Information in Support of the 2017 COSEWIC Assessment and Status Report on the Lake Sturgeon (*Acipenser fulvescens*) in Canada

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2018

Canadian Manuscript Report of

Fisheries and Aquatic Sciences 3166

Fisheries and Oceans Canada Pêches et Océans Canada

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Cat. No. Fs 97-4/3166E-PDF ISBN 978-0-660-28950-2 ISSN 1488-5387

Correct citation for this publication:

Barth, C.C., Burnett, D., McDougall, C.A., and Nelson, P.A. 2018. Information in support of the 2017 COSEWIC assessment and status report on the Lake Sturgeon (*Acipenser fulvescens*) in Canada. Can. Manuscr. Rep. Fish. Aquat. Sci. 3166: vi + 115 p.

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ABSTRACT

Barth, C.C., Burnett, D., McDougall, C.A., and Nelson, P.A. 2018. Information in support of the 2017 COSEWIC assessment and status report on the Lake Sturgeon (*Acipenser fulvescens*) in Canada. Can. Manuscr. Rep. Fish. Aquat. Sci. 3166: vi + 115 p.

Lake Sturgeon (*Acipenser fulvescens*) was assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2017, eleven years after the previous report was released in 2006 (COSEWIC 2006). The purpose of the assessment and status report was to provide the best available information on biology, population status, range, and threats, to the committee for their use in determining a status category (i.e., special concern, threatened, endangered) for Lake Sturgeon within the four designatable units defined for this species in Canada. Due to the wealth of information (both scientific and grey literature) generated on Lake Sturgeon since the 2006 report, some information included in initial drafts of the 2017 COSEWIC document was not included in the final report. This report includes information submitted to COSEWIC that was not included in the final 2017 COSEWIC assessment and status report.

RÉSUMÉ

Barth, C.C., Burnett, D., McDougall, C.A., and Nelson, P.A. 2018. Information in support of the 2017 COSEWIC assessment and status report on the Lake Sturgeon (*Acipenser fulvescens*) in Canada. Can. Manuscr. Rep. Fish. Aquat. Sci. 3166: vi + 115 p.

Le Comité sur la situation des espèces en péril au Canada (COSEPAC) s'est penché sur le cas de l'esturgeon jaune (*Acipenser fulvescens*) en 2017, soit 11 ans après la publication de son rapport précédent en 2006 (COSEPAC 2006). L'objectif de l'évaluation et du rapport de situation était de fournir les meilleurs renseignements disponibles sur la biologie, l'état de la population, l'aire de répartition et les menaces au comité pour qu'il détermine la catégorie de statut (c.-à-d. espèce préoccupante, menacée ou en voie de disparition) de l'esturgeon jaune dans les quatre unités désignables définies pour cette espèce au Canada. En raison de la multitude de documents (scientifiques et parallèles) qui ont été produits sur l'esturgeon jaune depuis la publication du rapport 2006, certains renseignements inclus dans les versions provisoires du rapport 2017 du COSEPAC ne se trouvent pas dans la version définitive de ce document. Le présent rapport comprend de l'information qui a été soumise au COSEPAC, mais qui n'a pas été incluse dans la version définitive de l'évaluation et du rapport de situation 2017 du COSEPAC.

INTRODUCTION

The Lake Sturgeon is one of five sturgeon species found in Canada. Their range stretches from the North and South Saskatchewan rivers in Alberta in the west, to the St. Lawrence River estuary in the east, and from various rivers that empty into Hudson Bay in the north, to several boundary waters (e.g., Rainy River, Great Lakes) in the south. Lake Sturgeon has a rich historical significance to First Nations peoples and has a long history of commercial harvest in Canadian waters. Four designatable units were identified for the species in Canada based on biogeography and genetics: DU1 – Western Hudson Bay; DU2 – Saskatchewan-Nelson rivers; DU3 – Southern Hudson Bay-James Bay; DU4 – Great Lakes-Upper St. Lawrence River (COSEWIC 2017).

Lake Sturgeon occupy a wide variety of aquatic ecosystem types (e.g., stepped-gradient Boreal Shield rivers, low-gradient meandering Prairie rivers, low gradient Hudson Plain rivers, Great Lakes and associated tributaries in Boreal Shield and Mixedwood Plain) across their Canadian range and require a variety of habitats to complete their lifecycle. Spawning habitat is typically characterized by fast-moving water found at the base of falls, rapids, or dams. After hatch, larvae rely on gravel substrate in which to bury and may remain in the substrate while development continues. Once the yolk sac is absorbed, larvae drift downstream via water currents. Habitat requirements at the age-0 stage are not well understood, however, as Lake Sturgeon grow, the habitat requirements of the middle to later life stages (juveniles and adults) are relatively broad.

Lake Sturgeon are considered carnivorous benthic generalists at each life-stage, and consume a variety of prey types depending on the aquatic ecosystem. Young (age-0) Lake Sturgeon feed on zooplankton until large enough to consume small invertebrates. As Lake Sturgeon grow, the diversity of aquatic organisms found in their diet can also increase to include fish, fish eggs, crayfish, and mussels.

Movement patterns are driven by the physical separation of habitats needed to complete life-history processes and have been found to vary by aquatic ecosystem type. In low-gradient systems, the species may need to migrate hundreds of kilometres between spawning, foraging, and overwintering habitats. In stepped-gradient systems, habitat diversity can occur over small spatial scales and recruiting populations are known to occur in hydroelectric reservoirs as small as 10 km in length.

This report provides information on Lake Sturgeon juvenile and adult diet, movement and habitat use, and population sizes and trends that was not included in the 2017 COSEWIC status report.

