70) were captured in the Gull Lake area. Spring gillnetting in 2003 and 2005 indicated that 80% were immature or non-spawners (Barth and Ambrose 2006). The current status of MU3 is thought to be cautious although the trajectory is unknown (Table 1).

Kettle GS – Long Spruce GS (MU4)

Research conducted in recent years indicates there are small numbers of Lake Sturgeon in this MU. Within this reach, there are fish younger than the age of the impoundment but there is no confirmed evidence of spawning. Population status and trajectory in MU4 are critical and unknown, respectively (Table 1).

Long Spruce GS – Limestone GS (MU5)

Research conducted in recent years indicates there are small numbers of Lake Sturgeon in this MU. Within this reach, there are fish younger than the age of the impoundment but there is no confirmed evidence of spawning. Population status and trajectory in MU5 are critical and unknown, respectively (Table 1).

Limestone GS – Hudson Bay (MU6)

The 2004/2005 population estimate for the lower Nelson River from Limestone GS to Hudson Bay is 5,467 adult Lake Sturgeon (95% CI: 3,768-8,018) (North/South Consultants Inc., unpubl. data). Over 300 Lake Sturgeon have been known to congregate in the vicinity of the Weir River mouth during spring (MacDonell 1997). In spite of the fact that MU6 does not contain prime Lake Sturgeon habitat and experiences large daily variations in flow as a result of hydroelectric generation, it supports a substantial Lake Sturgeon population likely due to its inaccessibility to exploitation. Prior to construction of the Conawapa road, around 1990, this area was almost completely inaccessible to all but the most knowledgeable local harvesters. The status of Lake Sturgeon in MU6 is healthy although the population trajectory in 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). A number of spawning locations are known for DU3 (Macdonald 1998) and there are many other suspected spawning locations. Lake Sturgeon in the Sipiwesk Lake – Kelsey GS (MU2) are known to spawn in the Nelson River mainstem and in the Landing River (Macdonald 1998). Hundreds of Lake Sturgeon used to spawn in the rapids at the mouth of the Landing River, a tributary to the Nelson River downstream of Sipiwesk Lake although few spawn there now (Macdonald 1998). Upstream of Sipiwesk Lake, Bladder Rapids is also an important area for Lake Sturgeon spawning (Macdonald 1998). Lake Sturgeon between Kelsey GS and Kettle GS (MU3) are known to spawn at First Rapids on the Burntwood River, Long Rapids and Birthday Rapids on the Nelson River and at Gull Rapids. Below Limestone GS (MU6), Lake Sturgeon are known to spawn in the Lower Limestone Rapids, at the mouths of the Angling and Weir rivers and in the Gods River upstream of Shamattawa.

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).

Within DU3, extensive habitat mapping has been conducted or is underway from Whitemud Falls to Kelsey GS (MU2), from Kelsey GS to Kettle GS (MU3) and from Limestone GS to the Nelson River estuary (MU6).

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 the Nelson River system (DU3) is fragmented by dams which negatively affect spawning habitat. More dams are planned so it is anticipated that further habitat fragmentation and degradation (e.g., changes in flow regime) is likely in the future. The availability of spawning habitat may become limiting for Lake Sturgeon in some MUs if access to necessary habitat is affected. It is essential that conditions that optimize the survival and recovery of Lake Sturgeon be maintained in DU3, 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 DU3 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 974 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 DU3 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 DU3 is to protect and maintain healthy, viable populations of Lake Sturgeon in all MUs on the Nelson River. To reach this goal, each MU must have at least 413 spawning females each year (i.e., 4,130 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).

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 DU3. 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).

The recovery potential and importance to recovery of each of the six Lake Sturgeon MUs in DU3 was evaluated on the basis of available information (e.g., quantitative population data) and expert opinion (Table 1). Available information for MU1 suggests there are relatively few indigenous Lake Sturgeon left so recovery is unlikely if left unaided. Potential for recovery of the non-indigenous (stocked) Lake Sturgeon in this MU is unknown as the stocked fish have not yet reached maturity. Recovery potential in MUs 2 and 3 is thought to be moderate. Both MUs are long, have known spawning areas and population estimates in the range of 1,300 and 875 adults, respectively. Thus, recovery may be possible within the recommended timeframe (i.e., three generations). Recovery potential for MUs 4 and 5 is low as both are relatively short in length and largely contain flooded forebay areas above GSs. Thus their recovery may be, at best, very protracted and likely limited by available habitat. The current population estimate for MU6 is 5,467 adults (95% CI: 3,768-8,018) so recovery within the recommended timeframe is highly probable and, therefore, rated as high. The importance of MUs 2, 3 and 6 to species recovery in DU3 is thought to be high while the importance of MUs 1, 4 and 5 is low.

