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Information Relevant to a Recovery Potential Assessment of Lake Sturgeon: Red-Assiniboine Rivers – Lake Winnipeg Populations (DU4)

Renseignements pertinents pour l'évaluation du potentiel de rétablissement de l'esturgeon jaune : populations des rivières Rouge et Assiniboine et du lac Winnipeg (UD 4)

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ABSTRACT

The Lake Sturgeon (*Acipenser fulvescens*) was common in nearshore waters across much of Canada in the nineteenth century, but intensive fishing, habitat loss and degraded water quality caused severe reductions in population size or extirpation across their range. Today they remain extant from the North Saskatchewan River in Alberta, to Hudson Bay in the north, and eastward to the St. Lawrence River estuary. In November 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed Lake Sturgeon in Canada. Designatable Unit (DU) 4, the Red-Assiniboine rivers – Lake Winnipeg populations, includes Lake Sturgeon in the Red and Assiniboine rivers, Lake Winnipeg and all eastern tributary rivers to Lake Winnipeg excluding the Winnipeg River upstream of Pine Falls. COSEWIC assessed and designated DU4 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, especially in the southern portion of the DU. Historically, over-exploitation from commercial fisheries was probably the primary threat, whereas more recently habitat degradation and loss associated with agriculture, urban development, dam/impoundments and other barriers and industrial activities, and bycatch from the commercial fishery on Lake Winnipeg have become the most important threats.

DU4 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 DU4, 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 DU4 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.

Eight Lake Sturgeon Management Units (MUs) have been identified for DU4. Available data and expert opinion indicate that due to stocking the current status of the stocked fish in MUs 1-3 is critical and their population trajectories are increasing. The indigenous Lake Sturgeon from MUs 1-3 are either extirpated or functionally extirpated. The current status, trajectory and potential for recovery of MUs 4-7 are unknown except in the Ontario portion of Berens River (MU6) where recent information suggests they are cautious, increasing and high, respectively. The status and population trajectory of MU8 is critical and unknown respectively. Limited data indicates that low numbers of Lake Sturgeon are now present throughout much of DU4. The long-term recovery goal is to protect and maintain viable populations of Lake Sturgeon in all MUs.

RÉSUMÉ

L'esturgeon jaune (*Acipenser fulvescens*) était abondant dans les eaux côtières de la majeure partie du Canada au dix-neuvième siècle, mais la pêche intensive, la perte d'habitat et la dégradation de la qualité de l'eau ont entraîné de graves diminutions de la taille de la population ou, encore, sa disparition dans l'ensemble de son aire de répartition. Aujourd'hui, les populations subsistent de la rivière Saskatchewan Nord en Alberta à la baie d'Hudson au nord et à l'estuaire du fleuve Saint-Laurent à l'est. En novembre 2006, le Comité sur la situation des espèces en péril au Canada (COSEPAC) a évalué l'esturgeon jaune au Canada. L'unité désignable (UD) 4, à savoir les populations des rivières Rouge et Assiniboine et du lac Winnipeg, comprend les esturgeons jaunes présents dans les rivières Rouge et Assiniboine, le lac Winnipeg et tous les tributaires à l'est du lac Winnipeg, sauf la rivière Winnipeg en amont de Pine Falls. Le COSEPAC a évalué l'UD 4 et l'a désignée comme étant en voie de disparition, car l'esturgeon jaune dans cette UD a connu un grave déclin au cours du siècle dernier ainsi que la dégradation ou la perte d'une partie importante de son habitat, particulièrement dans le sud de l'UD. Historiquement, la surexploitation par la pêche commerciale était probablement la principale menace, tandis que, plus récemment, la dégradation et la perte de l'habitat causées par l'agriculture, le développement urbain, les barrages, les ouvrages de retenue et autres obstacles ainsi que les activités industrielles et les prises accessoires provenant de la pêche commerciale dans le lac Winnipeg sont devenues les menaces les plus importantes.

L'esturgeon jaune (*Acipenser fulvescens*) était abondant dans les eaux côtières de la majeure partie du Canada au dix-neuvième siècle, mais la pêche intensive, la perte d'habitat et la dégradation de la qualité de l'eau ont entraîné de graves diminutions de la taille de la population ou, encore, sa disparition dans l'ensemble de son aire de répartition. Aujourd'hui, les populations subsistent de la rivière Saskatchewan Nord en Alberta à la baie d'Hudson au nord et à l'estuaire du fleuve Saint-Laurent à l'est. En novembre 2006, le Comité sur la situation des espèces en péril au Canada (COSEPAC) a évalué l'esturgeon jaune au Canada. L'unité désignable (UD) 4, à savoir les populations des rivières Rouge et Assiniboine et du lac Winnipeg, comprend les esturgeons jaunes présents dans les rivières Rouge et Assiniboine, le lac Winnipeg et tous les tributaires à l'est du lac Winnipeg, sauf la rivière Winnipeg en amont de Pine Falls. Le COSEPAC a évalué l'UD 4 et l'a désignée comme étant en voie de disparition, car l'esturgeon jaune dans cette UD a connu un grave déclin au cours du siècle dernier ainsi que la dégradation ou la perte d'une partie importante de son habitat, particulièrement dans le sud de l'UD. Historiquement, la surexploitation par la pêche commerciale était probablement la principale menace, tandis que, plus récemment, la dégradation et la perte de l'habitat causées par l'agriculture, le développement urbain, les barrages, les ouvrages de retenue et autres obstacles ainsi que les activités industrielles et les prises accessoires provenant de la pêche commerciale dans le lac Winnipeg sont devenues les menaces les plus importantes.

On a relevé huit unités de gestion (UG) de l'esturgeon jaune pour l'UD 4. Les données disponibles ainsi que les opinions d'experts indiquent qu'en raison de l'ensemencement, l'état actuel des poissons ensemencés dans les UG 1 à 3 est critique et la trajectoire des populations est à la hausse. L'esturgeon jaune indigène des UG 1 à 3 est disparu ou fonctionnellement disparu. L'état actuel, la trajectoire et le potentiel de rétablissement des UG 4-7 sont inconnus, sauf dans la partie ontarienne de la rivière Berens (UG 6) pour laquelle de nouvelles informations semblent indiquer que l'état se situe dans la zone de prudence, la trajectoire est à la hausse et le potentiel de rétablissement est élevé.L'état de l'UG 8 est critique et la trajectoire de la population est inconnue. Les données limitées indiquent que l'esturgeon jaune est maintenant présent en faible nombre dans presque l'ensemble de l'UD 4. Le but du rétablissement à long terme est de protéger et de maintenir des populations d'esturgeons jaunes viables dans l'ensemble des UG.

INTRODUCTION

The Lake Sturgeon (*Acipenser fulvescens*) is part of an evolutionarily ancient, temperate freshwater fish family. They are slow-growing and long-lived, and their extended reproductive cycles make them vulnerable to human-induced population declines. The Lake Sturgeon was common in nearshore waters across much of Canada in the nineteenth century, but over the past century have undergone severe reductions in population size, or extirpation, in response to intensive fishing, habitat loss and degraded water quality. Eight Canadian designatable units (DUs) of Lake Sturgeon are recognized by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). DU4 includes Lake Sturgeon in the Red and Assiniboine rivers, Lake Winnipeg and all eastern tributary rivers to Lake Winnipeg excluding the Winnipeg River upstream of Pine Falls (Figure 1). COSEWIC assessed and designated this DU as Endangered in November 2006 (COSEWIC 2006). The Lake Sturgeon has cultural significance and importance for subsistence harvesting to First Nations peoples. This species is valued by recreational fishers for catch-and-release and is of value to the tourist industry. Maintaining Lake Sturgeon populations in Canada, including DU4, is important for the long-term survival and recovery of this species.

SPECIES BIOLOGY AND ECOLOGY

The Lake Sturgeon is a bottom-dwelling freshwater fish that is heavy, cartilaginous and torpedo-shaped with an extended, hard snout and shark-like caudal fin. Larval and juvenile fish have conspicuous bony plates (scutes) in five rows along the body which become less obvious with age as they embed in the body wall. The pointed snout has four prominent barbels located ventrally and well in front of the mouth. The Lake Sturgeon is typically light to dark brown or grey in colour on the back and sides with a lighter-coloured belly. They can attain over 3 m in length and 180 kg in weight, though they mostly range about 0.9-1.5 m in length and about 5-35 kg in weight (Scott and Crossman 1973). Females are usually larger than males (Harkness and Dymond 1961, Mosindy and Rusak 1991).

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

The Lake Sturgeon usually occurs at depths of 5-10 m or more over mud, clay, sand or gravel substrates in water temperatures within the range of 3-24°C (COSEWIC 2006). In the Winnipeg River, juvenile Lake Sturgeon prefer deep water areas greater than 13.7 m (Barth *et al.* 2009), while most adults were captured in 4-19 m depths (D. MacDonell, pers. comm.). The Lake Sturgeon has been described as largely sedentary (Threader and Brousseau 1986, Fortin *et al.* 1993, Haxton 2003) with high site fidelity except to move over longer distances for spawning. A low proportion of adult fish migrate long distances, sometimes in excess of hundreds of km, but most make localized (1-20 km) seasonal movements between feeding areas in large rivers or lakes and spawning areas, and typically exhibit site fidelity to spawning areas and sometimes to “home” or “activity” centres for feeding and/or overwintering (Sandilands 1987, Kempinger 1988, Fortin *et al.* 1993, Auer 1996, Rusak and Mosindy 1997, Borkholder *et al.* 2002, Knights *et al.* 2002, Barth and Ambrose 2006). Tagging studies indicate that in contiguous lake-river systems, basin-wide movement patterns may be the most prevalent during the ice-free season, especially during the spawning and post-spawning period when water temperatures increase, while fairly limited movements are typical during the winter months (Mosindy and Rusak 1991, Rusak and Mosindy 1997, Borkholder *et al.* 2002). Tagging studies also indicate that younger, smaller Lake Sturgeon do not move as far as older, larger individuals (Mosindy and Rusak 1991, Swanson *et al.* 1991, Holtgren and Auer 2004, Benson *et al.* 2005, Smith and King 2005). Further, some mark-recapture and acoustic telemetry data from DU5 indicate that habitat transitions, specifically areas characterized by shallow water depths (1-5 m) and fast moving (> 1.0 $m \cdot s^{-1}$) water, may limit or restrict juvenile movement (Barth, unpubl. data).