JUVENILE AND ADULT DIET

As noted by Pollock et al. (2015), Lake Sturgeon diet is diverse across the species range. Amphipods, ephemeropteran larvae, trichopteran larvae, mollusks (including Zebra Mussel [*Dreissena polymorpha*]), dipteran larvae, chironomids, crayfishes, snails, and leeches have all been reported as accounting for high proportions of juvenile stomach contents (Kempinger 1996; Chiasson et al. 1997; Beamish et al. 1998; Jackson et al. 2002; Smith and King 2005; Nilo et al. 2006; Guilbard et al. 2007; Barth et al. 2013). Small quantities of fish eggs (including sturgeon; C. Barth, unpubl. data) and small fishes

(Jackson et al. 2002; McDougall and Pisiak 2014) have also been found in the stomachs of larger juveniles. Within particular sections of river sampled over lengthy intervals, variation in prey composition among sampling months has been documented, likely reflecting seasonal differences in abundance of food (Nilo et al. 2006; Guilbard et al. 2007; Barth et al. 2013). A few studies have revealed evidence for positive selection of drifting organisms such as ephemeropterans and amphipods (Chiasson et al. 1997; Nilo et al. 2006); however, juveniles typically adhere to a generalist strategy, 'grazing' on or very close to the benthos, consuming small organisms as they are encountered (Chiasson et al. 1997; Beamish et al. 1998; Jackson et al. 2002; Nilo et al. 2006; Barth et al. 2013; Pollock et al. 2015; Smith et al. 2016).

Likely because lethal sampling is required to definitively assess gut contents when larger food items are being consumed, there has been little thorough examination of diet of adult Lake Sturgeon in most of the river systems the species inhabits. However, commercially harvested specimens are (or have been) available to researchers working in certain systems, and stable isotope characterization, which does not require lethal sampling, has also been employed in recent years. Higher-level carbon sources can increasingly supplement the invertebrate-based juvenile diet as Lake Sturgeon body size increases (Jackson et al. 2002; Werner and Hayes 2004; Stelzer et al. 2008; Smith et al. 2016). This ontogenetic shift is probably the most relevant generality in the context of differentiating adult from juvenile diet.

Adult Lake Sturgeon, at least periodically, feed at higher trophic levels; Harkness and Dymond (1961) reported fish eggs being consumed by adults, while Cuerrier (1966) observed both eggs and small fishes in stomach contents. Despite a plethora of bait choices employed, set lines baited with Round Goby (*Neogobius melanostomus*) were nearly exclusively (99%) responsible for the capture of a wide size range of Lake Sturgeon (both juveniles and adults) in the St. Clair River (Thomas and Haas 1999), which also speaks to diet selection. On the Winnipeg River, MB, anglers target adult Lake Sturgeon using a combination of earthworms and Emerald Shiner (*Notropis atherinoides*) (D. Kroeker, Manitoba Fisheries Branch, pers. comm.).

Two published studies indicate fish can comprise a high proportion of the adult diet (Stelzer et al. 2008; Smith et al. 2016). Stelzer et al. (2008) determined that an average of 37% of assimilated carbon in Lake Winnebago sturgeon was derived from Gizzard Shad (*Dorosoma cepedianum*). The authors reasoned that during the open-water season, chironomids (which contributed 49%) probably comprised the bulk of the diet, as previously suggested by Choudhury et al. (1996). However, during winter, the Lake Sturgeon gorged on the comparatively protein-rich food source that accumulates on the river bottom following annual die-offs (Stelzer et al. 2008). Both gut content and stable isotope results indicated Lake Sturgeon from Lake Winnebago do not rely on littoral production to any significant degree (Stelzer et al. 2008).

Based on gut contents of commercially harvested adult Lake Sturgeon in Lake of the Woods and Rainy River, Ontario/Minnesota, crayfishes, ephemeropterans, and chironomids comprised approximately 70% of the summer diet (Mosindy and Rusak 1991). More recently, Smith et al. (2016) used stable isotope analysis to examine diet in the same system and, while juveniles appeared to rarely consume higher-

level proteins, the analysis revealed up to a 50% assimilation owing to fish consumption for larger adults. Whether the more recent finding reflects a change in diet over the past few decades, or fish consumption is simply more common during winter (as seems to be the case on Lake Winnebago (Stelzer et al. 2008)), is not clear.

It is important to note fish do not seem to be a major component of the diet of adults in all populations and diet may also vary spatially within a given waterbody, likely in relation to habitat variation. In one riverine section of the Saskatchewan River, centred on the confluence of the North and South Saskatchewan rivers and characterized by shallow depths (<5 m), low to moderate velocities, and sand substrates, stable isotope analysis indicated ~80% of the diet was comprised of crayfish (I. Phillips, unpubl. data in Pollock et al. 2015). Approximately 70 km downstream, in the Codette Lake river/reservoir transition zone (decreased water velocities, increased depths, finer sediments begin to settle out), where juvenile Lake Sturgeon are densely aggregated year-round (Henderson et al. 2016a), opportunistic sampling of mortalities (314–936 mm fork length [FL]) in September 2015 revealed stomachs consistently full of chironomid larvae, with crayfish being entirely absent (L. Henderson, North/South Consultants, pers. comm.).

MOVEMENT AND HABITAT UTILIZATION

Movement and habitat utilization of middle life stages has been a focus of recent Lake Sturgeon research, and patterns vary considerably between aquatic ecosystem types.

LARGE STEPPED-GRADIENT RIVERS

Large stepped-gradient rivers offer a diversity of habitats over short spatial scales; the hydraulic gradient of these rivers is highly concentrated in discrete locations (i.e. major falls and rapids), otherwise interspersed with low-gradient (or semi-lacustrine) habitat. Because of the quantity of biological information accumulated for large stepped-gradient rivers, movement and habitat utilization are delineated; however, it should be acknowledged that they are related.

Movement

In large, stepped-gradient rivers, juveniles marked with passive tags or active transmitters have predominately been relocated in close proximity to where they were tagged. While basin fidelity has been suggested (Haxton 2003; Barth et al. 2011), the definition needs to be considered cautiously. There is evidence suggesting fine-scale fidelity (i.e., the tendency to return to a previously occupied location; (Switzer 1993)) in juveniles from several populations in stepped-gradient rivers (Haxton 2003; Barth et al. 2011; McDougall et al. 2013); however, on a coarse scale, a general lack of movement past river narrows which subdivide multi-basin reaches (Barth et al. 2011; McDougall et al. 2013) is also relevant (perhaps more so) to the broad understanding of spatial population structure.

