RECOVERY POTENTIAL ASSESSMENT OF LAKE STURGEON: WINNIPEG RIVER-ENGLISH RIVER POPULATIONS (DESIGNATABLE UNIT 5)

Lake Sturgeon Acipenser fulvescens
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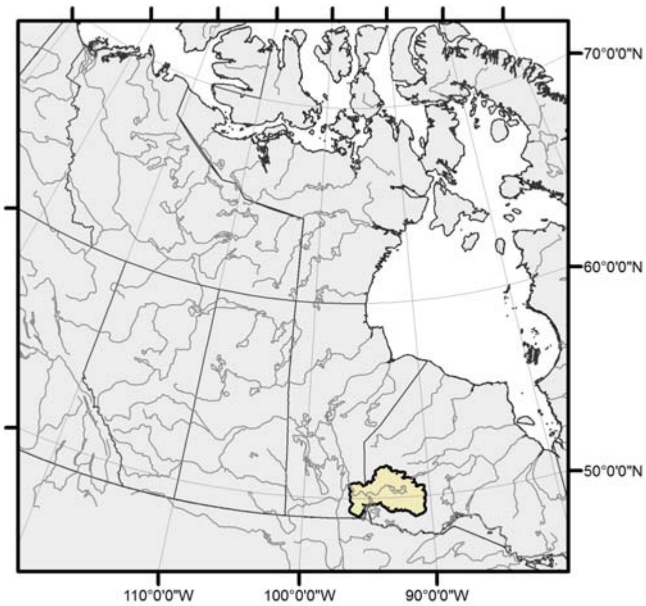

Figure 1. DU5 for Lake Sturgeon (coloured area).

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) 5, the Winnipeg River-English River populations, includes Lake Sturgeon in the Winnipeg River from Pine Falls upstream to Kenora and the English-Wabigoon river system. Lake Sturgeon in this region is considered a distinct DU on the basis of distinguishable variation in three nuclear microsatellite loci (Robinson and Ferguson 2001, COSEWIC 2006). COSEWIC assessed and designated DU5 as Endangered as Lake Sturgeon in this DU declined severely over the past century and a significant portion of their habitat has been degraded or lost. Historically, over-exploitation from commercial fisheries was probably the primary threat, whereas more recently habitat degradation or loss resulting from industrial activities and dams/impoundments and other barriers, genetic contamination from stocking, fishing and population fragmentation, resulting from dams/impoundments and other barriers, have become the most important threats.

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

SUMMARY

- Nine Management Units (MUs) have been identified for DU5: MU1 is the Wabigoon River, MU2 is the English River downstream of Manitou Falls, MU3 is the Winnipeg River between Norman Generating Station (GS) and Whitedog Falls GS, MU4 is between Caribou Falls GS and Whitedog Falls GS and Pointe du Bois GS, MU5 between Pointe du Bois GS and Slave Falls GS, MU6 between Slave Falls GS and Seven Sisters GS, MU7 between Seven Sisters GS and McArthur GS, MU8 between McArthur GS and Great Falls GS and MU9 between Great Falls GS and Pine Falls GS.
- Available data and expert opinion indicate that there are several thousand adult Lake Sturgeon in this DU and juveniles are abundant in some areas; there is evidence of population recovery in some MUs.
- The current status and population trajectories of MUs 1, 2, 8 and 9 are unknown.
- In MUs 3 and 4, the status is critical and the population trajectory is decreasing in MU3 and unknown or possibly decreasing in MU4.
- MUs 5 and 6 are both healthy and population trajectory is stable or increasing in MU5 and stable in MU6.
- The status of MU7 is cautious and population trajectory is unknown.
- Survival and recovery of Lake Sturgeon in DU5 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 DU5 is to protect and maintain healthy, viable populations of Lake Sturgeon in the lower English River (MU2) and Winnipeg River (MUs 3-9).
- The most important current threats to survival and recovery of Lake Sturgeon in DU5 are habitat degradation or loss resulting from industrial activities and dams/impoundments and other barriers, genetic contamination resulting from stocking, mortality, injury or reduced survival resulting from fishing, and population fragmentation resulting from dams/impoundments and other barriers.
- Mitigation measures that would aid recovery include protection of habitat, prevention of mortality, public education and ensuring no genetic contamination.
- Activities that damage or destroy functional components of habitat or key life components of the life cycle pose a very high risk to the survival or recovery of Lake Sturgeon in MUs 3 and 4, high to very high risk in MUs 1, 2, 8 and 9, high risk in MU7 and moderate risk in MUs 5 and 6.