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

Tagging studies in Round Lake, on the Pigeon River, indicate that young Lake Sturgeon are relatively sedentary (Dick 2004). On the other hand, 30 of 378 Lake Sturgeon originally tagged and stocked in the Ottertail River (Minnesota) in 1997 and 1998 were recaptured in the Manitoba portion of the Red River and south basin of Lake Winnipeg between 1998 and 2007 (Manitoba Fisheries Branch (MFB), unpubl. data). The maximum distance from tagging location to recapture was 500 km but these movements are from translocated juvenile fish that may have abnormal migratory behaviour. Stocking with fry and fingerlings has resulted in shorter movements. Locations of recaptured immature fish in the Assiniboine River ranged as far as 200 km upstream and 150 km downstream from the City of Brandon (MFB, unpubl. data).

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

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

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

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

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

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

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

ASSESSMENT

HISTORIC AND CURRENT DISTRIBUTION AND TRENDS

DU4 includes the Red and Assiniboine rivers and their tributaries, Lake Winnipeg and all eastern tributary rivers to Lake Winnipeg except the Winnipeg River upstream of Pine Falls (Figure 1). The Lake Sturgeon in this region has been identified as a designatable unit, although there was likely some sub-structuring between those that reside in rivers versus lakes, and across this large and diverse area (COSEWIC 2006).

Eight Lake Sturgeon MUs have been identified in DU4 (Figure 1): (1) the Assiniboine River and tributaries upstream of the Portage la Prairie Diversion, (2) Red River and tributaries upstream of Lockport, including the Assiniboine River to the Portage la Prairie Diversion, (3) Red River downstream of Lockport (4) Bloodvein River, (5) Pigeon River, (6) Berens River, (7) Poplar River and (8) Lake Winnipeg, including the Winnipeg River below Pine Falls Generating Station (GS). Within each of these MUs there may be one or more spawning stocks.

Scientific knowledge of the historic distribution of Lake Sturgeon in DU4 is limited. Loss of populations has likely resulted in a significant decline in distribution in the southern portion of DU4 and recent stocking has been undertaken. The Lake Sturgeon currently occurs in all eight MUs and their area of occupancy in DU4 is estimated to be < 250,000 km^2 (COSEWIC 2006).

Assiniboine River and tributaries upstream of the Portage la Prairie Diversion (MU1)

The Assiniboine River is a seventh order stream at the Manitoba-Saskatchewan border and is 782 river km in length from Lake of the Prairies to the Portage la Prairie Diversion. The river is characterized by a low gradient and meandering channel with deeper outside bends and shallow inside point bars. Oxbows are abundant throughout the MU and provide evidence of a dynamic hydrological history. The substrate is primarily sand or sand/silt with intermittent glacial till exposures. Underwater visibility is low but seasonably variable. Thirty-eight fish species have been identified in the mainstem which increases to 65 when the tributaries are included, and 12 freshwater mussels have been recorded. Shellmouth Dam and the Portage la Prairie Diversion were constructed in the late 1960s primarily for flood control and became operational in the early 1970s. Prior to that, only the Manitoba Hydro Thermal Generating Station (TGS) weir and the Brandon Third Street Dam were barriers to fish passage in the mainstem and only during lower flows. Currently, a fishway is proposed to facilitate passage at the Third Street Dam and the rock weir at the hydro thermal station has been breached and allows passage. The Assiniboine River has three major tributaries in MU1: the Little Saskatchewan, Souris and Qu'Appelle rivers.

The Little Saskatchewan River is 272 river km in length from its headwaters in Riding Mountain National Park to its confluence with the Assiniboine River, 25 river km upstream of the City of Brandon. This river was an important spawning tributary and this is supported by historical evidence of a large Lake Sturgeon that was caught and mounted in the late 1800 at Tanner's Crossing in the Town of Minnedosa. The lower reaches of this tributary are characterized as a medium meandering stream with rock riffles and pools. In the middle and upper reaches, the river is a low-gradient meandering stream with a sand/silt/organic substrate. A total of 28 fish species have been identified for the river from current and historical fishery survey work. The main barrier to fish passage in this tributary is the Lake Wahtopanah dam near the community of Rivers. The other two dams on the river, located at Rapid City and Minnedosa, have pool and riffle fishways which provide fish passage.

The Souris River is 1,264 river km in length, of which 400 river km is located in Saskatchewan and 280 river km in Manitoba. It joins the Assiniboine River 47 river km downstream of the City of Brandon. Barriers to fish passage in this tributary date from the 1930s and include the Wawanesa, Souris, Hartney and Melita dams, as well as numerous ford crossings in Manitoba and several dams in North Dakota and Saskatchewan. The Souris River is a low-gradient meandering stream with the lower reaches having numerous rock rapids and riffles and upper reaches that have been channelized. This river has many of the fish species found in the Assiniboine River.

The Qu'Appelle River is 430 river km in length from its origin at Qu'Appelle Valley GS on Lake Diefenbaker in Saskatchewan to its confluence with the Assiniboine River in Manitoba, 33 river km from the Saskatchewan border at the Town of St. Lazare. Water flows increased and became more reliable in the Souris River when water was diverted from Lake Diefenbaker in the late 1960s. Water quality and habitat were affected by channel modifications and water management beginning in the 1980s.

The Lake Sturgeon was historically resident in the Assiniboine River and its tributaries upstream of the Portage la Prairie Diversion (B. Bruederlin, pers. comm.). The lower reaches of the Little Saskatchewan River was an important spawning tributary. Spawning also may have occurred in the Souris River and Qu'Appelle River, including Pasqua, Echo, Mission, Katepwa, Crooked and Round lakes (R. Hlasny, pers. comm.). By the time the Portage la Prairie Diversion and Shellmouth Dam were constructed in 1970, the Lake Sturgeon had been extirpated in MU1 (Table 1). Stocking was undertaken in the Assiniboine River between 1996 and 2008 from the Saskatchewan River (DU2), Nelson River (DU3) and Winnipeg River (DU5) (MFB, unpubl. data). Since 2007, anglers have reported catching and releasing Lake Sturgeon between Brandon and the Little Souris River (MFB, unpubl. data). There have been recent arrivals of fish species, including Lake Sturgeon, from downstream areas in the Assiniboine River to the Qu'Appelle River (R. Hlasny, pers. comm.). While there are a few known historical spawning sites on the Assiniboine River (e.g., Waggle Springs and Brandon Rapids), fish passage past barriers that have been constructed in this MU would be required to allow Lake Sturgeon access to additional suitable spawning habitat (e.g., Little Saskatchewan River, Souris River).

Red River and tributaries upstream of Lockport, including the Assiniboine River to the Portage la Prairie Diversion, (MU2)

The Red River is a slow meandering turbid river that is 198 river km in length from the United States border to Lockport. This portion of the Red River has mostly low-velocity runs with variable substrate ranging from mud and silt to sand, gravel and rubble with some woody debris and boulder structure (Stewart and Watkinson 2004). The Red River Floodway Control Structure can be a barrier to fish passage during high flows when the flood gates are raised and the backwater effect forces river flow into the man-made floodway channel. A total of 70 fish species have been recorded for Manitoba's portion of the Red River watershed.

The Red River has several tributaries upstream of Lockport: the Pembina, Roseau, Morris, Rat, La Salle and Seine rivers.

The Pembina River is 319 river km in length from its headwaters in Manitoba southeast to the international border. A water retention dam at Walhalla, North Dakota, built in the 1890s effectively blocked fish movement upstream into the Canadian portion of the river (MES Environmental 1997). Barriers include water control structures at Grassy Marsh, La Riviere, Rock Lake, Pelican Lake, and numerous ford crossings. Water quantity, quality and available habitat are the limiting factors in the upper reaches within Manitoba. The lower reach of the river is located in North Dakota. A total of 24 fish species have been recorded from the Pembina River.

The mainstem of the Roseau River is about 229 river km in length from its source in Minnesota to its confluence with the Red River in Manitoba (Stepaniuk 1994). The natural course of the river follows a meandering path, principally in a northwesterly direction; it crosses the Canada-U.S. border at approximately the mid-point of its course. The river is characterized by a poorly defined river channel that has little vertical erosion and predominately cuts laterally, establishing new channels and abandoning old ones. A number of man-made alterations have affected the natural course of the river (i.e., diversions, channelization and blockages) in both the U.S. and Canada. A total of 40 fish species have been recorded from the Roseau River.