Haxton (2003) used fixed-wing radio telemetry to monitor the movements of large (750–875 mm FL) juveniles, in the Ottawa River, ON/QC. There was no evidence of movements throughout the study

reach during the 2.5 year interval; rather, individuals were detected over a maximum range of 10.6 km and only within, or at, the periphery of the basin in which they were tagged (Haxton 2003).

Barth et al. (2011) used mark-recapture to examine movement patterns of juveniles (213–879 mm FL) in the Slave Falls Generating Station (GS) to Seven Sisters Falls GS (Seven Sisters Reservoir) section of the Winnipeg River, MB. Despite access to 41 km of habitat, over a 2.5 year period, 90.8% of recaptures occurred within 2 km of their initial tagging location. Distance between recaptures was correlated with the distance between the rapids that subdivide the reach; apparently driving this pattern, juveniles rarely moved either upstream or downstream through these rapids. There was no evidence home range of juveniles (based on distances between recaptures) was correlated with body size. Acoustic telemetry data for fish 364–505 mm FL also suggested minimal movement extents. Based on the results of the study, it was clear year-round habitat requirements (i.e., foraging and overwintering) for juveniles can be met in short sections of large rivers (Barth et al. 2011).

Labadie (2011) used acoustic telemetry to examine the movement of adults (870–1,570 mm FL) within the Slave Falls GS to Seven Sisters Falls GS section of the Winnipeg River. Despite a lack of true barriers to passage within the reach, movements were restricted to the three uppermost basins from which fish were tagged; during the open-water season, inter-basin movements occurred, but were infrequent. Summer home ranges based on 95% kernel density estimators averaged 6.0 km (range: 0.7–14 km). Winter home ranges averaged 4.4 km (range: 0.6–6.6 km). While Labadie (2011) observed no movement of adults from upstream sections to the lower sections of the reservoir, it should be noted habitats appear suitable and small numbers of adults have been captured therein (C. Barth unpubl. data).

McDougall et al. (2013) monitored the movements of acoustically tagged fish in the 9.8 km Pointe du Bois GS to Slave Falls GS (Slave Falls Reservoir) section of the Winnipeg River, MB over 1.5 years using a stationary receiver array. Movements of small (339–509 mm FL) and large (516–709 mm FL) juveniles tended to be restricted to sections of contiguous deep-water (>15 m) habitat (i.e., basins) 2–6 km in length; movements through the two river narrows (historical falls now inundated by backwatering from the Slave Falls GS) that subdivide this small reservoir were rare. Movement extents of adults (853–1,357 mm FL) were greater than for juveniles, which was attributed to adults moving upstream or downstream through river constrictions, albeit infrequently (McDougall et al. 2013). Ongoing mark-recapture monitoring in the Slave Falls Reservoir confirms there is minimal redistribution of juveniles among the Slave Falls Reservoir's three basins (Koga et al. 2013; Henderson et al. 2014a; Lacho et al. 2015b).

Movement patterns of larger juveniles and adults in the Slave Falls Reservoir were also examined in relation to abiotic influence on entrainment susceptibility (McDougall et al. 2014c). Considerable individual variation was observed, but tracked adults increasingly utilized the lower sections of the reservoir when water and air temperatures were high, daylight hours long, and river flow high or increasing. Movements of some large juveniles were correlated with seasonal and flow variables, but a population-level pattern corresponding with abiotic influence was not observed. On average, movement

ranges during open-water months were 2 to 4 times greater than during winter months and redistribution was minimal under ice-cover (McDougall et al. 2014c).

Hrenchuk et al. (2017) examined the movements of juveniles (322–570 mm FL) in the Stephens Lake section of the Nelson River, MB. During the first open-water season, movement extents ranged from 0.9 to 21.4 km, primarily utilizing the reservoir transition zone downstream of a set of major rapids. As winter progressed, juveniles moved farther downstream into the reservoir. This pattern was attributed to the build-up of ice and resultant scouring that occurs in the reservoir transition zone. Most tracked individuals moved back upstream into the transition zone after spring break-up (Hrenchuk et al. 2017). Juvenile movement monitoring is ongoing, and the study has been expanded to monitor the 'population' that occurs upstream in Gull Lake, a lotic environment (Lacho and Hrenchuk 2016). Annual juvenile movements were between 0.3 and 17.5 km (although skewed towards smaller distances) during open-water periods in Stephens Lake, and 0 and 14.9 km in Gull Lake during open-water periods (again skewed towards smaller distances). Consistent with the findings reported by Hrenchuk et al. (2017), in Stephens Lake, there was a seasonal downstream redistribution of fish from the river/reservoir transition zone during winter (Lacho and Hrenchuk 2016).

Hrenchuk and Barth (2016) reported on an adult acoustic telemetry project centered on Gull Rapids, the construction site of the Keeyask GS (construction began in July 2014). Upstream of Gull Rapids, many adults showed affinity to core-areas during both summer and winter over the 5-year monitoring period. Individuals tagged downstream of Gull Rapids frequently resided close to the rapids during the open-water period. During winter, adults moved downstream out of the river/reservoir transition zone, likely influenced by ice-build up and scouring that occurs in the area. Movement through Gull Rapids (both upstream and downstream) occurred rarely over the duration of monitoring. The next hydroelectric dam occurs >100 km upstream of Gull Rapids; however, only in one instance was a significant upstream movement observed.

Foraging Habitat Utilization

Because juveniles exhibit restricted movement patterns (Haxton 2003; Barth et al. 2011; McDougall et al. 2013), and because habitat in large riverine systems is highly heterogeneous, it is likely foraging habitat utilization patterns are partially driven by spatial distributions determined prior to age-1 (Barth 2011; McDougall et al. 2013; 2014b; Barth and Anderson 2015). For example, juveniles are frequently captured in high densities in the Winnipeg River, which may reflect habitat preferences, but likely also the cumulative result of a high proportion of larvae settling out in discrete areas along the flow axis, subsequent fine-scale site fidelity, and a resistance to movement through river narrows (McDougall et al. 2008b; 2013; 2014b; 2014c; Barth et al. 2009; 2011; Barth and Anderson 2015; Lacho et al. 2015b). Sociality may also play a role (Allen et al. 2009).

