RECOVERY POTENTIAL ASSESSMENT OF LAKE STURGEON: NELSON RIVER POPULATIONS (DESIGNATABLE UNIT 3)

Lake Sturgeon Acipenser fulvescens
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Figure 1. DU3 for Lake Sturgeon (coloured area).

Context:

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. The Lake Sturgeon in this region is considered a distinct DU unit on the basis of distinguishable variation in three nuclear microsatellite loci. COSEWIC assessed and designated DU3 as Endangered as Lake Sturgeon in this DU declined severely over the past century. 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.*

SUMMARY

- Six Management Units (MUs) have been identified for DU3: MU1 is located between Playgreen Lake and Whitemud Falls, MU2 between Whitemud Falls and Kelsey Generating Station (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.
- Available data and expert opinion indicates that Lake Sturgeon abundance in DU3 ranges from very low to moderate.
- In MU1, the current status is critical, population trajectory is increasing due to stocking but recovery potential is low for the indigenous population and unknown for the stocked population.
- The status, trend and recovery potential of MU2 is cautious, stable or possibly increasing and moderate, respectively.
- The status, trend and recovery potential of MU3 is cautious, unknown and moderate, respectively.
- In MUs 4 and 5, population status is critical, trajectory is unknown and recovery potential is low.
- The status of MU6 is healthy, trajectory is unknown and recovery potential is high.
- Survival and recovery of Lake Sturgeon in DU3 depend 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.
- The long-term recovery goal for DU3 is to protect and maintain healthy, viable populations of Lake Sturgeon in all MUs in the Nelson River system.
- The most important current threats to survival and recovery of Lake Sturgeon in DU3 are habitat degradation or loss resulting from the presence of dams/impoundments and other barriers, mortality, injury or reduced survival resulting from fishing, and population fragmentation resulting from the presence of dams/impoundments and other barriers.
- Mitigation measures that would aid recovery include prevention of mortality, protection of habitat and public education.
- 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.

BACKGROUND

Rationale for Assessment

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated Lake Sturgeon in DU3 as Endangered in 2006 (COSEWIC 2006) and it is now being considered for listing under the *Species at Risk Act* (SARA). When COSEWIC designates an aquatic species as Threatened or Endangered and the Governor in Council decides to list it, the Minister of

Fisheries and Oceans Canada (DFO) is required by the SARA to undertake a number of actions. Many of these actions require scientific information such as the current status of the DU, the threats to its survival and recovery, and the feasibility of its recovery. Formulation of this scientific advice has typically been developed through a Recovery Potential Assessment (RPA). This allows for the consideration of peer-reviewed scientific analyses in subsequent SARA processes, including recovery planning. If listed, decisions made on permitting of harm and in support of recovery planning need to be informed by the impact of human activities on the species, mitigation measures and alternatives to these activities and the potential for recovery. The information and scientific advice provided in this document 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.

Species Biology and Ecology

The Lake Sturgeon is a large bottom-dwelling freshwater fish. 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 (Cleator *et al.* 2010). 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 (Cleator *et al.* 2010). Fish surveyed in the Kelsey Generating Station (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 (Cleator *et al.* 2010). Females are usually heavier than males.

This species is found in large rivers and lakes usually 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). The Lake Sturgeon has been described as largely sedentary, making localized (1-20 km) seasonal movements, with high site fidelity except to move over longer distances for spawning. Lake Sturgeon in the Nelson River can remain in small local areas for periods of up to five years, while others have been shown to undertake movements of over 300 km (Cleator *et al.* 2010). Tagging studies indicate that younger, smaller Lake Sturgeon do not move as far as older, larger individuals (Cleator *et al.* 2010).

Sexual maturity (i.e., the age at which spawning is first observed) typically occurs between 14 and 33 years of age in females and between 14 and 22 years in males (Cleator *et al.* 2010). 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 (Cleator *et al.* 2010). In the lower Nelson River (MU6), females have been found to mature at 71.5 cm (fork length (FL)) and males at 63.5 cm (FL) (Cleator *et al.* 2010).