The mainstem of the Rat River is approximately 262 river km from its source to its confluence with the Red River. The main tributary of the Rat River is Joubert Creek. Historic fisheries investigations of the Rat River and Joubert Creek indicated that 31 fish species inhabited these waters (MFB, unpubl. data). During a recent aquatic and riparian assessment of the Rat River and Joubert Creek, a total of 13 fish species were captured at various locations (Graveline *et al.* 2005). Overall, the assessment indicated that these waterbodies are moderately to highly impacted by anthropogenic forces. Fish habitat within the river system is being affected by excessive nutrient and sediment loading from urban and agricultural development. Fish migration blockages and low flow rates during the fall and winter months also impact fish species within the system. The St. Malo Dam, located approximately 35 km upstream of the confluence with Red River, is the largest barrier to fish migration on the Rat River system. In general, substrate found in the Rat River ranges from fine sediment to cobble substrates though some till outcrops and courser substrates occur in headwater reaches.

The La Salle River is approximately 180 river km in length from its source to the confluence with the Red River. As a tributary of the Red River, the La Salle River could provide habitat for many Red River species. During a recent aquatic habitat and riparian assessment conducted on the La Salle River, a total of 13 fish species were captured along various reaches of the river (Graveline and Larter 2006) though 31 have been reported (D. Watkinson, pers. comm.). Overall, the assessment indicated that this waterbody is highly to severely impacted by anthropogenic influences. A succession of dams along the La Salle River has resulted in a series of impoundments which can fill with sediment and block fish moment, and has produced a relatively homogeneous habitat in terms of water velocities, depths, substrate composition and shoreline conditions. Water quantity and quality issues also impact fish species within the river system. In general, substrate found in the La Salle River appears to be mostly mud and silt with some areas of gravel and cobble.

The mainstem of the Seine River is approximately 120 river km in length from its source to the confluence with the Red River. The Seine River Diversion was constructed in the mid 1960s (mid-reaches) to mitigate flooding to downstream communities including Winnipeg. The Diversion stretches east from St Anne for approximately 36 river km to its confluence with the Red River north of St. Adolphe. Past fishery work done in the late 1990s documented the presence of up to 27 fish species in the Seine River (MFB, unpubl. data). A more recent Seine River survey indicated that the mid- and upper-reaches of river are highly impacted by anthropogenic influences (Dillon Consulting Ltd 2004). Water quality and quantity issues, along with fish migration blockages, are impacting aquatic resources including fish presence in the river system. Two major barriers to upstream fish migration are the siphon at the Red River Floodway and the Diversion structure at Ste Anne. In addition, seven other barriers were noted during the study. Bottom substrate found in the Seine River appears to consist of mostly mud and silt in most sampled areas. Submerged vegetation was common in all sites sampled whereas very little cobble or gravel bottom was found.

MU2 also includes the Assiniboine River downstream of the Portage la Prairie Diversion, approximately 159 river km to the confluence with the Red River. This portion of the Assiniboine River has been diked since the 1970s. The substrate in the upper reaches near the Diversion is sand whereas further downstream near the Red River there are glacial till exposures and finer material in the banks. The lower reach is often backwatered by the Red River and likely contains the same species of fish as the Red River.

Historically, the Lake Sturgeon was present in the Red River basin (Minnesota Department of Natural Resources (MNDNR) 2002). They were reported to migrate up the Pembina River, prior to construction of the Walhalla Dam (Lea 1909, as cited in Pembina Valley Protection Association Inc. 1992), and the Roseau River (COSEWIC 2006). They likely spawned there and in the Rat, La Salle and Seine rivers. By the mid-1900s, the Lake Sturgeon was virtually extirpated from MU2. Stocking on the U.S. side of the Red River drainage has been underway since 1997 (MNDNR 2002) and there have been a few recent anecdotal reports of Lake Sturgeon being observed or caught in the Red River by Manitoba anglers (MFB, unpubl. data). Stocking also occurred in the lower Assiniboine River near Whitehorse Plains in 1997 (MFB, unpubl. data).

Red River downstream of Lockport (MU3)

The length of the Red River downstream of the St. Andrews Lock and Dam at Lockport to the confluence with Lake Winnipeg is 44 river km. This reach of the river is the most popular angling area in Manitoba and also has a large baitfish fishery. Bottom substrate along this stretch of the river contains rock, cobble, gravel, hard clay and mud-silt (D. Watkinson, pers. comm.). At the lower reaches, the river flows through the Netley-Libau marsh prior to entering Lake Winnipeg.

Cooks Creek is a main tributary of the Red River downstream of Lockport. It is 70 river km in length from its source to its confluence with the Red River. The lower reaches contain pool and riffle habitat with gravel substrate. Closer to the confluence with the Red River, channels are wider with open pond-like areas bordered by emergent vegetation. These ponds generally exceed a 1 to 2.8 m in depth and contain mud substrate. Channelization has occurred on middle and upper reaches of Cooks Creek.

Historically, the Lake Sturgeon was present in the Red River basin but virtually extirpated from MU3 by the mid-1900s (MNDNR 2002). Several fish species currently found in the Red River near Selkirk use the lower reaches of Cooks Creek for spawning and nursery habitat during the spring and summer seasons (UMA Engineering Ltd 2005). Lake Sturgeon also likely used the creek for spawning habitat. Since the mid-1970s, a few Lake Sturgeon have been caught between Lockport and Netley Creek (Lysack 1986, Dick and Lysack, unpubl. data, MFB, unpubl. data). Stocking on the U.S. side of the Red River drainage has been underway since 1997 (MNDNR 2002).

Bloodvein River (MU4)

From the Manitoba border to Lake Winnipeg, the Bloodvein River is 193 river km in length. This river extends 106 river km into Ontario. It flows westward, toward Lake Winnipeg, through regions characterized by a landscape of rock outcrops and granite cliffs interspersed with a complex of bogs, fens, marshes, rivers and river-bottom forest. The channel typically alternates from constricted, a fast-water gorge less than 20 m wide, to open, calm water marshes and small lakes. The river remains relatively undisturbed with limited road access. Natural barriers to fish movement likely exist (Dick 2004). The Lake Sturgeon is reported to occur in MU4 (Dick 2004) but no historic scientific information is available.

Pigeon River (MU5)

From the Manitoba border to Lake Winnipeg, the Pigeon River is 141 river km in length. It flows westward, toward Lake Winnipeg, through regions characterized by a landscape of rock outcrops and granite cliffs interspersed with a complex of bogs, fens, marshes, rivers and river-bottom forest. The channel typically alternates from constricted, a fast-water gorge less than 20 m wide, to open, calm water marshes and small lakes. The river remains relatively undisturbed with limited road access. Natural barriers to fish movement likely exist (Dick 2004). The Lake Sturgeon is reported to occur in MU5 (Dick 2004), including Round Lake, but no historic scientific information is available.

Berens River (MU6)

From the Manitoba border to Lake Winnipeg, the Berens River is 183 river km in length. This river extends roughly 310 river km into Ontario. It flows westward, toward Lake Winnipeg, through regions characterized by a landscape of rock outcrops and granite cliffs interspersed with a complex of bogs, fens, marshes, rivers and river-bottom forest. The channel typically alternates from constricted, a fast-water gorge less than 20 m wide, to open, calm water marshes and small lakes. The river remains relatively undisturbed with limited road access. Natural barriers to fish movement likely exist but have only been assessed in the Ontario portion.

The Lake Sturgeon is reported to occur in the Manitoba portion of MU6 (Dick 2004) but no historic scientific information is available. On the Ontario side, the historic distribution of Lake Sturgeon was extensive. Today, the Lake Sturgeon is reported to occur in Berens Lake, the Berens River system and Pikangikum Lake (L. Skitt, pers. comm.). There are no dams, control structures or impoundments in the region so Lake Sturgeon habitat remains intact including historic spawning locations. Recent tagging results showed that Lake Sturgeon use the Berens system below Mikami Falls which is likely a natural barrier to upstream movements (L. Skitt, pers. comm.).

Poplar River (MU7)

From the Manitoba border to Lake Winnipeg, the Poplar River is 141 river km in length. It flows westward, toward Lake Winnipeg, through regions characterized by a landscape of rock outcrops and granite cliffs interspersed with a complex of bogs, fens, marshes, rivers and river-bottom forest. The channel typically alternates from constricted, a fast-water gorge less than 20 m wide, to open, calm water marshes and small lakes. The river remains relatively undisturbed with limited road access. Natural barriers to fish movement likely exist but have not been assessed. The Lake Sturgeon is reported to occur in MU7 (Dick 2004) but no historic scientific information is available.

Lake Winnipeg, including the Winnipeg River below Pine Falls (MU8)

In surface area, Lake Winnipeg is the tenth largest body of freshwater in the world, covering an area of 23,750 km^2 (Lake Winnipeg Implementation Committee 2005). It is also the third largest hydroelectric reservoir, after lakes Superior and Victoria (Lake Winnipeg Implementation Committee 2005). Seventy percent of the water received by Lake Winnipeg comes from the Winnipeg (39.6%), Saskatchewan (22.1%) and Red (8.2%) rivers. The Nelson River flows out of Lake Winnipeg to Hudson Bay. Lake Winnipeg is relatively shallow, with an average depth of 12 m (maximum depth: 36 m), and nutrient rich. The south basin and channel areas are turbid while the north basin is clearer. Lake Winnipeg contains at least 60 native and an additional 10 introduced species of fishes and supports a large commercial fishery for Walleye, Sauger and Lake Whitefish (MFB, unpubl. data). Lake Sturgeon occurred in Lake Winnipeg (MU8) historically and is still present though at significantly reduced numbers.