In the Ottawa River, ON/QC, which tends to stratify, the probability of capturing juveniles in a gill net and their relative abundance, was greatest in the 12–20 m depth range and lowest at the 35–50 m range in both unimpounded and impounded river reaches (Haxton 2011). On average, fish captured in the

shallowest (1–3 m) and deepest (50–75 m) habitats tended to be smallest and largest, respectively. However, juveniles tended to be smaller in the lower portions of unimpounded reaches and larger in lower sections of impounded reaches (Haxton 2011).

Vertical utilization patterns seem to be different in systems that do not (or rarely) stratify; essentially juvenile Lake Sturgeon prefer deep-water main-channel habitats, year round. In the Winnipeg River, MB/ON, the highest densities of juveniles within individual basins occur at depths >15 m (McDougall and MacDonell 2009; Barth et al. 2009; 2011; Peacock 2014; McDougall et al. 2014b). Acoustic telemetry data from the Slave Falls Reservoir indicates frequent juvenile utilization of depths in excess of 50 m (C. McDougall, unpubl. data), so there may be no true lower limit. In Stephens Lake on the Nelson River, the old-river channel (10–40 m deep) seems to be used exclusively during the open-water season and also primarily during the winter; however, there was some evidence of off-current, backwatered shallows being used during winter (Hrenchuk et al. 2017)

Despite an apparent preference for deep-water habitat in large stepped-gradient rivers that do not stratify, the persistence of actively recruiting populations in reaches that have considerably shallower available depth distributions (e.g., the lower Churchill River, MB) suggests, if deep water habitat is required, the upper threshold might be 6 m or less (Blanchard et al. 2014; Dolce and Barth 2015; Ambrose and McDougall 2016).

In the Winnipeg River, MB, depth appears to be the primary predictor of juvenile location within a basin. Juveniles have been captured during the foraging season in areas characterized by water velocities >0.2 m/s (Barth et al. 2009) and also in areas that, at the time of sampling, were essentially slack water (McDougall 2011b; Barth et al. 2011; McDougall et al. 2014b). Similarly, juveniles have been captured over essentially every substrate type (from bedrock to silt) present along the heterogeneous flow axis (Barth et al. 2009; McDougall 2011b; Koga et al. 2013; Henderson et al. 2014a, Henderson and McDougall 2015; Lacho et al. 2015b). Due to the confounding influence of early life-history processes and the dynamic nature of riverine environments, teasing out velocity and substrate preferences remains elusive on both the Winnipeg and Nelson rivers (Hrenchuk et al. 2017). Of course, depth, water velocity and substrate are intrinsically linked in riverine systems (Hjulstrom 1935) and, therefore, it is problematic to partition their relative influence on behaviour.

There has been little focus on foraging habitat utilization by adults in large stepped-gradient rivers, likely because it seems unimportant in the context of conservation concerns. Recent telemetry results suggest foraging requirements of adults can be met in small sections of large riverine systems, including upper sections of reservoirs that essentially overlap with spawning locations (McDougall et al. 2013; 2014c; Struthers 2016). Adults seem to be less restricted to deep water habitats relative to juveniles based on gillnetting catches from the Slave Falls Reservoir (McDougall et al. 2008b), although acoustic telemetry detections with corresponding pressure sensor (depth) data indicate that main-channel habitats are still primarily utilized (C. McDougall, unpubl. data). In the Seven Sisters Reservoir, substrate availability did not appear to explain utilization patterns within a given basin, nor did it explain residence patterns on an inter-basin scale (Labadie 2011). On the Nelson River, in the riverine section

between Sipiwesk Lake and the Kelsey GS, concentrations of large juveniles and adults are captured in relation to non-spawning tributary inflows and the edges of the main channel (D. Macdonald, MCWS, unpubl. data).

Overwintering Habitat Utilization

Overwintering behaviour has not been a focus of study in large, stepped-gradient riverine systems, but some information exists. In the Slave Falls Reservoir, acoustic telemetry results indicated both juveniles and adults are well-dispersed throughout the reservoir's three basins when ice-up occurs, similar to patterns observed during the open-water season; there does not appear to be one specific area within a given basin that all juveniles or adults utilize for overwintering (McDougall et al. 2013; 2014c). There is some evidence which supports the avoidance of flow hypothesis; large juveniles resident in the upper basin tended to utilize habitats farther downstream of the Pointe du Bois GS (upstream end), where depth is greater and velocities are reduced (McDougall et al. 2014c). Similarly, while juveniles frequent the upstream vicinity of the Slave Falls GS (downstream end) throughout the open-water season, the lack of acoustic detections in this area from November to March suggested the low-moderate velocity environment is not used for overwintering (McDougall et al. 2014a; 2014c). Similarly, Barth et al. (2011) reported some juveniles resident in the upper section of the Seven Sisters Reservoir moved downstream slightly, into marginally lower velocity habitats during fall, prior to ice up. In the upper to middle sections of the Seven Sisters Reservoir, no areas were used by adults solely for overwintering; rather, they tended to overlap with those areas used for foraging (Labadie 2011). In Stephens Lake on the Nelson River, overwintering patterns were apparently influenced by frazzle-ice buildup and scouring which occurs in the river/reservoir transition zone, as acoustic telemetry data indicated juveniles moved downstream as winter progressed; the old river channel still appeared to be primarily utilized, but a few fish were detected in backwatered areas that were off-current shallow, several kilometres away from the primary flow axis (Hrenchuk et al. 2017).

SMALL STEPPED-GRADIENT RIVERS

Small stepped-gradient rivers differ from larger counterparts both in terms of flow volumes and the severity of the hydraulic gradients; however, compared to other river types, they still offer a diversity of riverine and lacustrine habitats over short spatial scales.