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).

The Lake Sturgeon in DU3 was commercially fished intermittently since about 1902, beginning in Playgreen Lake (Stewart 2009). During periods of fishing, production would rise to a peak and then decline as stocks became depleted, followed by closure of the fishery (1911-1916, 1934-1936, 1947-1952 and 1961-1969) (Stewart 2009) to allow stocks to rebuild. This cycle was repeated several times although harvest in the first twenty years of the fishery totaled more than the harvest in the fishery over the last sixty years (Macdonald 1998). Some closures were driven by province-wide initiatives, not specifically as responses to stock conditions on the Nelson River. The 1911-16 and 1961-69 closures were province wide (MacDonell 1997). The high market value and vulnerability of Lake Sturgeon to the fishery led to over-exploitation, from which they have not recovered. Commercial fishing on the Nelson River completely ceased in 1991. Commercial net fisheries for others species occur on all of the major waterbodies within the DU with the exception of Stephens Lake. Incidental catches of Lake Sturgeon are rarely reported though they are known to occur occasionally between Sipiwesk Lake and Kelsey GS (in MU2).

The domestic fishery for Lake Sturgeon was, and remains to a slightly lesser degree, an important fishery for First Nations along the Nelson River (Wagner 1986, Hannibal-Paci 2000). Today, most Lake Sturgeon harvested in DU3 are taken through a legal subsistence harvest. The Nelson River Sturgeon Co-management Board was established in 1992 to provide for the subsistence and cultural needs of local communities and for the preservation of the declining Lake Sturgeon stock. A conservation closure is in place on the Nelson River from Whitemud Falls to Kelsey GS (MU2), which prohibits fishing for Lake Sturgeon until after July 15 every year. A year-round closure exists for a small stretch of the Nelson River extending 8 km up and downstream of the mouth of the Landing River. There are no harvest limits or mesh size restrictions during the open season. Although the current levels of legal harvesting through the subsistence fishery are low, and poaching has not been confirmed for this DU, the removal of juveniles and adults affects recovery

(Vélez-Espino and Koops 2009). Recreational angling is allowed in this DU, though any captured individuals must be released. Recreational angling directed at Lake Sturgeon is minimal.

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).

Five hydroelectric GSs were developed on the Nelson River: Kelsey (completed in 1960), Kettle (1970), Jenpeg (1975), Long Spruce (1977) and Limestone (1990). At least two more hydroelectric GSs (Keeyask, formerly called Gull, and Conawapa) are planned (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. Fragmentation is one of the limiting factors for MUs 4 and 5 on the lower Nelson River, however changes in flow regime and alteration of habitat are more significant throughout the DU. 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. By the late 1970s, the perception of community fishermen on the Nelson River was that all combined Lake Sturgeon harvests had drastically decreased in response to the construction and operation of hydroelectric GSs (Hannibal-Paci 2000).

In summary, the most important current threats to survival and recovery of Lake Sturgeon in DU3 are habitat degradation or loss resulting from dams/impoundments and other barriers, 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 DU3. 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

[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.

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 DU3 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 suggest 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 DU3, 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.
- Examine ways and means of altering commercial net fisheries to reduce impacts on recovering Lake Sturgeon populations (e.g., trapnets versus gillnets, netting off the bottom, area closures such as limiting fishing near river mouths, close fishery).
- 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.
- Educate the public about the importance of Lake Sturgeon and what measures they can take to prevent over-exploitation.
- Ensure effective enforcement of regulations.

Mortality, injury or reduced survival: population fragmentation

- Prevent any additional fragmentation, particularly downstream of the Limestone GS, to prevent further loss of connectivity in this region.
- 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 DU3. They reported that once the main causes of population decline are removed, maximum allowable harm should not exceed reductions of 1.7-2.4% in adult survival, 3.5-6.6% in juvenile survival, 11.8% in age-0 survival and 14.2-49.0% in fertility rates (Table 3).