The Winnipeg River below Pine Falls GS has an average depth of about 7 m (Stantec Consulting Ltd 2007). Along the main river channel, the bottom is generally bedrock and cobble with mud and sand occurring closer to the shorelines. Woody debris, ranging from bark chips to logs, resulting from various operations related to the newsprint mill at Pine Falls, occur in the depositional zones on the river bottom. The substrate changes as the Winnipeg River enters Lake Winnipeg at

Traverse Bay and consists of both cobble areas (reefs) and large mud flats (Stantec Consulting Ltd 2007). Several fish species found in Lake Winnipeg including Lake Sturgeon are present in the Winnipeg River below the Pine Falls GS but no historical information is available for this portion of MU8.

The Lake Sturgeon was reported to occur historically in the Dauphin, Brokenhead, Icelandic rivers and other tributaries of Lake Winnipeg but no recent information is available for these waterbodies.

HISTORIC AND CURRENT ABUNDANCE AND TRENDS

The Lake Sturgeon was reported to be historically abundant in Lake Winnipeg (MNDNR 2002) until a commercial fishery was established in Lake Winnipeg in 1885 (Stewart 2009). Historic sizes of Lake Sturgeon populations in the rivers within DU4 are poorly known though large spawning populations were reported in the Assiniboine (or its tributaries), Red and Roseau rivers (COSEWIC 2006). Historical evidence indicates that tributaries to the Red and Assiniboine rivers fulfilled spawning and early life history requirements however did not support resident populations. Over the past century, the Lake Sturgeon has virtually disappeared from much of the southern portion of DU4 due to a history of intermittent over-exploitation, combined with the construction of dams that blocked migration routes (COSEWIC 2006).

Today, the Lake Sturgeon is occasionally observed or captured in the Assiniboine River (MU1), Red River (MUs 2 and 3) and Lake Winnipeg (MU8). There is no evidence of naturally-reproducing populations and Lake Sturgeon stocked in recent years will not be old enough to reproduce for another decade. The rivers along the east side of Lake Winnipeg that contain Lake Sturgeon (MUs 4-7) likely continue to support modest numbers (COSEWIC 2006) though current status and trajectory of Lake Sturgeon are generally unknown except for the Ontario portion of MU6 which is thought to be cautious and increasing, respectively. The one location in DU4 where Lake Sturgeon may be relatively common and their population stable is Round Lake on the Pigeon River in MU5. The overall number of mature individuals in DU4 is unknown but probably less than 1,000 (COSEWIC 2006).

The current conservation status (Figure 2), based on the precautionary framework (DFO 2005), of each of the MUs in DU4 was evaluated on the basis of available information and expert opinion (Table 1).

<u>Assiniboine River and tributaries upstream of the Portage la Prairie Diversion (MU1)</u>

In the Assiniboine River, photos taken in 1938 revealed that “spawning Lake Sturgeon was so thick at Waggle Springs [south of Shilo] that you could walk across the river on their backs” (pers. comm. to B. Bruederlin). Photographic evidence indicates that Lake Sturgeon used to frequent the lower reaches of the Little Saskatchewan River for spawning purposes (MFB, unpubl. data). In the Qu’Appelle area, fishing activity was always common after the 1880s but Lake Sturgeon catches were not reported in government records from the 1920s (or earlier) or in discussions with local people. Lake Sturgeon may not have been abundant there historically due to intermittent flows (R. Hlasny, pers. comm.). By 1970, the Lake Sturgeon had been extirpated in MU1 (Table 1).

In an attempt to re-establish an Assiniboine River population, approximately 16,500 Lake Sturgeon fry, fingerlings, juveniles and adults were stocked between 1996 and 2008 from DUs 2, 3 and 5 (MFB, unpubl. data). Between 1998 and 2002, anglers reported catches of more than 280 Lake Sturgeon, ranging in total length from 20-100 cm, in a 20-km stretch between Brandon and the

Little Souris River. Since 2007, angler catches have increased and Lake Sturgeon over 140 cm total length have been caught and released (MFB, unpubl. data). The indigenous population of Lake Sturgeon in MU1 is extirpated while the current status and trajectory of the stocked population is thought to be critical and increasing (Table 1), respectively, though there is no evidence yet for reproduction.

Red River and tributaries upstream of Lockport, including the Assiniboine River to the Portage la Prairie Diversion (MU2)

The Lake Sturgeon was reported to be historically abundant in the Red River basin until the late 1880s and virtually extirpated by the mid-1900s (MNDNR 2002). A 20-year Lake Sturgeon stocking program in the U.S. portion of the Red River drainage began in 2002 with the goal of releasing 34,000 fingerlings and 600,000 fry annually through 2022 from the Rainy River stock (DU6) (MNDNR 2002). In addition, in 1997 and 1998 MNDNR stocked 378 Lake Sturgeon from the Rainy River (fish aged 4-10 years) in Big Detroit Lake and Ottertail River (MNDNR 2002). During surveys conducted in the Red River between the Manitoba-U.S. border and Lockport in fall 2002 and spring and summer 2003, there was no Lake Sturgeon caught (Watkinson, as cited in COSEWIC 2006). However, in 2005 two Lake Sturgeon were captured at the City of Winnipeg floodway inlet control gates during a tagging study (Graveline and MacDonell 2005) and there are recent anecdotal reports of Lake Sturgeon being observed or caught within the City of Winnipeg (COSEWIC 2006). Between 1998 and 2005, anglers in Manitoba reported catching nine Lake Sturgeon that had been tagged and released by MNDNR in the Ottertail River.

Prior to construction of a dam across the Pembina River at Walhalla, North Dakota, around the early 1880s, the Lake Sturgeon was reported to migrate up the Pembina River, (Lea 1909, as cited in Pembina Valley Protection Association Inc. 1992). Some Lake Sturgeon caught in the Pembina River “at the rapids above the Missouri Trail” in 1880 measured 5 feet (1.5 m) in length. Since that time, fish passage above the Walhalla dam has been blocked and presumably the Lake Sturgeon is no longer found in the Manitoba portion of the river.

A large spawning population used to occur in the Roseau River (COSEWIC 2006). Historical information indicates this was a significant spawning stream. First Nations elders maintained that historically, the Lake Sturgeon was so plentiful that one could nearly walk across the river on their backs during the June spawning run (Waddell 1970). The largest Lake Sturgeon caught in Manitoba, a female weighing 184.6 kg and measuring 4.6 m in length, was caught in the Roseau River east of Dominion City in 1903 (COSEWIC 2006). The fish was estimated to be 150 years old and full of roe. Construction of a dam downstream of Dominion City blocked Lake Sturgeon migration up the Roseau River until 1996 when it was modified to facilitate fish passage (MFB, unpubl. data). Studies conducted in the Roseau River since the 1970s, which targeted other species, have not resulted in incidental catches of Lake Sturgeon (MFB, unpubl. data).

Historically, the Lake Sturgeon likely spawned in the Rat, La Salle and Seine rivers. In the past 40 years, they have not been captured incidentally during various fish surveys conducted in those waterbodies.

In the Assiniboine River downstream of the Portage la Prairie Diversion, 200 juvenile (18+ cm) Lake Sturgeon, likely from the Winnipeg River (DU5), were stocked near Whitehorse Plains in October 1997 (MFB, unpubl. data).

The indigenous population of Lake Sturgeon in MU2 is functionally extirpated while the current status and trajectory of the stocked population is thought to be critical and increasing (Table 1), respectively, though there is no evidence yet for reproduction.

Red River downstream of Lockport (MU3)

The Lake Sturgeon was reported to be historically abundant in the Red River basin until the late 1880s and was virtually extirpated by the mid-1900s (MNDNR 2002). Only a few incidental catches of Lake Sturgeon has been reported between Lockport and Netley Creek since the mid-1970s in spite of considerable angling effort in the lower Red River (Lysack 1986, Dick and Lysack (unpubl. data) and Lysack (pers. comm.), all as cited in COSEWIC 2006). The two largest fish measured about 199 cm in total length and likely were born before construction of the Lockport Dam. Of the incidental catches taken between 1998 and 2005, 11 had been tagged and released by MNDNR in the Ottertail River. There was no Lake Sturgeon collected during electrofishing surveys conducted in fall 2002 and spring and summer 2003 (Watkinson, as cited in COSEWIC 2006), however the surveys did not target Lake Sturgeon and most fishing effort was directed along shorelines (D. Watkinson, pers. comm.). Four Lake Sturgeon were recorded in a creel census conducted on the Red River at Lockport during 2008 (MFB, unpubl. data). No incidental or inventory catches of Lake Sturgeon have been documented for Cooks Creek (MFB, unpubl. data).

The indigenous population of Lake Sturgeon in MU3 is functionally extirpated while the current status and trajectory of the stocked population is thought to be critical and increasing (Table 1), respectively, though there is no evidence yet for reproduction.

Bloodvein River (MU4)

The Lake Sturgeon is harvested by aboriginal communities (Dick 2004) but no population estimates are available. The current population status and trend in MU4 are unknown (Table 1).

Pigeon River (MU5)

The Lake Sturgeon is harvested by aboriginal communities (Dick 2004) but no population estimates are available except for Round Lake where an estimated 800-1,000 Lake Sturgeon reside, with very few spawning females (Dick 2004). The current overall population status and trend in MU5 are unknown (Table 1).

Berens River (MU6)

In the Manitoba portion of MU6, the Lake Sturgeon is harvested by aboriginal communities (Dick 2004) but no population estimates are available. The current population status and trajectory are unknown (Table 1).