BACKGROUND

Rationale for Assessment

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated Lake Sturgeon in DU5 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 MU5 in 2006-2009 found that fork length (FL) and weight of captured Lake Sturgeon ranged between 0.12-1.6 m and 0.23-23.5 kg, respectively (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). In the Slave Falls reservoir (MU5), juvenile and adult Lake Sturgeon range between 4-40 m and 4-27 m in depth, respectively; no Lake Sturgeon was captured at depths < 3.5 m in summer or fall (Cleator *et al.* 2010). 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. In the Winnipeg River, tagged Lake Sturgeon traveled 45 km in a single day (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). Tagging studies in Numao Lake (MU6) indicate that young Lake Sturgeon are relatively sedentary (Cleator *et al.* 2010). Further, mark-recapture and acoustic telemetry data from MU5 indicate that habitat transitions, specifically areas characterized by shallow water depths (1-5 m) and fast moving (> $1.0\ m \cdot s^{-1}$) water, may limit or restrict juvenile movement (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). 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). Spawning can begin at temperatures as low as 8°C if spring is delayed (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).

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.

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). In the Winnipeg River, the juvenile (approximately 20-70 cm TL) diet is comprised almost entirely (97%) of insect larvae from three invertebrate taxa, trichoptera, diptera and ephemeroptera (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

DU5 includes the Winnipeg River from Pine Falls (in southeastern Manitoba), upstream to Kenora (in northwestern Ontario), and the English-Wabigoon river system (Figure 1).

Nine Lake Sturgeon MUs, separated from each other by natural or man-made barriers, have been identified in the Winnipeg River-English River system (DU5) (Figure 2): (1) the Wabigoon River (separated from the English River by falls), (2) the English River from Manitou Falls GS to Caribou Falls GS, (3) the Winnipeg River from Norman GS to Whitedog Falls GS, (4) from Caribou Falls GS and Whitedog Falls GS to Pointe du Bois GS, (5) from Pointe du Bois GS to Slave Falls GS, (6) from Slave Falls GS to Seven Sisters GS, (7) from Seven Sisters GS to

McArthur GS, (8) from McArthur GS to Great Falls GS and (9) from Great Falls GS to Pine Falls GS. Within each of these MUs there may be one or more spawning stocks.

In the mid-1920s, Lake Winnipeg and its tributary rivers including the Winnipeg River were considered prime Lake Sturgeon fishing areas and Manitoba waters were recognized as the last important stronghold for Lake Sturgeon on the continent (Cleator *et al.* 2010). In the Winnipeg River, the Lake Sturgeon was isolated from Lake Winnipeg by Pine and Great falls. The construction of hydroelectric GSs, beginning in 1906, further fragmented the distribution of this species and restricted upstream movement (Figure 2). Upstream fish passage was not provided at any of the GSs on the Winnipeg or English rivers and few Lake Sturgeon are thought to move downstream between MUs (Cleator *et al.* 2010). The Lake Sturgeon is currently known to occur in at least eight of the nine MUs in DU5 and their area of occupancy is estimated to be < 1,000 km^2 (COSEWIC 2006). The trend in habitat availability in DU5 has been stable for more than fifty years.

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

Wabigoon River (MU1)

It is not known whether the Lake Sturgeon was historically present in the Wabigoon River or occur there now (Cleator *et al.* 2010).

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

There are no documented records of Lake Sturgeon in the English River above Manitou Falls though they were known to occur in Lake St. Joseph and numerous other waterbodies and river systems to the north of there (Cleator *et al.* 2010). Over the past century, potential barriers to Lake Sturgeon migration have been constructed on the English River system and no substantive efforts at detecting Lake Sturgeon have been undertaken. It is possible that unknown populations exist in the upper English River system (Cleator *et al.* 2010). The Lake Sturgeon was known to occur historically below Manitou Falls GS. Recent anecdotal information indicates this species still persists in the lower English River system, including Umfreville and One Man lakes, Kettle Falls and Separation Lake (Cleator *et al.* 2010).