Spawning occurs in May and June, once the river is free of ice and water temperatures are in the range of 11.5–16°C (Cleator *et al.* 2010). In the Lower Nelson River (MU6), spawning occurs when water temperatures are in the range of 11-17°C (Cleator *et al.* 2010). Adults move upstream to suitable areas containing rapids or below barriers (e.g., falls or dams) where they typically spawn in swift current near shore with individual spawning females surrounded by several males (Cleator *et al.* 2010). Females may contain between about 50,000 and >1,000,000 eggs, with heavier individuals producing more eggs. The interval between successive spawnings is estimated to be 3-7 years for females and 2-3 years for males (Cleator *et al.* 2010). 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, and remained burrowed in the substrate until the yolk sac is absorbed. The young typically emerge at night within 13-19 days after hatching, and disperse downstream with the current (up to 40 km) before returning to a benthic habitat. By that time they resemble miniature adults and start feeding. 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).

The sex ratio at birth is assumed to be 1:1, based on data from populations with little or no anthropogenic mortality, but following maturation can favour either females or males as a result of targeted exploitation. Information about survival is limited. In Lake Winnebago during 1936-1952, survival of Lake Sturgeon aged 16-36 years was 0.946 and older than 36 years was 0.866 (Cleator *et al.* 2010). 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 (Cleator *et al.* 2010). 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% (Cleator *et al.* 2010). The annual estimate of survival, taking into account natural and fishing mortality, in the Gull Lake area of the Nelson River (MU3) is currently thought to be about 0.85 (Cleator *et al.* 2010).

There are historic records of Lake Sturgeon living up to 150 years of age. Lifespan today is typically more in the range of 25-50 years, with an average generation time of about 26-30 years (Cleator *et al.* 2010). Shorter average lifespan today may reflect current and/or past effects of harvest. Out of a small sample of Lake Sturgeon caught and aged from the lower and upper Nelson River in the 1990s, the oldest were 43 and 90 years of age, respectively (Cleator *et al.* 2010). 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 (Cleator *et al.* 2010). 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 (Cleator *et al.* 2010). Some pelagic feeding has also been reported. The Lake Sturgeon feeds actively throughout the year, though consumption may decline in the fall and winter.

ASSESSMENT

Historic and Current Distribution and Trends

DU3 includes the Nelson River, which flows from the north end of Lake Winnipeg to Hudson Bay for a distance of about 660 km, and its immediate drainages in northeastern Manitoba (Figure 1). Five hydroelectric GSs currently exist on the Nelson River, resulting in a series of lake-like impoundments interspersed with unimpounded river sections. Recent tagging data indicate that Lake Sturgeon from the Nelson River (DU3) move into the Hayes River (DU7) from Hudson Bay which brings into question the boundaries of these two DUs (Cleator *et al.* 2010).

Six Lake Sturgeon MUs, separated from each other by natural or man-made barriers, have been identified in the Nelson River (DU3) (Figure 2): (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) from

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, particularly between Kettle and Limestone GSs (Figure 2). The current area of Lake Sturgeon 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).

Cleator *et al.* (2010) contains detailed physical descriptions of each MU.

Playgreen Lake – Whitemud Falls (MU1)

The Lake Sturgeon was present in Playgreen and Cross Lakes between the 1890s and 1920s, but then largely disappeared due to over-exploitation by commercial fisheries (Cleator *et al.* 2010). Stocking was undertaken in MU1 starting in the mid-1990s.

Whitemud Falls – Kelsey GS (MU2)

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 remain in MU2 and are known to spawn upstream of Sipiwesk Lake at Bladder Rapids and downstream at the mouth of the Landing River (Cleator *et al.* 2010).

Kelsey GS – Kettle GS (MU3)

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 (Cleator *et al.* 2010). Today, the Lake Sturgeon occurs throughout the MU (Cleator *et al.* 2010).