The Lake Sturgeon was commercially harvested extensively in the Ontario portion of MU6 throughout the 1930s-1950s, with the fishery ending in the 1970s. Since then, there has been little recreational pressure and some subsistence fishing from First Nations. The subsistence harvest is considered to be limited at this time (L. Skitt, pers. comm.). Recently-collected length-age data from that region indicate the Lake Sturgeon population there is still recovering from the negative impacts of historical commercial harvest as most of the fish captured were small. Thirty-five Lake Sturgeon captured there in 2003 and 2009 ranged in total length from 0.50-1.38 m (L. Skitt, pers. comm.). Based on the available data, the current status of Lake Sturgeon in the Ontario portion of MU6 is thought to be cautious (Table 1). With limited harvest pressure and no other known threats, it is postulated the population trajectory may be increasing.

Poplar River (MU7)

The Lake Sturgeon is harvested by Aboriginal communities (Dick 2004) but no population estimates are available. The current population status and trend in MU7 are unknown (Table 1).

Lake Winnipeg, including the Winnipeg River below Pine Falls (MU8)

A commercial Lake Sturgeon fishery was established in Lake Winnipeg in 1885. A history of over-exploitation followed (Stewart 2009), resulting in severe population declines. For example, between 1898 and 1905, annual catches in excess of 200,000 kg, with a maximum annual harvest of 445,110 kg, were taken. Since the early 1970s, annual fish surveys have been conducted in the north and south basins of Lake Winnipeg but there was no Lake Sturgeon collected. While these studies targeted other fishes, the standard index gillnets used (i.e., 2-5¼ in. mesh) should have caught juvenile Lake Sturgeon if they had been present in the areas sampled. Three Lake Sturgeon have been reported in Lake Winnipeg (two fish under 2 kg and one fish about 15 kg) over the past 28 years (Campbell, cited in COSEWIC 2006). An additional three fish have been reported from the Hecla Island area in recent years (D. Kroeker, pers. comm.). Between 1998 and 2005, anglers have reported catching seven Lake Sturgeon which were tagged and released by MNDNR in the Ottertail River. The Lake Sturgeon is present in the Winnipeg River below the Pine Falls GS. The current population status in MU8 is critical and trend is unknown (Table 1).

INFORMATION TO SUPPORT IDENTIFICATION OF CRITICAL HABITAT

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

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

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

Some evidence indicates that after their first year, juveniles are found in the same habitats as adults (Priegel and Wirth 1974). In Round Lake (in MU5), adults and juveniles use the same areas but larger fish use a larger portion of the lake (Dick 2004). Other evidence indicates that age-0 and juvenile Lake Sturgeon may occupy habitats different than those of adults to avoid competition and that younger fish use individual areas of activity rather than the core areas used by adult groups in riverine environments (Smith and King 2005). The habitat requirements of young Lake Sturgeon appear to be more restricted (Chiasson *et al.* 1997) and, thus, availability of suitable habitat may be more limiting for age-0 and early juvenile life stages than for adults. Adult life stages tend to be more plastic, adapting to various habitat conditions (Werner and Hayes 2005).

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

Adults typically spawn in late spring, in water temperatures of 11.5-16°C in high-gradient reaches of large rivers, often below rapids or dams, with current velocities of 0.5-1.3 $m \cdot s^{-1}$, water depths of 0.5-10 m, and over substrates of cobble, boulders, coarse gravel, hardpan, or sand (McKinley *et al*. 1998, Peterson *et al.* 2007, Randall 2008, R. Wallace, pers. comm.). Cascades and/or suitable water flows are necessary to keep the eggs healthy by ensuring strong oxygenation and cleaning action preventing sediment deposition while eggs incubate. Conditions necessary for successful spawning are typically found below dams and other barriers. During the incubation period, eggs adhere to the substrate. Spawning success is dependent on the availability of prime substrates, as sub-optimal substrates can significantly reduce spawning success if flushing flows occur during the incubation period and carry eggs downstream. Spawning habitat is also used for hatching and by the newly-hatched young for a period of about one month before larval drift occurs (Randall 2008). Fidelity to spawning sites is known in Lake Sturgeon though these may vary among years in response to flow conditions (Barth and MacDonell 1999). There were known historic spawning areas in MUs 1-3 (e.g., in the Assiniboine, or its tributaries, Red and Roseau rivers) (COSEWIC 2006). Recent research in the Ontario portion of Berens River and Lake has found that spawning occurs at Dog Rib and Mikami falls (L. Skitt, pers. comm.).

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

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

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

In summary, maintaining the functional attributes of habitat, including the ecologically-based flow regimes, needed for spawning, egg incubation, juvenile rearing, summer feeding and overwintering, as well as migration routes between these habitats, is critical to the survival and recovery of Lake Sturgeon. The current distribution of Lake Sturgeon in the Red and Assiniboine rivers and some tributaries (DU4) is fragmented by dams and barriers which negatively affect spawning habitat. In addition, channelization and alterations to stream morphology and flow have reduced available habitat for all life stages. Rivers on the east side of Lake Winnipeg remain un-impacted by development. It is essential that conditions that optimize the survival and recovery of Lake Sturgeon be maintained in DU4, especially during the spawning and incubation periods.

RESIDENCE

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

RECOVERY TARGETS

DFO has determined that Population Viability Analysis (e.g., minimum viable population (MVP)) is a good approach for setting recovery targets for species at risk (DFO 2010) and meets the SARA requirement for demographic sustainability. MVP size has often been used as the abundance target. Vélez-Espino and Koops (in prep.) used MVP analysis of stage-structure demographic matrices to calculate recovery targets for Lake Sturgeon in DUs 1-5. They calculated that each MU in DU4 would need at least 413 spawning females per year (i.e., 4,130 adults) to achieve a 99% probability of persistence of Lake Sturgeon over 250 years, given a probability of catastrophe (50% decrease in the abundance of all life stages in one year) of 14% per generation, and assuming a balanced sex ratio and 5-year spawning periodicity and a sufficient number of juveniles to support the adult population goal. They used annual number of spawning females as it is the most tractable to sampling. Using MVP combined with information on area per individual and stable stage distributions, Vélez-Espino and Koops (in prep.) calculated that at least 1,193 ha of Lake Sturgeon habitat for lotic (riverine) environments, or approximately twice as much for lentic (lake) environments, is needed to support all life stages of a viable MU in DU4 at the recommended recovery target. On average, age-0 individuals would require 2.3% of the total area of required habitat, juveniles 45.3% and adults 52.3%.

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

On the basis of this information, a recovery goal and population and distribution objectives were developed. The long-term recovery goal for DU4 is to protect and maintain healthy, viable populations of Lake Sturgeon in all MUs. To reach this goal, each MU must have at least 413 spawning females (i.e., 4,130 adults) each year and at least 1,193 ha of suitable riverine habitat or 2,386 ha of suitable lake habitat. The aim is to reach these population and distribution objectives within three generations (i.e., about 108 years). Re-establishing indigenous populations is the preferred goal to retain the original genetic profile. This is not possible in MUs 1-3 where no indigenous Lake Sturgeon remains, or very few in MUs 2 and 3, thus returning them to those MUs requires stocking.

Vélez-Espino and Koops (in prep.) chose a recovery target that, if undertaken, would achieve a significant reduction in the probability of extinction of Lake Sturgeon in DU4. If a less precautionary recovery target is chosen, the number of spawning females per year would be reduced and years to recovery increased accordingly.

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

The recovery potential and importance to recovery of each of the eight Lake Sturgeon MUs in DU4 was evaluated on the basis of available information and expert opinion (Table 1). The status of the indigenous populations in MUs 1 (Assiniboine River), 2 (Red River above Lockport) and 3 (Red River below Lockport) are extirpated (or functionally extirpated), therefore their recovery potential is nil as is their importance to recovery[1]. No genetic data for indigenous populations in DU4 is available, thus it is not known if Lake Sturgeon in this DU were genetically distinct from others. Lake Sturgeon from DUs 2, 5 and 6 had, and may still have, the potential to move into DU4. So stocking using Lake Sturgeon from another DU may still have conservation value for recovery of DU4. Potential for recovery of the non-indigenous (stocked) Lake Sturgeon in MUs 1-3 is unknown as the stocked fish have not yet reached maturity. Currently, barriers also limit the ability of Lake Sturgeon in MU1 to migrate to historical spawning sites in tributaries. The Red River is a larger river system than the Assiniboine and flows directly into Lake Winnipeg. For these reasons, MU1 is

[1] Henceforth, unless otherwise stated in this document, “recovery” in MUs 1-3 will refer to the recovery of Lake Sturgeon based on stocking from other DUs rather than recovery of DU4 (i.e., indigenous) Lake Sturgeon.

considered to be of low importance to recovery while MUs 2 and 3 are moderate. Low numbers of stocked fish and barriers to spawning areas in some tributaries suggest that recovery will be protracted in MUs 1-3. The recovery potential and importance to recovery of MUs 4, 5, 7 (Bloodvein, Pigeon and Poplar rivers) and the Manitoba portion of MU6 (Berens River) are unknown. In the Ontario portion of MU6, recovery potential is thought to be high though importance to recovery is unknown. Not enough is known about MUs 4-7 to determine time to recovery. The potential for recovery of Lake Sturgeon in MU8 (Lake Winnipeg) is likely low because they are taken as bycatch in the commercial fisheries for other species on the lake. However, given the central location of Lake Winnipeg within the Nelson River Drainage Basin, the importance of MU8 to recovery of Lake Sturgeon in DU4 is high. Recovery in this MU is expected to be protracted.