Norman GS – Whitedog Falls GS (MU3)

No historic scientific information about Lake Sturgeon distribution is available for MU3. Recent netting efforts throughout the MU produced only two Lake Sturgeon at Norman Dam (Cleator *et al.* 2010).

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

No historic scientific information about Lake Sturgeon distribution is available for MU4. In recent years, the Lake Sturgeon has been found in both the Ontario and Manitoba portions of this MU. Adult Lake Sturgeon spawn at Caribou Falls and South Boundary Falls (near the Ontario-Manitoba border) and are suspected to spawn at Whitedog GS (Cleator *et al.* 2010).

Pointe du Bois GS – Slave Falls GS (MU5)

Lake Sturgeon likely occurred in MU5 historically though scientific information dates back only several decades. Today, this species is found throughout much of the MU (Cleator *et al.* 2010).

Slave Falls GS – Seven Sisters GS (MU6)

Lake Sturgeon likely occurred in MU6 historically though scientific information dates back only several decades. Today, this species is found in at least some reaches of the MU (Cleator *et al.* 2010).

Seven Sisters GS – McArthur GS (MU7)

The Lake Sturgeon was historically present in MU7. Angler reports, as well as results from experimental netting programs, in recent years indicate that the Lake Sturgeon is present in MU7 (Cleator *et al.* 2010).

McArthur GS – Great Falls GS (MU8)

The Lake Sturgeon is reported to occur in MU8 (Cleator *et al.* 2010) but no historic scientific information is available.

Great Falls GS – Pine Falls GS (MU9)

The Lake Sturgeon is reported to occur in MU9 (Cleator *et al.* 2010) but no historic scientific information is available.

Historic and Current Abundance and Trends

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

The current conservation status, based on the precautionary framework (see Cleator *et al.*, 2010 for explanation), of each of the MUs in DU5 was evaluated on the basis of available information and expert opinion (Table 1).

Wabigoon River (MU1)

There appear to be no confirmed current or historical records of Lake Sturgeon occurrences in the Wabigoon River (Cleator *et al.* 2010). The current population status and trajectory of Lake Sturgeon in MU1 are unknown (Table 1).

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

Below Manitou Falls GS, the Lake Sturgeon was known to occur historically, but now likely remain only as remnant populations in the lower reaches of the English River. Recent interviews with lodge operators and anglers indicate that Lake Sturgeon are often seen at and above Kettle Falls, though rarely in Umfreville and One Man lakes, and that recruitment is taking place (Cleator *et al.* 2010). Given the limited information available, current population status and trend of Lake Sturgeon in MU2 are unknown (Table 1).

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

No Lake Sturgeon was caught incidentally in nets in MU3 over a six-year period in the early 2000s (Cleator *et al.* 2010). Over 100,000 Lake Sturgeon fry were recently stocked in this portion of the Winnipeg River from DU6 (Lake of the Woods – Rainy River populations) in an effort to recover the remnant Lake Sturgeon population. In 2008 and 2009, intensive netting for adult and juvenile Lake Sturgeon throughout the entire MU resulted in the tagging and release of two adults at the Norman GS (Cleator *et al.* 2010). The current status and trend of Lake Sturgeon in MU3 is critical and decreasing, respectively (Table 1).

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

Hundreds of juvenile and adult Lake Sturgeon have been tagged in the Ontario portion of this MU in recent years. Most age classes are represented though adult fish are relatively uncommon, and there is evidence of recruitment but it is relatively low and sporadic (Cleator *et al.* 2010). The potential for recovery exists if conditions that support recruitment can be improved. Peaking and ponding operations occur at the two Ontario GSs. Lake Sturgeon are known or suspected to spawn below the GSs in years when spilling occurs. In years when no spilling occurs, there is little or no recruitment (DFO 2010) which may impact time to recovery for this MU.