Kettle GS – Long Spruce GS (MU4)

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

Long Spruce GS – Limestone GS (MU5)

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

Limestone GS – Hudson Bay (MU6)

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) demonstrating they can move between the mouth of the Nelson and Hayes rivers (Cleator *et al.* 2010). 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 that Lake Sturgeon in the Hayes River was more closely related to Lake Sturgeon from the Gull Lake reach (MU3) than the lower Nelson River (MU6). 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 (Southern Hudson Bay and James Bay populations).

Historic and Current Abundance and Trends

The Lake Sturgeon was historically abundant in DU3. Commercial fisheries in the Nelson River were established by 1902 (Cleator *et al*., 2010) and the last fishery closed in 1991 (COSEWIC 2006). Over the past 50 years, a history of over-exploitation, combined with the construction of hydroelectric dams that blocked migration routes, resulted in population declines in DU3. Today, the Lake Sturgeon in the Nelson River continues 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, based on the precautionary framework (see Cleator *et al.* 2010 for explanation), 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 1900 (Cleator *et al*., 2010). In 1925, the annual limit for Lake Sturgeon was 40,000 lbs (18,144 kg) in Playgreen and Cross Lakes (Cleator *et al*., 2010). 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 (Cleator *et al*., 2010) (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 (Cleator *et al*., 2010). The initial population estimates of 12,000 adult Lake Sturgeon in the early 1960s and corrected estimates of 6,000 in 1987 (Cleator *et al*., 2010) 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 (Cleator *et al*., 2010). 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 (Cleator *et al*., 2010). This spawning run was heavily harvested from 1991 until 1993. 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. Upstream of Sipiwesk Lake, Bladder Rapids is also an important area for Lake Sturgeon spawning (Cleator *et al*., 2010).

Growth rates in Lake Sturgeon were similar in the 1990s to those recorded in the 1950s, prior to hydro development (Cleator *et al*., 2010), 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 indicate both adult and, especially, juvenile Lake Sturgeon are increasing in number and showing signs of recovery (Cleator *et al*., 2010). As younger fish reach sexual maturity, the population trajectory may improve. The current population status and trend of MU2 is 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 (Cleator *et al*., 2010). 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 (Cleator *et al*., 2010). 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 is 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 is 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) (Cleator *et al*., 2010). Over 300 Lake Sturgeon have been known to congregate in the vicinity of the Weir River mouth during spring (Cleator *et al*., 2010). 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

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, from shallow water to depths > 10 m, substrates comprised of clay, sand and gravel/cobble, and water velocities of 0.1-0.3 m/s^{-1} (Cleator *et al.* 2010). 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, however they have also been found in areas of coarse-sand and pea-sized gravel. Juveniles use water depths ranging from 3-6 m to > 14 m and currents of 0.25-0.50 $m \cdot s^{-1}$ (Cleator *et al.* 2010). Depth was shown to be the primary abiotic factor influencing habitat selection in juveniles from the Winnipeg River (Cleator *et al.* 2010). The habitat requirements of young Lake Sturgeon appear to be more restricted, 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 (Cleator *et al.* 2010).

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, that 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. In riverine environments, adults generally prefer water depths of ≥ 5 m with moderate water flow (< 0.6 $m \cdot s^{-1}$), and appear to avoid areas with high current velocity, except during spawning (Cleator *et al.* 2010).

The Lake Sturgeon is 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. Migration 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.

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 to 10 m, and over substrates of cobble, boulders, coarse gravel, hardpan, or sand (Cleator *et al.* 2010). Cascades and/or suitable water flows are necessary to keep the eggs and newly-hatched young healthy yet prevent them from being carried downstream before larval drift occurs. Seasonal and annual changes in flow may affect fidelity to specific spawning and feeding areas. A number of actual and suspected spawning sites are known for DU3 (Cleator *et al.* 2010).

Not as much is known about the habitat preferences of Lake Sturgeon during winter. One study reported that adults spend the winter at water depths of 6-8 m (max. 20 m) and water velocities of ≤ 0.2 $m \cdot s^{-1}$ (max. 0.4 $m \cdot s^{-1}$), over silt and sand substrate (Cleator *et al.* 2010). Juveniles tended to congregate at approximately the same depths, substrate types and flow velocities, although some were observed at flow velocities as high as 0.4-0.6 $m \cdot s^{-1}$ (Cleator *et al.* 2010). In the upper Nelson River, Gull Lake may provide overwintering habitat (DFO 2010).