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

THREATS TO SURVIVAL AND RECOVERY

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

The commercial harvest of Lake Sturgeon in DU4 ended in 1988 following a long intermittent history which began in 1876 (Stewart 2009). Catches in excess of 200,000 kg were taken from Lake Winnipeg between 1898 and 1905. Since 1970, commercial catches averaged less than 100 kg.

In DU4, aboriginal harvest of Lake Sturgeon by First Nations for subsistence, cultural and ceremonial purposes continues on a limited basis. Any Lake Sturgeon caught while fishing recreationally must be released. In the Berens system in Ontario, the Lake Sturgeon was heavily exploited by a commercial fishery between the late 1930s and 1970s. The last commercial fishing licence held by an aboriginal person was issued in May 2005; 454 kg of Lake Sturgeon were taken from Berens River between Poplar Hill and Nechegona Lake (L. Skitt, pers. comm.). A small subsistence fishery by the community of Pikangikum continues; it is unknown whether other First Nations in the region fish Lake Sturgeon for subsistence. Subsistence harvesting may be occurring in the Manitoba portion of the Berens and Bloodvein rivers, and in the Pigeon and Poplar rivers, but the level of harvest is unknown. Poaching has been identified as a potential concern in DU4 (COSEWIC 2006). Although the current levels of legal harvesting through the subsistence fishery are low, and poaching has not been confirmed for this DU, the removal of juveniles and adults affects recovery (Vélez-Espino and Koops 2009). The existing commercial net fishery for other species on Lake Winnipeg poses a significant threat to recovery as juvenile and adult Lake Sturgeon are susceptible to the gear.

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

Many dams, barriers and other structures are present throughout the southern portion of DU4. On the Assiniboine River the primary ones include the Shellmouth Dam, in western Manitoba, and the Portage la Prairie Diversion, which diverts water from the Assiniboine River into Lake Manitoba. Both were built in 1970 for flood control and are also used for irrigation purposes. Two dams are located in or near Brandon, one of which is associated with a Manitoba Hydro TGS which has been in operation since 1958 and the City of Brandon's Third Street Dam which has been in operation since 1962. Currently, a fishway is proposed to facilitate passage at the Third Street Dam and the rock weir at the TGS has been breached and allows passage. On the Red River, St. Andrews Lock and Dam, at Lockport, was constructed for navigation purposes and officially went into operation in 1910. Just downstream is the Selkirk TGS, with no dam, which has been in operation since 1960. In 1968, construction of an artificial flood control waterway for the City of Winnipeg was completed. The 47 km diversion channel, known as the Red River Floodway, is used during extreme flood emergencies to divert some flow from the Red River (MU2) around the eastern side of Winnipeg and discharge it back into the Red River near Lockport (MU3). The floodway gates in the Red River have the potential to block fish movement upstream during periods of operation. To the south of Manitoba, work began in 1997 to remove dams or make them passable to Lake Sturgeon, in the Red River in North Dakota and Minnesota, in an effort to restore connectivity in the Red River basin (MNDNR 2002).

Dams and control structures elsewhere have been shown to alter the natural flow regime and fragment habitat resulting in degradation and/or loss of Lake Sturgeon habitat, loss of genetic diversity, reduced spawning success, reduced prey availability (through removal of prey items by flushing flows and entrainment or exposure during low flows) and mortality (e.g., excessive siltation leading to loss of critical age-0 fish) (see review in Pratt 2008). Dam construction can extirpate local Lake Sturgeon populations (Dumont *et al.* 1987) by preventing fish from accessing spawning areas and stranding fish between impassable barriers. Fish near a TGS can be entrained into the inflow pipe or may be exposed to thermal shock from the plume of heated cooling water discharged at the outflow pipe(s), especially during winter. During the 1980s, one or more fish kills occurred in winter near the outflow from the Selkirk TGS in Cooks Creek due to abrupt changes in thermal regime resulting from operation of the TGS (T. Schwartz, pers. comm.). Fish screens and operational changes at this TGS have mitigated these threats. The Brandon TGS uses cooling towers which prevent this from occurring. Although there are no hydroelectric dams in DU4, agricultural and urban water intakes have the potential to cause entrainment[2] and impingement[3] mortality.

Other human activities have also contributed to the degradation of Lake Sturgeon habitat in DU4. The construction of drainage ditches has created unfavourable conditions for Lake Sturgeon by increasing water flows and suspended sediments during spawning, and reducing flows afterwards in juvenile feeding habitat, in the Roseau and other rivers within the historic range of Lake Sturgeon in DU4 (COSEWIC 2006). In addition, channelization and alterations to stream morphology have resulted in negative impacts to critical physical habitat for most life stages. Water quality has deteriorated over the past century in MUs 1-3, due to urban and agricultural development along the full length of the rivers. The lower reaches of the Assiniboine River, for example, were an important area for Lake Sturgeon historically because of the rich supply of macroinvertebrates found there (Choudhury and Dick 1993). Overall water quality in this stretch of the river has deteriorated because of erosion, suspended sediments and the addition of sewage effluents, nutrients and water withdrawals. In the Qu'Appelle River, a mix of improvements and

[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.

losses occurred as a result of human activities: in some areas water flows increased and became less intermittent while in other areas channelization and eutrophication occurred. Declining water quality in Lake Winnipeg (MU8) has also occurred from a variety of human activities (e.g., nutrient inputs from land-use practices) throughout the drainage basin.

The overall effect of construction and operation of dams, barriers and other structures, as well as habitat alteration, is that Lake Sturgeon habitat has been fragmented, degraded or lost, and injury or mortality to Lake Sturgeon increased, throughout the southern portion of DU4.

As a result of extirpation (or functional extirpation) of Lake Sturgeon in MUs 1-3, stocking of fry, fingerlings and older fish from other DUs (DUs 2, 5 and 6) has been undertaken. The genetic make-up of Lake Sturgeon in these MUs is unknown. Thus, stocking in MUs 2 and 3 can be viewed as possible genetic contamination, if some indigenous Lake Sturgeon remained in those MUs, or as an initiation of recovery action from a variety of sources and genetic compositions.

In recent years, a proposal has been discussed to build a new hydro corridor and/or road along the east side of Lake Winnipeg. If this goes ahead, there is potential for easier access to the four rivers that flow into the east side of Lake Winnipeg and, thus, the possibility of increased fishing pressure and habitat degradation or loss.

In summary, the most important current threats to survival and recovery of Lake Sturgeon in DU4 are habitat degradation or loss resulting from agriculture, urban development, dams/impoundments and other barriers and industrial activities, and mortality, injury or reduced survival resulting from bycatch from the commercial fishery on Lake Winnipeg (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 DU4. The timeframe and impacts of climate change are unknown.

LIMITING FACTORS FOR POPULATION RECOVERY

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

MITIGATION, ALTERNATIVES AND ENHANCEMENTS

As with the impacts of threats, suggested mitigations and alternatives can also differentially affect survival or productivity of certain life stages. Vélez-Espino and Koops (2009) examined the effects of five hypothetical recovery scenarios that represented positive and increasing impacts on the Lake Sturgeon vital rates derived from habitat rehabilitation, stocking, modified fishing regulations, and improved fish passage at barriers. They used a stage-structured projection matrix with five life stages. Young-of-the-year, referred to as age-0 in this document, was the stage from eggs to age-1. The juvenile stage was defined as the period from the end of the first year to the mean age at first maturity, with the early and late juvenile stages being the first and second half of this period. The early and late adult stages referred to the first and second half of the adult period, respectively, and covered the period from mean age at first maturity to maximum reproductive age where total length is 95% of asymptotic length. Their modelling results indicated that even if the main causes of population decline are removed from Lake Sturgeon in DU4, their geometric mean population growth rates will continue to show declining abundances. The Lake Sturgeon in this DU is highly sensitive to harm with early adults most sensitive, followed by late juveniles, late adults, early juveniles and age-0 (in decreasing order). These modelling results do not take into account recently stocked fish in MUs 1-3, most of which have not yet reached sexual maturity. Whether they become successfully established has yet to be determined.

These results highlight the importance of reducing mortality on adults and late juveniles (e.g., from fishing) as the key to recovering this DU, and indicate that any recovery measures that maximize survival of these stages will increase the likelihood of, or shorten the time to, recovery (Vélez-Espino and Koops 2009). Fishing mortality, one of the main causes of population decline in the southern portion of DU4, has been largely eliminated in MUs 1-3 over the past few decades. Reducing mortality on adults and late juveniles is important in MUs 1-3 where survival and recovery of Lake Sturgeon is dependent on stocked fish reaching reproductive age and successfully reproducing. It is particularly important in MU8 (Lake Winnipeg) where bycatch from commercial fisheries is thought to be highly detrimental to the survival and recovery of Lake Sturgeon.

While elimination of mortality to early adults and late juveniles can produce significant improvements in recovery timeframes, the potential for improving survival of early adults is low relative to the potential in age-0 and young juveniles (Table 3) (Vélez-Espino and Koops 2009). Therefore, the possibility of implementing recovery strategies that improve age-0 and juvenile survival (e.g., habitat rehabilitation) should also be considered. For example, in some circumstances it may be possible and desirable to improve age-0 and young juvenile survival by capturing pre-spawn adult Lake Sturgeon, stripping them of their eggs and sperm, fertilizing and hatching the eggs, and raising the larvae to fingerlings before releasing them back into their natal waters. Conservation stocking programs must address potential impacts on genetic variability, artificial selection and transmission of disease from cultured to native fish (LaPatra *et al.* 1999). In an effort to conserve genetic variability in the native population, a better alternative would be to capture drifting larval fish or fertilized eggs and raise them in onsite facilities prior to release. While conservation stocking using fish from the same genetic stock has the potential to improve survival of age-0 and young juvenile fish, it should be undertaken only after careful consideration and as part of a comprehensive conservation stocking strategy for the DU, not a substitute for other effective mitigation measures or alternates outlined in this document. In DU4, measures that improve age-0 and juvenile survival are particularly important in MUs 1-3 where Lake Sturgeon survival and recovery depend on the survival of young stocked fish and their future reproductive success.