In the Manitoba portion of MU4, anglers have reported both visual observations and occasional catches of Lake Sturgeon. Between Lamprey Rapids and the Pointe du Bois GS during 2006-2009, spring gillnetting caught only two adult fish (catch per unit effort (CPUE) 0.13 fish/100 m net/24 h) and additional netting efforts captured 14 juvenile fish (30-80 cm FL) during summer and fall and four adult fish during spring (Cleator *et al.* 2010). At present, the current status of Lake Sturgeon in MU4 is thought to be critical and population trend to be unknown or possibly decreasing (Table 1).

Pointe du Bois GS – Slave Falls GS (MU5)

Ageing data collected in MU5 from 1991 to 1999 shows a population comprised of strong cohorts from the 1960s to the late 1970s and a significant decline in cohort strength from 1979 to 1984 (Cleator *et al.* 2010). This pattern mirrors the results of the data collected in the Nutimik-Numao reach in MU6. Annual population estimates were developed for MU5 between 1994 and 1997 which ranged between 360 (95% CI: 186-2,903) and 1,100 (95% CI: 498-7,154) (Cleator *et al.* 2010). A recent study in MU5, starting in 2006, produced CPUEs based on spring gillnetting ranging between 7.8-18.7 and a population estimate in 2007 of 2,205 (95% CI: 921-4,095) Lake Sturgeon greater than 80 cm in length (Cleator *et al.* 2010). Fall gillnetting in 2007 found that approximately 80% of captured Lake Sturgeon were juveniles (i.e., < 80 cm in length). This MU contains a relatively high density of Lake Sturgeon, indicating the population could be near the carrying capacity of the habitat. Stocking for research and management purposes has occurred at least once in MU5 (in 2009), using broodstock from MU5 (Cleator *et al.* 2010). The current status of Lake Sturgeon in MU5 is healthy and population trajectory is stable or increasing (Table 1).

Slave Falls GS – Seven Sisters GS (MU6)

Ageing data collected in MU6 from 1991 to 1999 shows a population comprised of strong cohorts from the 1960s to the late 1970s and a significant decline in cohort strength from 1979 to 1984 (Cleator *et al.* 2010). Since that time, cohort strength has continually improved and the early cohorts in this group have now reached sexual maturity (Cleator *et al.* 2010). In the late

1990s, an estimated 2,352 Lake Sturgeon were present between Pointe du Bois and Seven Sisters GSs (MUs 5 and 6), of which about 660 (28%) were sexually mature (i.e., > 26 years) (COSEWIC 2006). This population estimate may be positively biased as some assumptions used to derive the estimate may not be valid. Between 1989 and 2003, CPUE data collected in MU6 decreased by 54.9%; the majority of the decrease likely occurred in 1989-1990 (COSEWIC 2006). Since 2003, CPUE data shows an upward trend primarily due to significant increases in catches from the 14 cm (5.5 inch) mesh. Recent research indicates that several thousands of juveniles (25-70 cm FL) exist in certain river reaches of MU6 (Cleator *et al.* 2010) as a result of natural reproduction. Stocking for research and management purposes has occurred in MU6 at least eleven times (between 1998 and 2005), using broodstock likely from, in most cases, MUs 5 and/or 6 (Cleator *et al.* 2010). The current status of Lake Sturgeon in MU6 is healthy and population trajectory is stable (Table 1).

Seven Sisters GS – McArthur GS (MU7)

Before construction of the Seven Sisters GS, there was an important Lake Sturgeon spawning and nursery area located below the GS site (COSEWIC 2006). Fewer Lake Sturgeon may occur in this MU now than did historically, though a current study indicates that the Lake Sturgeon is relatively common, at least within several km downstream of the Seven Sisters GS, they still spawn below the GS and recruitment is occurring (Cleator *et al.* 2010). Angler reports, as well as results from experimental netting programs, indicate that various size classes of Lake Sturgeon are represented (Cleator *et al.* 2010). Stocking for research and management purposes has occurred in MU7 at least six times (between 1997 and 2008), using broodstock likely from, in most cases, MUs 5 and/or 6 (Cleator *et al.* 2010). The current status of Lake Sturgeon in MU7 is thought to be cautious although population trend is unknown (Table 1).