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

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[1]. The aim is to reach these population and distribution objectives within three generations (i.e., 3 x 36 years = about 108 years) (Cleator *et al.* 2020). If undertaken, this recovery target would achieve a significant reduction in the probability of extinction of Lake Sturgeon in DU3. If a less precautionary recovery target is

[1]Population viability analysis of stage-structure demographic matrices was used to determine recovery targets (Cleator *et al.* 2010). Minimum viable population (MVP) was defined as the number of adults necessary 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, 5-year spawning periodicity and a sufficient number of juveniles to support the adult population goal.

chosen, the number of spawning females per year would be reduced and years to recovery increased accordingly.

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.

Modelling indicates that when current abundances are assumed to be 10% of the recovery target, times-to-recovery range from about 20 years to around 95 years (i.e., about 1-3 generations), depending on the recovery actions implemented (Cleator *et al.* 2010) (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. Without recovery actions, time to recovery would be significantly longer.

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 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.

Threats to Survival and Recovery

Mortality, injury or reduced survival resulting from fishing activities can pose a threat to Lake Sturgeon. While the Lake Sturgeon in DU3 is no longer fished commercially, 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 Lake Sturgeon was, and remains to a slightly lesser degree, an important domestic fishery for First Nations along the Nelson River (Cleator *et al.* 2010). Today, most Lake Sturgeon harvested in DU3 is 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. Current levels of legal harvesting through the subsistence fishery are low and poaching has not been confirmed.

Recreational angling directed at Lake Sturgeon is allowed in this DU, though it is minimal, and any captured individuals must be released.

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 (Cleator *et al.* 2010). 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 (Cleator *et al.* 2010).

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 2). 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 and mortality (Cleator *et al.* 2010). Dam construction can extirpate local Lake Sturgeon populations (Cleator *et al.* 2010) by preventing fish from accessing spawning areas and stranding fish between impassable barriers. Larger structures, like hydroelectric dams, can also cause direct mortality, injury or reduced survival by entrainment[1], impingement[2] and fish passing downstream through the turbines. 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. 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 (Cleator *et al.* 2010). 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.

In summary, the most important current threats to survival and recovery of Lake Sturgeon in DU3 are habitat degradation or loss resulting from the presence of dams/impoundments and other barriers, mortality, injury or reduced survival resulting from fishing, and population fragmentation resulting from the presence of 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 larvae to exogenous feeding) is a critical life stage for Lake Sturgeon.

[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.

Mitigation, Alternatives and Enhancements

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) (Cleator *et al.* 2010). These results highlight the importance of reducing mortality on, and maximizing survival of, adults and late juveniles as the key to recovering this DU. However, the potential for improving survival of adults is low relative to the potential in age-0 and young juveniles (Table 3), therefore the possibility of implementing recovery strategies that improve age-0 and juvenile survival (e.g., habitat rehabilitation) should also be considered. For example, conservation stocking using fish from the same genetic stock has the potential to improve survival of age-0 and young juvenile fish so long as it also addresses potential impacts on genetic variability, artificial selection and transmission of disease from cultured to native fish. Conservation stocking 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 or alternate measures outlined in this document.

Fertility rates in both early and late adult stages are less sensitive to perturbation (Cleator *et al.* 2010). Regardless, 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 (Cleator *et al.* 2010). Complete blockage of spawners at barriers can eradicate a population in a generation from continuous reproductive failure and strong site fidelity for spawning (Cleator *et al.* 2010).

Table 4 provides an inventory of possible mitigation measures, alternatives and enhancements to anthropogenic activities that pose threats to Lake Sturgeon survival and recovery. Mitigations, alternatives and enhancements for the most important threats for DU3, as identified in Table 2, are shown 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 are 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

Modelling analyses for DU3 indicate 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).