Fertility rates in both early and late adult stages are less sensitive to perturbation. Although eliminating or mitigating threats to adult mortality would have a substantially greater impact on recovery than threats that cause impacts on reproduction (e.g., denial of access to spawning through dams and barriers) (Vélez-Espino and Koops 2009), continuous and intense recruitment failure caused by blocking spawning migration by dams and barriers or habitat degradation can still produce more apparent population constraints than adult mortality (Jager *et al.* 2007). Complete blockage of spawners at barriers can eradicate a population in a generation from continuous reproductive failure and strong site fidelity for spawning (Swanson *et al.* 1991, Rusak and Mosindy 1997). Reduced access to suitable spawning habitat in MUs 1-3 and deteriorated water quality in MUs 1-3 and 8 potentially threaten the reproductive success of Lake Sturgeon in this DU.

Table 4 provides an inventory of possible mitigation measures, alternatives and enhancements to anthropogenic activities that pose threats to Lake Sturgeon survival and recovery. The mitigations/alternatives/enhancements for the most important threats for DU4, as identified in Table 2, are explained more fully below.

Mitigations and Alternatives

Habitat degradation or loss: agricultural 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).
- Advocate proper drainage (properly maintained functional drains will reduce direct loading to streams).
- Protect spawning and rearing habitat.
- 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.

Habitat degradation or loss: urban development

- Enforce discharge limits on potential pollutants (e.g., effluent from water treatment plants, pollution point sources).
- Improve effluent from water treatment plants.
- Increase protection during work permit reviews.
- 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 (e.g., weirs) 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.

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.

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.

Habitat degradation or loss: forestry and mining exploration/extraction

- 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).
- Protect spawning and rearing habitat.
- 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.

Enhancements

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

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

ALLOWABLE HARM

Decisions about whether harm from human-induced mortality and habitat modifications is allowable are informed by the potential for recovery and the impact of human activities as well as alternate and mitigation measures to those activities. Vélez-Espino and Koops (2009) modelled allowable harm for DU4. They reported that even if the main causes of population decline are removed, the minimum recovery efforts for individual vital rates that would be necessary to reverse declines in abundance would be approximately 4.3-27.2% increments in adult survival, 11.3-27.3% in juvenile survival, 29.6% in age-0 survival and 59.4-91.9% in fertility rates (Table 3). It is not feasible to increase survival rates sufficiently for late adults and fertility rates for early and late adults to achieve recovery (Table 3).

Negative impacts associated with habitat degradation or loss from agricultural activities, urban development, dams/impoundments and other barriers and industrial activities, as well as the bycatch from the commercial fishery on Lake Winnipeg, currently pose the most significant threats to the long-term survival and recovery of Lake Sturgeon in DU4, although their importance varies by MU. Dams and other barriers, and habitat degradation, have the potential to negatively impact all three life stages while fishing focuses on juveniles and adults. It may be possible to estimate harm resulting from threats such as entrainment, impingement, turbine mortality and fishing but assessing the levels of harm resulting from threats such as changes in flow regime, and habitat fragmentation and degradation, are more difficult to quantify.

While modelling allowable harm at the DU level provides useful information, careful examination of conditions within an MU is necessary to fully assess the level of risk posed by harm from human-induced mortality and habitat modifications. Available data and expert opinion indicate that the current status of MUs 1-3 is critical (Table 1) and that recovery is not possible without mitigation, alternatives or enhancements such as stocking. 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 in those three MUs, at least until there is evidence that the stocked fish have become successfully established (e.g., successful reproduction). The status of MU8 is also critical and current levels of harm appear to be too high, so harmful activities pose a very high risk to survival or recovery there too. As current status and trend of MUs 4, 5, 6 (Manitoba portion) and 7 is unknown, harmful activities may pose a high to very high risk to survival or recovery. In the Ontario portion of MU6, the status of Lake Sturgeon is cautious and trajectory is thought to be increasing. Harmful activities pose a moderate risk to populations there. Allowable harm in DU4 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 DU4 needs to be better understood, as does the current level of harvest. Obtaining reliable estimates of population size, population growth rate and harvest in each MU, including harvest from commercial bycatch in MU8, 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. Genetic profiling of individual MUs in DU4 is needed for comparison with source populations used for stocking.

SOURCES OF UNCERTAINTY

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

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

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

CONCLUSIONS

Eight MUs have been identified for DU4: MU1 is the Assiniboine River and tributaries upstream of the Portage la Prairie Diversion, MU2 is the Red River and tributaries upstream of Lockport, including the Assiniboine River to the Portage la Prairie Diversion, MU3 is the Red River downstream of Lockport, MUs 4-7 are the Bloodvein, Pigeon, Berens and Poplar rivers, respectively, and MU8 is Lake Winnipeg, including the Winnipeg River below Pine Falls GS.

Over the past century, Lake Sturgeon in DU4 declined severely, especially in the southern portion of the DU, primarily as a result of over-exploitation from commercial fisheries and, more recently, degradation or loss of a significant portion of their habitat. Limited data indicate that low numbers of Lake Sturgeon are now present throughout much of the DU.

Available data and expert opinion indicate that the current status of MUs 1-3 is critical though their population trajectories are increasing due to stocking. The current status, trajectory and potential for recovery of MUs 4-7 are unknown except in the Ontario portion of Berens River (MU6) where recent information suggests they are cautious, increasing and high, respectively. The status and population trajectory of MU8 is critical and unknown, respectively.

Survival and recovery of Lake Sturgeon in DU4 depends on maintaining the functional attributes of habitat, including the ecologically-based flow regimes, needed for spawning, egg incubation, juvenile rearing, summer feeding and overwintering, as well as migration routes between these habitats. It is essential that conditions that optimize the survival and recovery of Lake Sturgeon be maintained, especially during the spawning and incubation periods.

The long-term recovery goal for DU4 is to protect and maintain viable populations of Lake Sturgeon in all MUs. To reach this goal, each MU must have at least 413 spawning females each year (i.e., 4,130 adults) and at least 1,193 ha of suitable riverine habitat or 2,386 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. Re-establishing indigenous populations is the preferred goal to retain the original genetic profile. This is not possible in MUs 1-3, where no indigenous Lake Sturgeon remain, or very few in MUs 2 and 3, thus returning them to those MUs requires stocking.

The most important current threats to survival and recovery of Lake Sturgeon in DU4 are habitat degradation or loss resulting from agriculture, urban development, dams/impoundments and other barriers and industrial activities, and mortality, injury or reduced survival resulting from bycatch from the commercial fishery on Lake Winnipeg. 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 DU4 including protecting spawning and rearing habitat, minimizing activities that cause habitat degradation or loss, rehabilitating habitat in key areas and reducing impacts of the commercial net fishery on Lake Winnipeg to Lake Sturgeon. Conservation stocking using fish from the same genetic stock may be a useful enhancement tool as part of a comprehensive conservation stocking strategy for the DU and when combined with mitigation measures and alternatives.

Activities that damage or destroy functional components of habitat or key life components of the life cycle pose a very high risk to the survival or recovery of Lake Sturgeon in MUs 1-3 and 8, high to very high risk in MUs 4, 5, 7 and the Manitoba portion of MU6 and moderate risk in the Ontario portion of MU6. Research activities should be allowed in DU4 if they are beneficial to the species and would not jeopardize the survival or recovery of a Lake Sturgeon MU.

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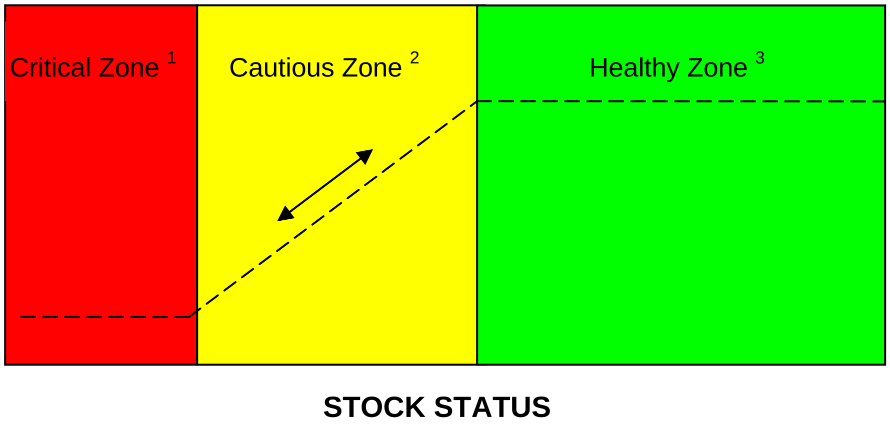
Figure 1. DU4 showing locations of MUs and place names mentioned in text.