McArthur GS – Great Falls GS (MU8)

Anglers are known to target Lake Sturgeon below McArthur GS. Experimental netting in 2003 yielded two Lake Sturgeon (1.0 m and 1.5 m in length) from five set locations with a CPUE of 0.4 (Cleator *et al.* 2010). Stocking for research and management purposes has occurred in MU8 at least three times (between 1996 and 2002), using broodstock likely from, in most cases, MUs 5 and/or 6 (Cleator *et al.* 2010). The current status and trend of Lake Sturgeon in MU8 are unknown (Table 1).

Great Falls GS – Pine Falls GS (MU9)

Experimental netting conducted in 2003 yielded 54 Lake Sturgeon ranging in size between 0.4-1.6 m from nine set locations with a CPUE of 6.0 (Cleator *et al.* 2010). Environmental monitoring studies conducted within an area extending nine kilometers upstream of Pine Falls GS in 2006 yielded a CPUE of 1.36 for Lake Sturgeon (Cleator *et al.* 2010). Stocking for research and management purposes has occurred in MU9 at least once (in 2002), using broodstock likely from, in most cases, MUs 5 and/or 6 (Cleator *et al.* 2010). The current status and trend of Lake Sturgeon in MU9 are 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 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 $m \cdot s^{-1}$ (Cleator *et al.* 2010). In MU5 of the Winnipeg River, deep sandy environments are preferred for nursery habitat (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). From spring to fall, juveniles were found congregating in deep water (depths > 13.7 m), with detectable water velocities (> 0.20 $m \cdot s^{-1}$) over a variety of substrate types, and were rarely located in shallow, low water velocity habitats (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 0.5-10 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 DU5 (Cleator *et al.* 2010, DFO 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 ≤ 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 summary, maintaining the functional attributes of habitat, including the ecologically-based flow regimes, needed for spawning, egg incubation, juvenile rearing, summer feeding and overwintering, as well as migration routes between these habitats, is critical to the survival and recovery of Lake Sturgeon. The current distribution of Lake Sturgeon in DU5 is fragmented by nine GSs which may negatively affect the spawning habitat. It is essential that conditions that optimize the survival and recovery of Lake Sturgeon be maintained in DU5, especially during the spawning and incubation periods.

Residence

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

Recovery Targets

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

If the Lake Sturgeon is found in the Wabigoon River, then recovery efforts should be undertaken there.

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.

[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.

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

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

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

Threats to Survival and Recovery

Mortality, injury or reduced survival resulting from fishing activities can pose a threat to Lake Sturgeon. An historical commercial fishery in the Winnipeg River harvested significant amounts of Lake Sturgeon: 79,000 kg in 1910; 145,437 kg between 1939 and 1947; and 28,800 kg between 1957 and 1959 (Cleator *et al.* 2010). The commercial harvest in DU5 ended in the 1960s in Manitoba and the 1970s in Ontario. A catch-and-release recreational fishery is allowed in the Manitoba portion of DU5. In Ontario, any Lake Sturgeon caught while recreational fishing for other species must be released. Aboriginal harvest of Lake Sturgeon by First Nations for subsistence, cultural and ceremonial purposes continues in Ontario but not in Manitoba. Poaching is a concern in DU5. Although the current levels of legal harvesting through the subsistence fishery (Ontario only) and illegal harvesting are low, the removal of juveniles and adults affects recovery (Cleator *et al.* 2010).

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).

Eight hydroelectric GSs were developed on the Winnipeg River over the past century (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[2], impingement[3] 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.

Other human activities likely have also contributed to the degradation of Lake Sturgeon habitat in DU5. Water quality deteriorated due to industrial activities, specifically pulp and paper processing. MUs 1 and 3 are still likely affected by flushing of residual discharge from the mills in Dryden and Kenora, respectively. Mining and forestry exploration and extraction, agricultural activities and urban development, particularly cottage developments, occur in various MUs within DU5. Their effects on Lake Sturgeon habitat are nil, low or unknown.