In the Namakan River, Trembath (2013) examined movement and habitat utilization of juvenile Lake Sturgeon <540 mm FL. Juveniles were captured in five locations along the flow axis, in lotic habitats >10 m deep, with density skewed towards upstream spawning locations. Average home range size for fish monitored using acoustic telemetry ranged from 3.0 to 6.3 km^2 in one lacustrine widening, and activity tended to peak with the onset of ice cover. Short (<2-week duration) movements outside of the home range did occur, with returns to apparent core areas indicative of site-fidelity (Trembath 2013).

In Namakan Lake (Reservoir), MN/ON, Shaw et al. (2013) examined the seasonal distribution and movement patterns in the context of sex and reproductive condition. No significant difference in the minimum distance traveled among seasons or between sexes was observed. Site residency for both sexes

was higher during winter, suggesting reduced rates of movement. Presumed reproductive females traveled greater distances than did non-reproductive females, especially during the pre-spawn, spawning and fall periods (Shaw et al. 2013).

Great Lakes and Tributaries

The Great Lakes are massive freshwater bodies, characterized by a multitude of inflows of various sizes, as well as inter-connections (e.g., Lake Superior flows into Lake Huron). Some small spawning tributaries are entirely riverine downstream of impassable barriers to where they empty into lakes Superior, Huron, Michigan, Erie, or Ontario. Gillnetting results indicated juveniles relate to spawning tributary mouths during the foraging season, with density decreasing with distance (T. Pratt, DFO, unpubl. data). Movement of juveniles between adjacent tributary mouths has been observed in several of Lake Superior's shallow bays based on mark-recapture data, but relative recapture rates suggested the frequency of redistribution is relatively low (T. Pratt, unpubl. data).

It is assumed adults do not utilize most of the smaller tributaries except to spawn, but little is known about adult movement or habitat utilization in these systems, or about the nature of spawning migrations. In larger tributaries, year-round utilization occurs (T. Pratt, unpubl. data).

The St. Mary's River connects the upstream Lake Superior to the downstream Lake Huron. Gerig et al. (2011) examined the movement and habitat utilization of adults within this system, which offers a diversity of depths (1–25 m), substrate (silt, sand, clay, gravel, cobble, boulder) and water velocity. All sites utilized were characterized by flowing water, and Lake Sturgeon were most frequently relocated over silt substrate. Primarily, utilization focused on the depositional areas where riverine habitat transitions to lacustrine habitat. Weekly movement rates ranged from <100 m to over 25 km (Gerig et al. 2011).

In the 65 km long St. Clair River, juveniles (513–705 mm FL) exhibited a preference for deep water areas for foraging; only 3.5% of the available habitat exceeds 18 m, 34.9% of detections of acoustically tagged juveniles during summer occurred at depths exceeding that threshold, and 97% of relocations occurred at depths greater than 9 m (Boase et al. 2014). Selection for specific substrates was also reported; juveniles avoided areas with silt or soft clay (but these were generally shallow) and clay edges (Boase et al. 2014). Juveniles >620 mm FL exhibited a preference for sand and gravel substrates mixed with Zebra Mussel and areas where Zebra Mussel cover was dense, while those <620 mm FL utilized all of these habitats with no evidence of selection. With all tracking occurring during the summer, juveniles in the St. Clair River moved little and displayed a high degree of site fidelity. Observed movement extents ranged from 0.37 to 6.6 km, over periods of several months to just over a year at large (Boase et al. 2014).

The sheer size of the Great Lakes makes it difficult to monitor non-tributary movement and habitat utilization of adults. Briggs et al. (2016) used archival tags to monitor temperature and depth utilization by adults in Lake Huron from 2002–2004. Thermal utilization patterns seemed to emulate surface-water temperature trends, and the overlap of histories suggested tagged adults exhibited preference for the

same range of temperatures or occupied similar habitats. Mean occupied depth was 16.3 m (range: 0.1–42.4 m) and variation was observed among seasons; most notably, deeper water tended to be utilized during fall and winter. There was also considerable variation in depth utilization among individuals (Briggs et al. 2016).

Other Large Lakes and Tributaries

On other tributaries to the Great Lakes, predominantly in the United States, one or more lakes occur along the length of a spawning tributary, upstream of the Great Lakes proper. Many of these smaller, intervening lakes are utilized by juveniles. On systems like Lake Winnebago, Wisconsin, and Black Lake, Michigan, Lake Sturgeon populations are contemporarily isolated from the Great Lakes proper by dams on the lower reaches of the tributary. Although not connected to the Great Lakes, both Lake of the Woods and Rainy Lake classify similarly based on size and in-stream habitat. Movement and habitat use of mid- to later life stages within these types of environments has been studied from various perspectives.

Most of the published literature regarding juvenile movement and habitat utilization in large lake/tributary systems comes from the United States. In Portage Lake, MI, which has a mean depth of 8 m and a maximum depth of 17 m, juvenile Lake Sturgeon moved from 0 to 3.7 km/day during summer, with detections occurring at depths ranging from 4.3 to 15.9 m (Holtgren and Auer 2004).

In Black Lake, MI, which has a mean depth of 7.5 m and a maximum depth of 16.8 m, small juveniles (age-1, ~310 mm FL) foraged in shallow nearshore (<1.5 m) habitats characterized by sand substrate and deep (>12.2–13.7 m) offshore habitats characterized by organic substrates (Smith and King 2005). Clay or sand-organic substrates were not used. Larger juveniles (~800 mm FL) used water >9.2 m deep in off-shore flats, characterized by silt or organic substrates. Larger juveniles tended to move farther than did smaller juveniles (Smith and King 2005).

In Muskegon Lake, MI, most juveniles were observed within 1.5 km of the Muskegon River mouth during summer (Altenritter et al. 2013). This lake is generally shallow (44.8% of the wetted habitat is 0–6 m) but has a maximum depth of 23 m. Mean detection depth in this area during summer was 7.5 m (+/- 1.3 m). In fall, the distribution of juveniles shifted downstream into the lakes deepest area; mean detection depth was 15.8 m (+/- 1.3 m) during winter. Movements coincided with fall turnover, and the authors presented evidence to suggest seasonal hypolimniotic changes in dissolved oxygen concentration likely influence the spatial distribution of juveniles (Altenritter et al. 2013).