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

Age estimates made using a longstanding technique (i.e., counting growth increments on pectoral fin spine cross sections) were recently 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 (Cleator *et al.* 2010). 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 in number primarily as a result of over-exploitation from commercial fisheries and a significant portion of their habitat has been degraded or lost as result of dams/impoundments and other barriers. Current information suggests 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 depend 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 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). 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 the presence of 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 enforcement. 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.

OTHER CONSIDERATIONS

There are several jurisdictions involved in the management and recovery of Lake Sturgeon in DU3 including the Nelson River Sturgeon Co-Management Board, Government of Manitoba and DFO.

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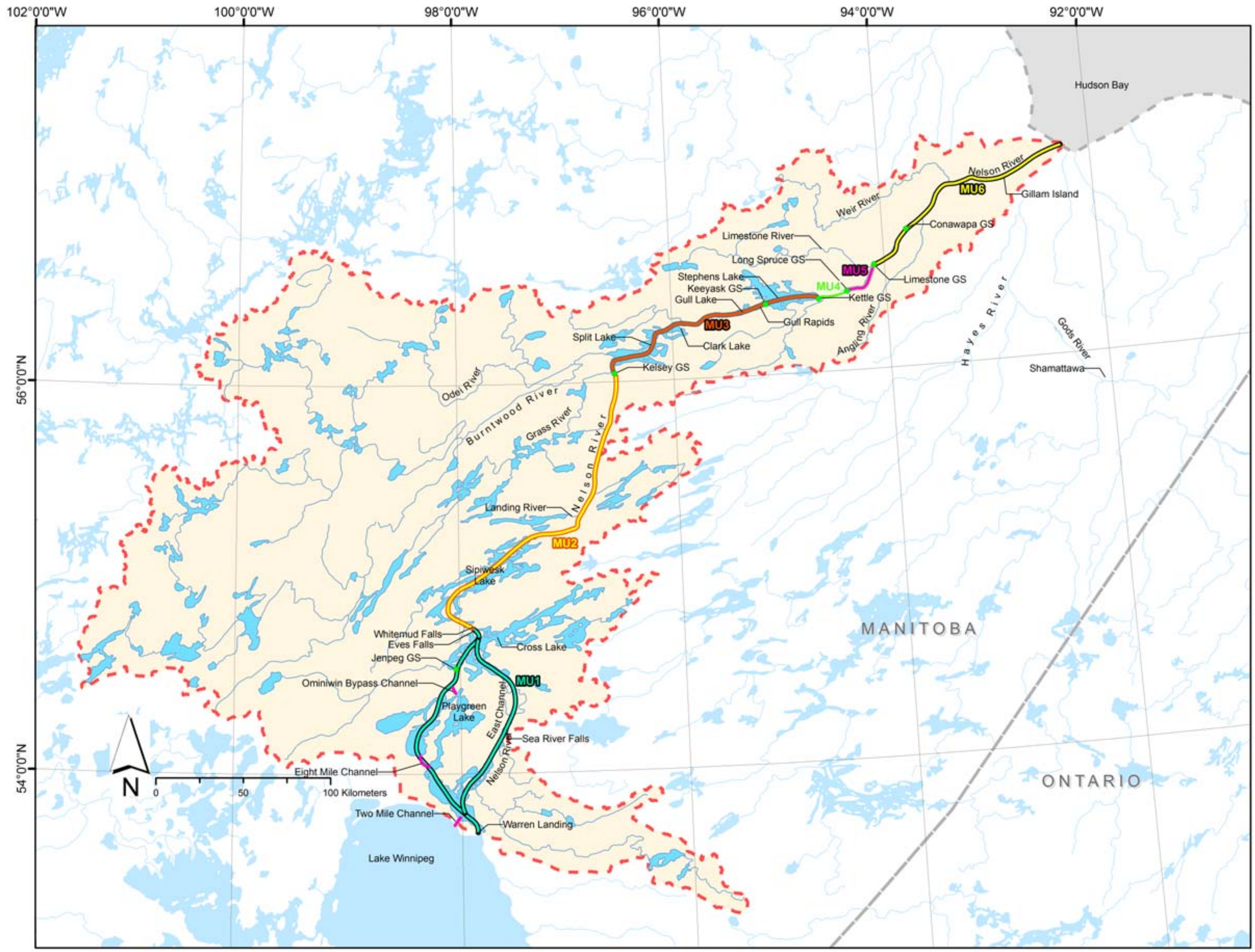

Figure 2. DU3 showing locations of MUs and place names mentioned in the text.