Stocking was undertaken in MU3 using fish from DU6 thus the risk of genetic contamination in the remnant population is relatively high. Over the past fifteen years or more, stocking has also been undertaken in MUs 5-9 using broodstock from that region of the river thus the likelihood of genetic contamination there is lower.

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

Limiting Factors for Population Recovery

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

[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.

Mitigation, Alternatives and Enhancements

The Lake Sturgeon in DU5 is most sensitive to harm on early adults, followed by late juveniles, late adults, early juveniles and age-0 (in decreasing order) (Cleator *et al.* 2010). Fishing mortality, one of the main causes of population decline in DU5, has been largely eliminated over the past few decades. Contrary to the modelling results, recent research in DU5 indicates that Lake Sturgeon is showing signs of recovery in at least two MUs (i.e., 5 and 6). While this is encouraging, the modelling results highlight the importance of reducing mortality on adults and late juveniles (e.g., from fishing) as the key to recovering this DU, and indicate that any recovery measures that maximize survival of these stages will increase the likelihood of, or shorten the time to, recovery (Cleator *et al.* 2010).

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). 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 DU5, as identified in Table 2, are shown below.

Mitigations and alternatives

Habitat degradation or loss: industrial activities

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

Habitat degradation or loss: dams/impoundments and other barriers

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

Sturgeon culture: genetic contamination

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

Mortality, injury or reduced survival: fishing

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

Mortality, injury or reduced survival: population fragmentation

- Prevent any additional fragmentation.
- Provide effective upstream and downstream fish passage for Lake Sturgeon at new dams and modernization of existing dams if necessary.
- Remove barriers that prevent Lake Sturgeon from migrating to known historical spawning sites, or provide effective upstream and downstream fish passage at current barriers if necessary.
- Rehabilitate habitat in key areas to mitigate habitat degradation or loss of important habitat (e.g., spawning sites) and to improve age-0 and juvenile survival.
- Select the most appropriate design option for new dams and modernization of existing dams to ensure Lake Sturgeon survival and recovery 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 DU5 indicate that once the main causes of population decline are removed, the minimum recovery efforts for individual vital rates that would be necessary to reverse declines in abundance would be approximately 4.7-27.2% increments in adult survival, 18.2-35.8% in juvenile survival, 39.7% in age-0 survival and 62.4-136.1% in fertility rates (Table 3). It is not feasible to increase survival rates sufficiently for late adults and fertility rates for early and late adults to achieve recovery (Table 3).

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

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

Data and Knowledge Gaps

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

Sources of uncertainty

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

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

Over the past century, Lake Sturgeon in DU5 declined 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 a result of dams/impoundments and other barriers. Current data indicate that there are several thousand adult Lake Sturgeon in this DU and juveniles are abundant in some areas. There is evidence of population recovery in some MUs.

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

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

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

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

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

OTHER CONSIDERATIONS

There are several jurisdictions involved in the management and recovery of Lake Sturgeon in this DU including the governments of Manitoba and Ontario and DFO.

SOURCES OF INFORMATION

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COSEWIC. 2006. COSEWIC assessment and update status report on the Lake Sturgeon *Acipenser fulvescens* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 107 p. / COSEPAC. 2006. Évaluation et Rapport de situation du COSEPAC sur l'esturgeon jaune (*Acipenser fulvescens*) au Canada - Mise à jour. Comité sur la situation des espèces en péril au Canada. Ottawa. xi + 124 p.

DFO. 2010. Proceedings of the Central and Arctic Regional Science Advisory Process on the Recovery Potential Assessment of Lake Sturgeon for Designatable Units 1-5; October 20-22, December 3 and 17, 2010. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2010/047.

Figure 2. DU5 (shaded) showing locations of MUs and place names mentioned in the text.