Negative impacts associated with habitat degradation or loss from dams/impoundments and other barriers, 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 DU3, 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. Available data and expert opinion indicate that survival and recovery would be, at best, very slow in MU1 and likely restricted in MUs 4 and 5. Thus, 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 Lake Sturgeon populations there. Recovery in MUs 2 and 3 may be possible within the recommended timeframe so harmful activities pose a moderate to high risk to survival or recovery. MU6 supports a substantial Lake Sturgeon population, likely because it contains prime habitat and is relatively inaccessible to exploitation, so recovery within the recommended timeframe seems highly probable. However the current population trajectory is unknown, there are no current data on levels of harvest and this section of the Churchill River is significantly impacted by variations in flow, thus activities that damage or destroy habitat or key life components pose a moderate risk to survival or recovery in MU6. Allowable harm in DU3 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 DU3 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 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

Six MUs have been identified for DU3: MU1 is located between Playgreen Lake and Whitemud Falls, MU2 between Whitemud Falls and the Kelsey GS, MU3 between Kelsey GS and Kettle GS, MU4 between Kettle GS and Long Spruce GS, MU5 between Long Spruce GS and Limestone GS and MU6 between Limestone GS and Hudson Bay.

Over the past century, Lake Sturgeon in DU3 declined primarily as a result of over-exploitation from commercial fisheries and degradation or loss of a significant portion of their habitat as a result of dams/impoundments and other barriers. Current data indicate that there are several thousand adult Lake Sturgeon in this DU.

Available data and expert opinion indicate that the current status of MUs 1, 4 and 5 is critical where relatively few Lake Sturgeon are known to occur. The population trajectory of MU1 is increasing, due to stocking, and unknown for MUs 4 and 5. The status of MUs 2 and 3 is deemed to be cautious with a trajectory that is stable or possibly increasing in MU2 and unknown in MU3. The status of MU6 is healthy and trajectory is unknown.

Survival and recovery of Lake Sturgeon in DU3 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 DU3 is to protect and maintain healthy, viable populations of Lake Sturgeon in all MUs within the Nelson River system. To reach this goal it will be necessary for each MU to have at least 413 spawning females (i.e., 4,130 adults) 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., 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 DU3 are habitat degradation or loss resulting from dams/impoundments and other barriers, 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 DU3 including protecting spawning and rearing habitat, minimizing activities that cause habitat degradation or loss, rehabilitating habitat in key areas and reducing impacts of the fishery through education and effective management of the fishery. 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 1, 4 and 5, a moderate to high risk in MUs 2 and 3 and a moderate risk in MU6. Research activities should be allowed in DU3 if they are beneficial to the species and would not jeopardize the survival or recovery of an MU.