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

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

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

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

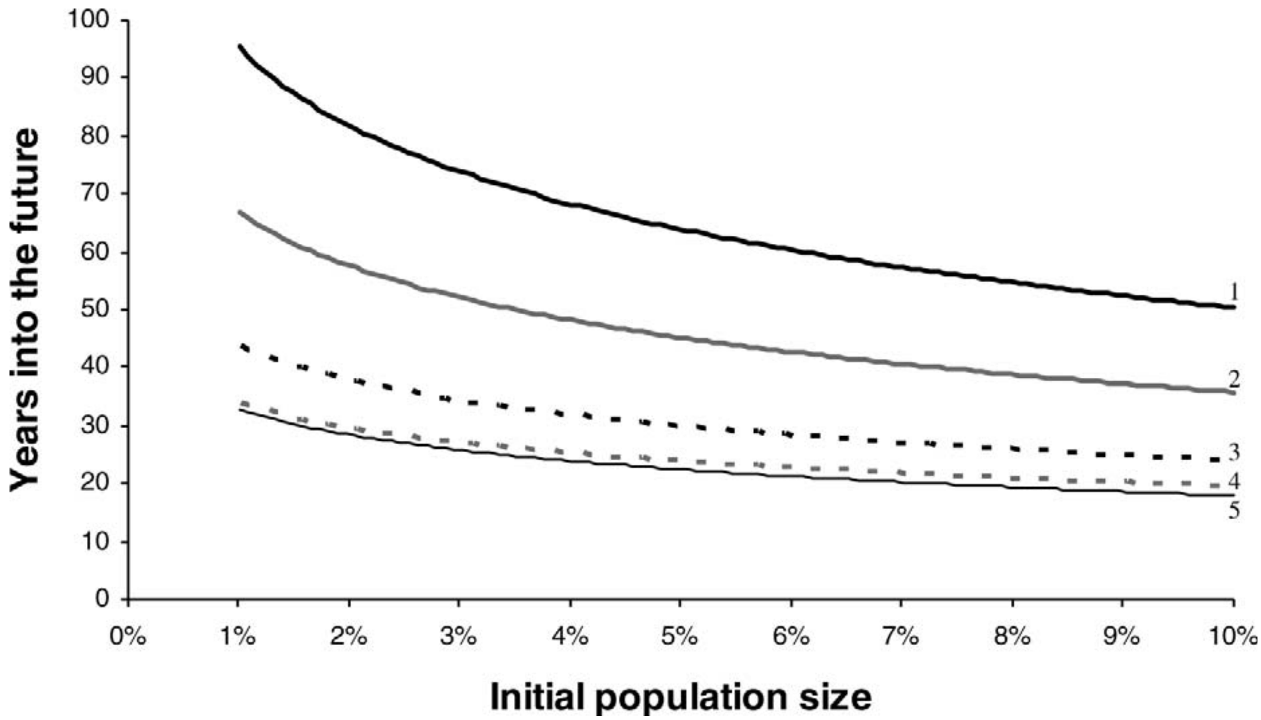


Figure 3. Stochastic projections of times to recovery for Lake Sturgeon based on initial population size (i.e., percentage of MVP) under five different recovery scenarios. Strategy 1 (solid black line) was the maximization of the survival rates of early adults, strategy 2 (solid grey line) added a 10%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

Table 1. Assessment of the current conservation status, population trajectory, overall importance to species recovery and recovery potential of the eight Lake Sturgeon Management Units (MUs) in the Red-Assiniboine rivers – Lake Winnipeg system. Conservation status (Figure 2) was based on the best available information and Precautionary Framework (DFO 2005); population trajectory was rated as Unknown, Stable, Increasing or Decreasing; importance to species recovery evaluates the importance of the MU to the overall recovery of Lake Sturgeon within DU4. 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. In MUs where the original indigenous population was extirpated (e.g., MU1), recovery is Nil though stocking from another DU will allow Lake Sturgeon to return to the waterbody. 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	Assiniboine River and tributaries upstream of the Portage la Prairie Diversion	Extirpated (Ind) Critical[1] (St)	Nil (Ind) Increasing[2] (St)	Nil (Ind) Low[3] (St)	Nil (Ind) Unknown (St)
2	Red River and tributaries upstream of Lockport, including the Assiniboine River to the Portage la Prairie Diversion	Functionally Extirpated (Ind) Critical[1] (St)	Virtually Nil (Ind) Increasing[2] (St)	Nil (Ind) Moderate[3] (St)	Nil (Ind) Unknown (St)
3	Red River downstream of Lockport	Functionally Extirpated (Ind) Critical[1] (St)	Virtually Nil (Ind) Increasing[2] (St)	Nil (Ind) Moderate[3] (St)	Nil (Ind) Unknown (St)
4	Bloodvein River	Unknown	Unknown	Unknown	Unknown
5	Pigeon River	Unknown[4]	Unknown[4]	Unknown[4]	Unknown[4]
6	Berens River	Unknown (MB) Cautious (ON)	Unknown (MB) Increasing (ON)	Unknown (MB) Unknown (ON)	Unknown (MB) High (ON)
7	Poplar River	Unknown	Unknown	Unknown	Unknown
8	Lake Winnipeg, including Winnipeg River below Pine Falls	Critical	Unknown	High	Low

[1] The stocked fish have not yet reached reproductive age.
[2] As a result of stocking programs in the MU or upstream of the MU, not reproduction.
[3] Stocking occurs and has value to species recovery in DU4.
[4] Data are available for Round Lake on the Pigeon River (see Dick 2004).

Table 2. Current status of threats to Lake Sturgeon in DU4 by Management Unit (MU), defined in terms of the likelihood of occurrence followed by level of severity, based on current knowledge of the MUs and the areas in which they occur. (0=Nil, L=Low, M=Moderate, H=High, U=Unknown). Status in Manitoba (MB) and Ontario (ON) were noted if different. The most important threats are highlighted. Note: In cases where a man-made barrier occurs at the start (upstream end) of an MU, it is included in the MU. For example, Pine Falls GS on the Winnipeg River and Grand Rapids GS on the Saskatchewan River are included in MU8.

THREATS	Assiniboine River	Red River, upstream of Lockport	Red River, downstream of Lockport	Bloodvein River	Pigeon River	Berens River	Poplar River	Lake Winnipeg
	MU1	MU2	MU3	MU4	MU5	MU6	MU7	MU8
Mortality, injury or reduced survival								
Entrainment, impingement and turbine mortality (e.g., from hydroelectric dams and other barriers, urban or irrigation intakes)	H,L	H,L	H,L	0,0	0,0	0,0	0,0	L,L
Population fragmentation (e.g., from dams/impoundments and other barriers)	M,L	0,0	M,L	0,0	0,0	0,0	0,0	0,0
Fishing: commercial net (bycatch)	0,0	0,0	0,0	0,0	0,0	0,0(MB) L,L(ON)	0,0	H,H
Fishing: domestic / subsistence	L,H	L,M	L,M	L,U	L,U	M,L	L,U	H,U
Fishing: recreational / commercial tourism	H,L	H,L	H,L	H,L	U,U	L,L	H,L	H,U
Fishing: illegal harvest	L,H	U,U	U,U	U,U	U,U	L,M	U,U	H,U
Habitat degradation or loss[1]								
Dams/impoundments and other barriers (e.g., hydroelectric dams or water control structures)	H,M	H,M	H,M	0,0	0,0	0,0	0,0	H,L
Industrial activities (including oil and gas, and pulp and paper)	H,M	H,M	H,M	0,0	0,0	0,0	0,0	H,L
Forestry exploration/ extraction	0,0	L,L	0,0	L,0	0,0	H,M	L,0	H,L
Mining exploration/extraction	0,0	L,L	0,0	H,U	H,U	H,M	H,U	0,0
Agricultural activities	H,H	H,H	H,H	0,0	0,0	0,0	0,0	H,M
Urban development	H,M	H,H	H,H	H,L	H,L	L,L	H,L	H,L
Sturgeon culture								
Genetic contamination	0,0[2]	H,U[3]	H,U[3]	L,U	L,U	L,U	L,U	H,U
Disease	H,U	H,U	H,U	L,U	L,U	L,U	L,U	H,U
Non-indigenous and invasive species	H,U	H,U	H,U	H,U	H,U	H,U	H,U	H,U
Climate change[4]	U,U	U,U	U,U	U,U	U,U	U,U	U,U	U,U

[1] Examples: changes in flow regime, water temperature, concentrations of sediments, nutrients and contaminants, habitat structure and cover, food supply and migration/access to habitat, surface hardening and pollution.
[2] The indigenous population is extirpated thus stocked fish pose no risk of genetic contamination.
[3] If some indigenous Lake Sturgeon remain, they may be subject to genetic contamination from stocked fish, however since the Red River stock is functionally extirpated, recovery without stocking from other genetic sources is not possible.
[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 DU4 based on results of modelling (Vélez-Espino and Koops 2009). Minimum recovery effort indicates the minimum increase in vital rates necessary to stabilize or stimulate population growth. Maximum allowable harm indicates the maximum reduction in survival or fertility rates in a population that can occur while still allowing the population to recover, once the main causes of population decline are removed. These percentages are not additive.

Vital Rates	Minimum Recovery Effort	Maximum Allowable Harm
Age-0 survival	29.6%[1]	0%
Early juvenile survival	27.3%[1]	0%
Late juvenile survival	11.3%[1]	0%
Early adult survival	4.3%[1]	0%
Late adult survival	27.2[1] (11.4%[2])	0%
Early adult fertility	91.9[1] (20.4%[2])	0%
Late adult fertility	59.4[1] (7.7%[2])	0%

[1] 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 DU4 model.

[2] 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.