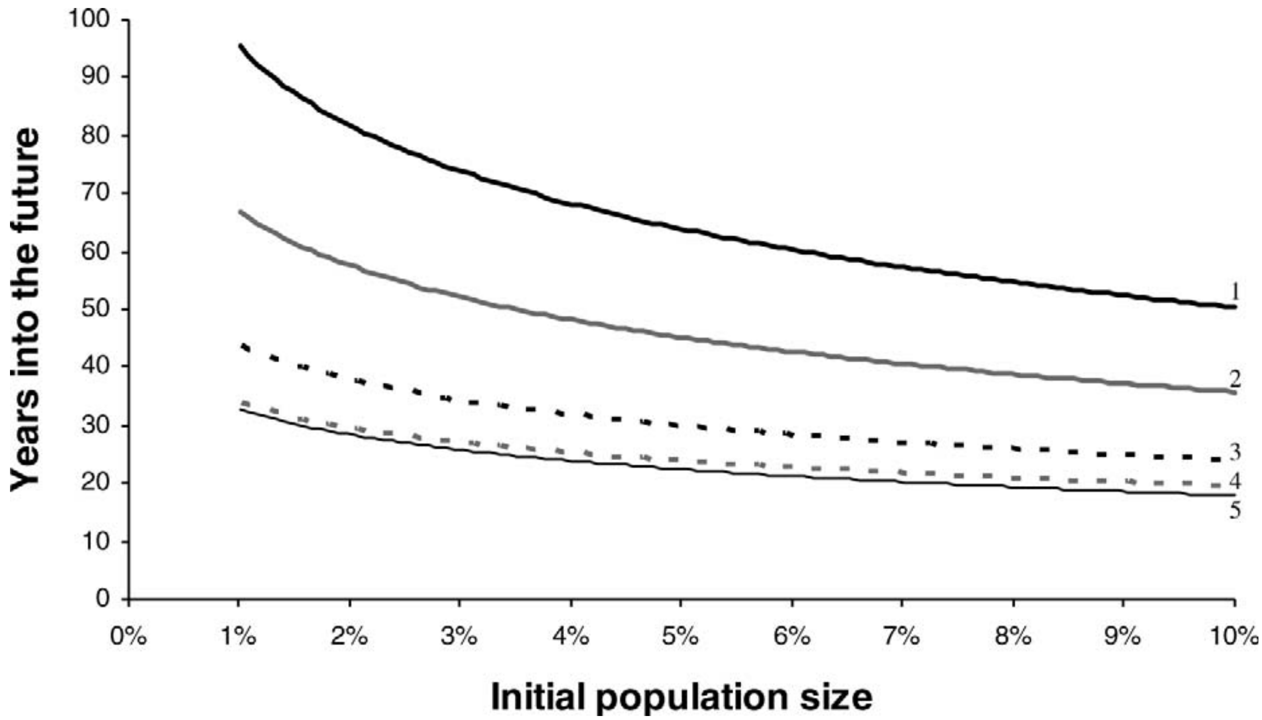

Figure 3. Stochastic projections of times to recovery for Lake Sturgeon based on initial population size (i.e., percentage of MVP) under five different recovery scenarios. Strategy 1 (solid black line) was the maximization of the survival rates of early adults, strategy 2 (solid grey line) added a 10% 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, as cited in Cleator et al. 2010).

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 was based on the best available information and Precautionary Framework (see Cleator et al. 2010 for explanation); 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, as cited in Cleator et al. *2010). 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

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