In Lake of the Woods and the large Rainy River tributary, located partially in Ontario and partially in Minnesota, Rusak and Mosindy (1997) used radio telemetry to monitor the seasonal movements of adults over a 3-year period. One group of fish, designated a lake population, consistently overwintered within Lake of the Woods proper, and commenced upstream migrations and spawned later than did the river population. The river population overwintered within the lower reaches of the Rainy River, where benthic communities had shown the greatest recovery from pulp and paper mill pollution (Beak Consultants Limited 1990 in Rusak and Mosindy 1997). Movement rates tended to be highest in spring

and summer and decreased with water temperature; fish that overwintered within Lake of the Woods moved more frequently than those that overwintered within the Rainy River. The only time Lake Sturgeon (from either population) spent time upstream of Long Sault Rapids was during the spawning season, and the authors noted the frequency of detections of Lake Sturgeon at sets of rapids downstream of spawning grounds seemed unlikely to be explained by chance alone (Rusak and Mosindy 1997). Winter or summer, both lake and river fish preferred areas characterized by moving water, such as lake peninsulas and channels at the mouth of the Rainy River. Lengthy movements and general habitat utilization within the lake during late spring and early summer seemed to occur in relation to shorelines and islands, and fish were generally located at depths of 6 m or greater in the relatively shallow (maximum depth: 11 m) southern section of Lake of the Woods (Rusak and Mosindy 1997).

LOW GRADIENT PRAIRIE RIVERS

Lacho (2013) used acoustic telemetry to track the movements of adults and juveniles for approximately 2 years in the South Saskatchewan River upstream of Lake Diefenbaker, AB/SK; including tributaries, Lake Sturgeon had barrier-free access to 1,100 km of riverine habitat. Generally, the larger the fish, the larger the movement. On average, juveniles (<1,150 mm FL) were detected over a mean range of 95 km (range: 0–626 km). The vast majority were detected over ranges of <350 km, with the distribution skewed towards small movement extents; 50% were detected over a range of 0–50 km. Adult fish (>1,150 mm FL) were detected over a mean range of 259 km (range: 0–1,062 km). Most fish moved in 251–350 km of river. Nearly all large movements occurred during the open water season with fish movement limited in the winter for both juveniles and adults. Overwintering was documented in deeper pool habitats (which are relatively rare in this section of river) and these same habitats tend to also be frequented during the open-water season. Substrate in overwintering locations consisted of gravel, cobble, bedrock, and sand (Lacho 2013).

Watkins (2016) used radio telemetry to track movement in 512 km of the North Saskatchewan River in Alberta from Drayton Valley to the AB/SK border. Highest movements were recorded during the spring and fall. Movements into SK were recorded during the spring and were attributed to spawning activity. Lake Sturgeon were detected throughout the range monitored but the vast majority (75%) of detections were recorded at ten “zones of congregation” in the river (Watkins 2016).

Wishingrad et al. (2014) examined movement of adults using radio telemetry from 2009 to 2012 in a section of the Saskatchewan River centered on the confluence of the North and South Saskatchewan rivers. Extensive and exclusive use of the confluence (The Forks) area was observed during summer and winter, respectively, as Lake Sturgeon were often located within deeper holes <12 km downstream. During the open-water season, adults were highly mobile within the monitored 100 km study area, with maximum annual cumulative distances covered ranging from 307–1,126 km (Wishingrad et al. 2014). However, the downstream extent of the study area was somewhat artificial given detection of radio transmitters is compromised by the presence of deep water, and this becomes increasingly prevalent in the river/reservoir transition zone located at the upstream end of Codette Lake. Furthermore, recent observations suggest a more complicated spatiotemporal pattern of Lake Sturgeon movement and

utilization than the results and interpretation put forward by Wishingrad (2014). Individuals appear to be, over time, wide ranging, as several fish with radio tags applied during the current study have been located >1000 km upstream on the North Saskatchewan River (O. Watkins, Alberta Fish and Wildlife, pers. comm.). There is also some evidence to suggest a drastic population-level shift in distribution relative to that reported by Wishingrad (2014); in 2014 and 2015, radio-telemetry runs and opportunistic monitoring focused on The Forks confluence, but only 8% of the tags theoretically still active were detected (Henderson et al. 2016a). Notably, high-water events occurred in 2013 (the 300-year 'High River, Alberta' flood) and 2014. While physical observations within the study area during the more severe event were scant, it was noted, during the 2014 high-water event, high sediment loads could be visually and audibly observed in the South Saskatchewan and downstream of the confluence, a scenario to which Lake Sturgeon may be averse (Henderson et al. 2015d). Based on observations made elsewhere on the Saskatchewan River, it also seems likely channel morphology was altered by the flood events (McDougall et al. 2016). Incidentally, Wishingrad et al. (2014) noted cumulative movement tended to be much more extensive during high-flow conditions observed in 2011 relative to normal flows in 2010 and 2012, so a more severe response of adults to even higher flow conditions seems conceivable. Indeed, it is expected, under flood conditions, much of the river would not provide suitable foraging habitat. Why a high proportion of the Lake Sturgeon radio tagged by Wishingrad et al. (2014) have apparently not returned to the Forks area is not well understood.

Movement studies focused on Codette Lake were initiated in spring 2015 (Henderson et al. 2016a). While only 6 months of acoustic telemetry data have been analyzed thus far, movements of juveniles have been predominantly restricted to the river/reservoir transition zone during the open-water season, although some movements into downstream reservoir habitats were observed. Furthermore, gillnetting studies conducted in fall 2014, spring 2015, and fall 2015 indicated the presence of a large aggregation of both adults and juveniles within the river/reservoir transition zone, which likely indicates the area is used for overwintering in addition to foraging (Henderson et al. 2016a). It seems unlikely utilization of Codette Lake is entirely a post-flood (2013 and 2014) phenomenon, because aggregations were also located in this area during 2011 and 2012 (F. Burton, Environnement Illimité, pers. comm.). In the adjacent Tobin Lake reservoir, juveniles have also been captured in the river/reservoir transition zone and telemetry data indicate movements are highly restricted to this area year-round (McDougall et al. 2016).