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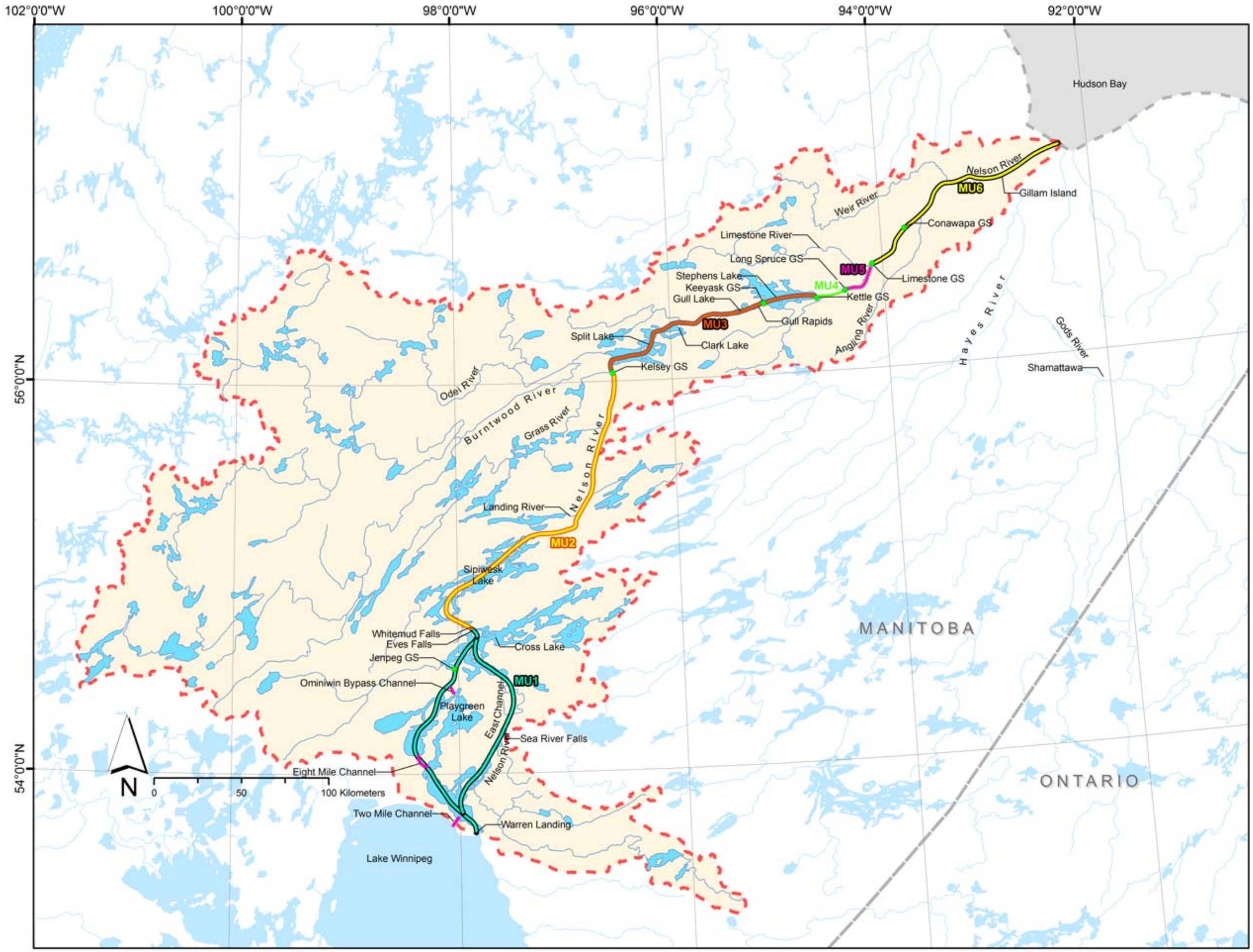
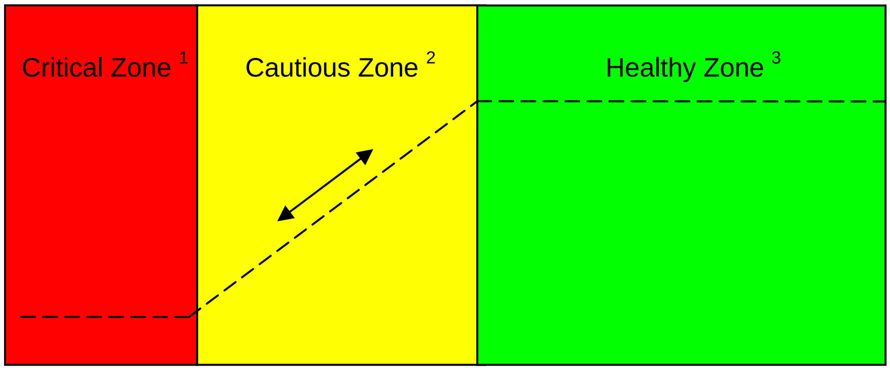


Figure 1. DU3 showing locations of MUs and place names mentioned in text.



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).