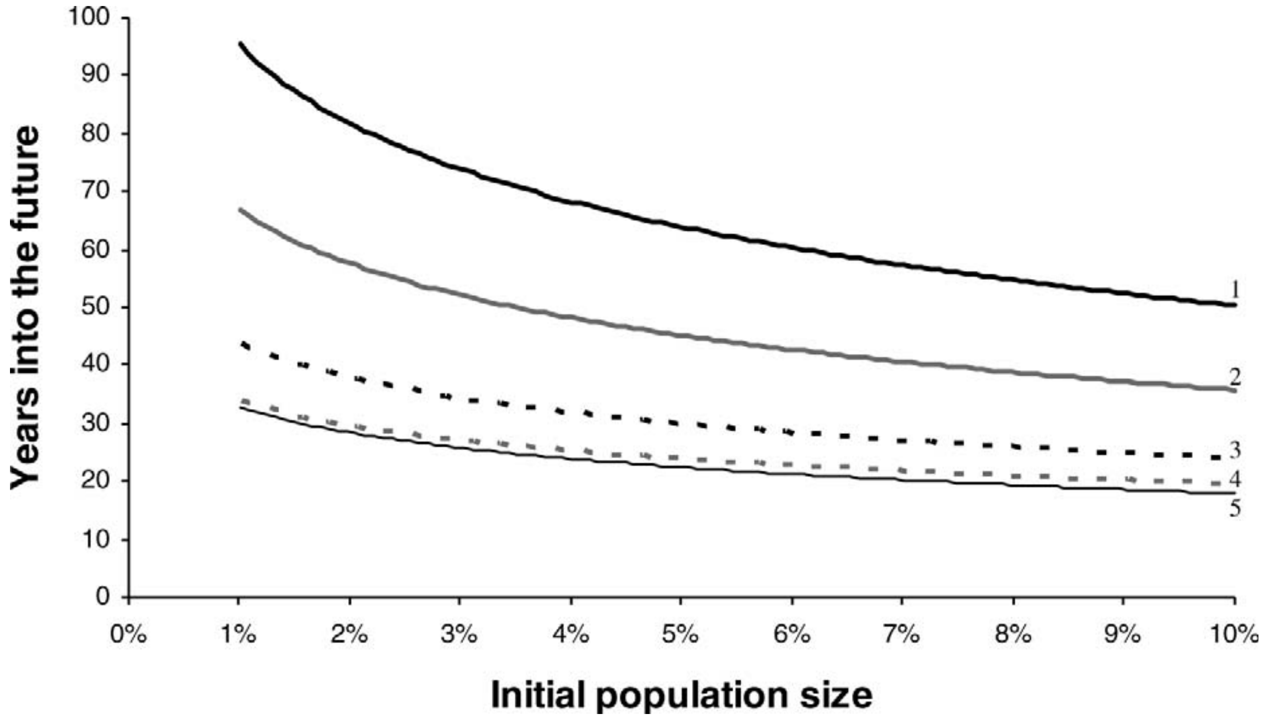

Figure 3. Stochastic projections of times to recovery for Lake Sturgeon based on initial population size (i.e., percentage of MVP) under five different recovery scenarios. Strategy 1 (solid black line) was the maximization of the survival rates of early adults, strategy 2 (solid grey line) added a 10% 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 nine Lake Sturgeon Management Units (MUs) in the Winnipeg River-English 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 DU5. For example, if a DU contained only one Lake Sturgeon MU whose conservation status was considered to be Healthy, then its importance to species recovery would be rated High as catastrophic loss of that MU would result in extirpation of the DU. Recovery potential is based on a combination of current conservation status and current threats status. Importance to species recovery and recovery potential were rated as Nil, Low, Moderate, High or Unknown.

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

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

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

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

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

Table 3. Minimum recovery effort and maximum allowable harm with respect to annual survival and fertility of Lake Sturgeon in DU5 based on results of modelling (Vélez-Espino and Koops 2009, 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	39.7%[1]	0%
Early juvenile survival	35.8%[1]	0%
Late juvenile survival	18.2%[1]	0%
Early adult survival	4.7%[1]	0%
Late adult survival	27.2%[2] (12.0%[3])	0%
Early adult fertility	136.1%[1] (18.3%[3])	0%
Late adult fertility	62.4%[1] (7.2%[3])	0%

[1]Value generated by the stochastic DU5 model.

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

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

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

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

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

Table 4. (Continued)

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

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

FOR MORE INFORMATION

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