Adult movement and habitat utilization have also been examined in Tobin Lake via acoustic telemetry (McDougall et al. 2016). Fish overwintered exclusively within the river/reservoir transition zone, essentially not moving when the system was ice covered. While all of the adults (>1000 mm FL) monitored had movement extents >50 km, very discrete areas were occupied the majority of the time during the open-water season; essentially, the river/reservoir transition zone was used most frequently for foraging, and the area immediately downstream of the Nipawin Hydroelectric Station (HS) was also utilized (albeit to a lesser extent) during the open-water season, both during and outside of the spawning period. Forays into the downstream lacustrine sections of the reservoir rarely occurred and, when

individuals did descend into these areas, they moved back upstream into apparent core areas within hours to days (McDougall et al. 2016).

LOW GRADIENT LOWLAND RIVERS

Habitat in low-gradient rivers (such as occur in the Hudson Plain) tends to be relatively homogeneous compared to stepped-gradient rivers, with diversity only occurring over large spatial scales. While little is known about Lake Sturgeon movement and habitat utilization in most lowland rivers, patterns in the lower Nelson and lower Hayes rivers have been studied.

During the open-water season, both adults and juveniles in the lower Nelson River (a ~110 km section located between the lowermost dam and the Hudson Bay estuary) have been found to be most concentrated in the deeper, slower section of the reach (between Angling River and Deer Island); however, they were distributed throughout the entire reach of the river and, to a lesser extent, also utilized the larger tributaries such as the Limestone, Weir, and Angling rivers (MacDonell et al. 1992; Ambrose et al. 2010a). Telemetry and mark-recapture results indicated most adults were relatively sedentary, but some undertake more extensive movements, apparently unrelated to spawning (MacDonell 1992; Ambrose et al. 2010a). Individuals have been observed to move upstream as far as the Limestone GS outside of the spawning period and the odd sturgeon will move up the Limestone River (MacDonell et al. 1992). Others have moved up the Angling River (the lower reaches of which are used for spawning) into Angling Lake, where a few remained for up to five years before suddenly moving back downstream, apparently to spawn (MacDonell 1992). Movements into the estuary and even into an adjacent river via a shared freshwater plume must, at least occasionally, occur as tagged fish have been recaptured several hundred kilometers up the Echoing River as far as Sturgeon Lake, ON, (Shamattawa First Nation, unpubl. data) and up the Gods River to as far as Red Sucker Rapids (Klassen 2012) however, high-resolution genetic analysis based on single-nucleotide polymorphisms indicated these forays do not result in effective dispersal (Gosselin et al. 2015), and 'there-and back-again' movements have been documented via mark-recapture (Ambrose et al. 2010a).

ST. LAWRENCE RIVER AND ESTUARY

The St. Lawrence River transitions from relatively narrow and swiftly flowing to wider and more moderate and has numerous tributaries. In addition to varying on the longitudinal axis, habitat differs along the transverse axis.

Fortin et al. (1993) used mark-recapture tagging to study the movements of adults along the 350 km lower St. Lawrence River between the Beauharnois–Les Cedres GS to the estuary, a study area which includes the reach of the Ottawa River between the Carillon GS and the confluence with the St. Lawrence River. Non-spawning fish were tagged at various locations in the river including Lac Des Deux Montagnes and Lac Saint Louis (located in the upper portion of the study area), and spawning fish were tagged at the Rivière Des Prairies and l'Assomption River spawning grounds (located in the central portion of the study area). Results indicated that although Lake Sturgeon move throughout the system, those tagged in Lac Des Deux Montagnes on the Ottawa River were sedentary relative to those tagged in

the St. Lawrence River. The authors reasoned adult Lake Sturgeon leave foraging grounds and move to common spawning areas in the central part of the study area and then return to their original foraging location (Fortin et al. 1993). More recent investigations have employed acoustic telemetry, revealing new insights on Lake Sturgeon intrapopulation variability in migration (Valiquette 2016). Valiquette (2016) showed that at least three distinct migration patterns exist within the Lake Sturgeon population in the lower St. Lawrence River. These included residents and two groups of migrants. Movements of migrants were associated with 1) reproduction, and 2) seasonal migrations between feeding (downstream) and overwintering (upstream) habitats (Valiquette 2016). Recent studies also showed that downstream spawning grounds are more actively used by Lake Sturgeon than previously thought (Valiquette 2016). Spawning grounds along the lower St. Lawrence River up to the estuary are now known to be extensively used by Lake Sturgeon.

Habitat utilization has also been investigated in the St. Lawrence River. During fall, juvenile catch occurred more frequently at stations over bottoms of clay and gravel in shallow depths (3–6 m), and in areas with moderate water current (0.25–0.50 m/s). During summer, they were found in deeper water (6.1–9.0 m) and at higher current speed (0.50–0.75 m/s). Higher catch per unit effort occurred on gravel substrate (Nilo et al. 1997). Further, a trawl was used to sample four types of in-stream habitat: littoral, channel margin, channel, and deep pool. Relative abundance of Lake Sturgeon, in general, was 3 to 4 times higher in deep pool and channel habitats compared to littoral and channel margin habitats; however, juvenile Lake Sturgeon were captured more frequently in shallow littoral habitats (de la Chenelière et al. 2015).

DISPERSAL

In the Great Lakes, there is evidence of adults straying among spawning tributaries. Homola et al. (2010) reported that in Lake Superior, genetic estimates indicated that 3.5% of the adults captured in the Sturgeon River belong to another population. In Lake Michigan, Homola et al. (2012) reported that straying of individuals to spawning tributaries different from their origin tributary occurred at an estimated rate of ~10.5% (range by tributary: 4.5% to 16.7%), with certain rivers being more likely to receive rather than export immigrants. The greatest rates of straying occurred between tributaries separated by relatively short distances. The authors noted the high rates of straying contrast with high inter-population FST[1] (at least in the context of genetic divergence in Lake Sturgeon) and suggested the straying rates are poor indicators of successful reproduction in non-origin tributaries.