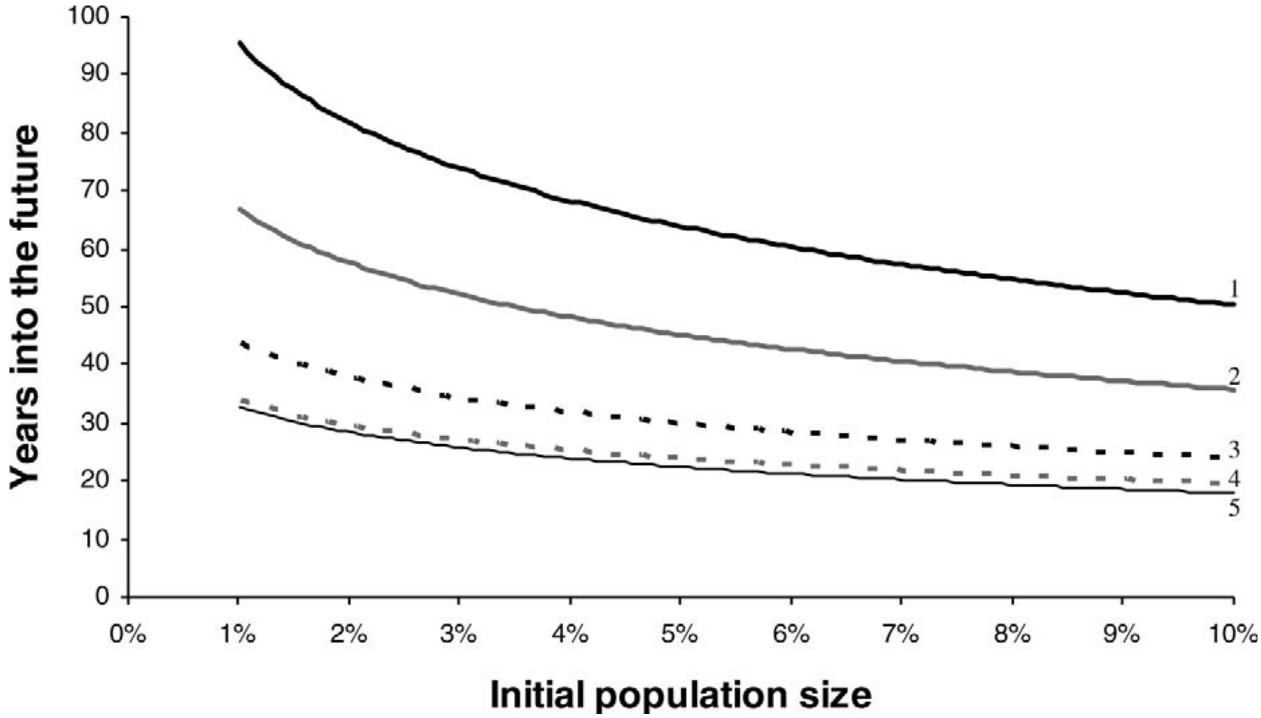


Figure 3. Stochastic projections of times to recovery for Lake Sturgeon based on initial population size (i.e., percentage of MVP) under five different recovery scenarios. Strategy 1 (solid black line) was the maximization of the survival rates of early adults, strategy 2 (solid grey line) added a 10% 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 six Lake Sturgeon Management Units (MUs) in the Nelson 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 DU3. 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; Ind=Indigenous, St=Stocked.

MU	Location	Conservation status	Population trajectory	Importance to DU recovery	Recovery potential
1	Playgreen Lake – Whitemud Falls	Critical	Increasing[1]	Low	Low (Ind) Unknown (St)[2]
2	Whitemud Falls – Kelsey GS	Cautious	Stable or possibly increasing	High	Moderate
3	Kelsey GS – Kettle GS	Cautious	Unknown	High	Moderate
4	Kettle GS – Long Spruce GS	Critical	Unknown	Low	Low
5	Long Spruce GS - Limestone GS	Critical	Unknown	Low	Low
6	Limestone GS – Hudson Bay	Healthy	Unknown	High	High

[1] As a result of stocking of offspring from MU2 broodstock.
[2] The stocked fish have not yet reached reproductive age.

Table 2. Current status of threats to Lake Sturgeon in DU3 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). 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, Limestone GS is included in MU6.

THREATS	Playgreen Lake – Whitemud Falls	Whitemud Falls – Kelsey GS	Kelsey GS – Kettle GS	Kettle GS – Long Spruce GS	Long Spruce GS – Limestone GS	Limestone GS – Hudson Bay
	MU1	MU2	MU3	MU4	MU5	MU6
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	0,0
Population fragmentation (e.g., from dams/impoundments and other barriers)	L,L	L,L	L,L	H,H	H,H	L,L
Fishing: commercial net (bycatch)	H,L	H,M	H,L	0,0	0,0	0,0
Fishing: domestic / subsistence	M,L[1]	H,H	H,H	0,0	0,0	H,H
Fishing: recreational / commercial tourism	0,0	0,0	0,0	0,0	0,0	0,0
Fishing: illegal harvest	0,0	M,M	M,M	0,0	0,0	M,M
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,H	H,H	H,M
Industrial activities (including oil and gas, and pulp and paper)	0,0	0,0	0,0	0,0	0,0	0,0
Forestry exploration/ extraction	H,0	H,0	0,0	0,0	0,0	0,0
Mining exploration/extraction	L,0	0,0	M,L	0,0	0,0	0,0
Agricultural activities	0,0	0,0	0,0	0,0	0,0	0,0
Urban development	H,L	0,0	0,0	H,L[3]	0,0	0,0
Sturgeon culture						
Genetic contamination	L,L	L,L	0,0	0,0	0,0	0,0
Disease	U,U	U,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
Climate change[4]	U,U	U,U	U,U	U,U	U,U	U,U

[1] Subsistence fishery does not target Lake Sturgeon in this MU.
[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] The Town of Gillam discharges its sewage into the Kettle River which flows into the Nelson between Kettle and Long Spruce GS (MU4).
[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 DU3 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%	11.8%
Early juvenile survival	27.3%	6.6%
Late juvenile survival	11.3%	3.5%
Early adult survival	4.3%	1.7%
Late adult survival		2.4%
Early adult fertility		14.2%
Late adult fertility		49.0%

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.