Similarly, a low frequency of movement by adults between rivers (e.g., from the Nelson to the Hayes) draining into Hudson Bay have been observed, but these movements do not appear to result in effective dispersal (Gosselin et al. 2015). Therefore, natal philopatry appears to be influential, but whether the mechanism relates to innate homing (i.e., cued by environmental parameters as in salmon) or learned behaviour is not clear.

[1] FST is the proportion of the total genetic variance contained in a subpopulation relative to the total genetic variance of the population. Values can range from 0 to 1. High FST implies a considerable degree of differentiation within populations.

The process of dispersal among populations (and potentially meta-populations) that occur along the flow axis of a given river is markedly different from dispersal that occurs between rivers that support year-round resident populations or between spawning tributaries of large lakes. Essentially, upstream-to-downstream larval drift theoretically provides another avenue for dispersal. On the Namakan River, ON/MN, numerous spawning locations have been identified along the flow axis and juveniles tend to occur most densely in deeper habitats located downstream of these locations (Trembath 2013). However, upstream movement of adults over various small falls and rapids has been observed, apparently resulting in enough gene flow to maintain genetic panmixia (Welsh and McLeod 2010). It is possible demographically independent 'stocks' occur along the flow axis, but to what degree larval drift and/or movement during early to middle life stages results in dispersal (presumably one-way, downstream) between them is uncertain.

On the Red River, MB, extensive stocking has been conducted in the headwaters located in Minnesota and the numerous Lake Sturgeon captured by anglers in the lower reaches are assumed to link to these stockings, >900 km downstream of the Otter Tail River headwaters where they were stocked (L. Aadland, MNDR, pers. comm.; D. Kroeker, MCWS, pers. comm.). However, given the geomorphology of the river and the assumed lack of spawning sites in the lower reaches (possible exception below St. Andrews lock and dam in Lockport), these events probably do not qualify as contemporary inter-population dispersal.

On the Ottawa River, ON/QC, hydroelectric dams can be reasoned to currently be limiting contemporary dispersal, relative to what must have occurred historically. Wozney et al. (2011) found no evidence to refute a historical panmixia hypothesis based on genetic analysis and reasoned no downstream movement of later life-stages past dams means downstream gene flow may only occur via larval drift, if it occurs at all. Because of the physical distance between dams (and the flow characteristics of the generally large forebays), larvae drifting past dams seems unlikely (T. Haxton, OMNR, pers. comm.). Therefore, 'natural' replenishment of a population within a hypothetically decimated Ottawa River impoundment, via dispersal inputs from other contemporarily depressed populations located farther upstream would likely be, at best, a very slow process.

In the Winnipeg and Nelson rivers upstream-to-downstream dispersal appears to be occurring at a relatively high rate. McDougall et al. (2014a) examined downstream passage of Lake Sturgeon through the Slave Falls GS, on the Winnipeg River, Manitoba. The rate of entrainment through the Slave Falls GS for adults tagged throughout the reservoir was determined to be approximately 3.1% per year; for large juveniles (sub-adults) tagged in the lowermost basin (upstream of Slave Falls), the entrainment rate was 21.1%. These downstream relocations are permanent and at least 91% of observed events were survived (McDougall et al. 2014a). In a related study, approximately 15% of the Lake Sturgeon, measuring between 525–700 mm FL, captured downstream of the Slave Falls GS were fast-growing outliers reasoned to have been former residents of the Slave Falls Reservoir (McDougall 2011a; McDougall et al. 2017b; McDougall et al. 2018).

The Slave Falls Reservoir is comprised of three basins, subdivided by two now-inundated historical falls. Juvenile Lake Sturgeon appear to be averse to moving either upstream or downstream through these river narrows (McDougall et al. 2013), and farther downstream on the Winnipeg River (Barth et al. 2011). Therefore, large quantities of juvenile Lake Sturgeon resident within the reservoir are essentially not susceptible to entrainment (McDougall et al. 2013). The Slave Falls Reservoir (10 km) currently supports approximately 2,000 adults and approximately 10,000 juvenile Lake Sturgeon (McDougall et al. 2017a); therefore, it is anticipated density dependence may soon be reached. Given the Slave Falls GS has been in operation since 1930, it is unlikely entrainment is a recent phenomenon. However, the size of the Slave Falls Reservoir population has probably increased considerably since the 1990s (Block 2001; McDougall et al. 2017a) and, therefore, the amount of upstream to downstream contribution (dispersal) may also have recently increased (McDougall et al. 2017b; 2018).

While the quantity of dispersal occurring via survived entrainment of later life stages at the Slave Falls GS may be considerably higher than other hydroelectric stations (even others on the Winnipeg River) due to the presence of bottom-draw regulating gates (McDougall et al. 2014a), recaptures of tagged fish provide evidence of successful descents over other Winnipeg River dams in Ontario (M. Duda, OMNRF, pers. comm.) and Manitoba (D. Kroeker, MCWS, pers. comm.). In addition, parentage identification indicates dispersal of Slave Falls Reservoir spawned larvae to the area downstream of the Slave Falls GS is also occurring (C. McDougall, unpubl. data), providing confirmation of another suspected avenue for upstream-to-downstream dispersal. However, habitat variation along the Winnipeg River flow axis (influenced by hydroelectric dam spacing) and variation in stock abundance is likely to drive how much dispersal will naturally occur on an inter-reservoir scale. Habitat variation is important to consider because juvenile abundance is skewed towards the upstream where hydraulic gradient is concentrated. Establishment of age-0 fish following larval drift occurs in close proximity to the hydraulic gradient from riverine to lacustrine combined with a resistance to downstream redistribution past constrictions at the juvenile stage (Barth et al. 2009; 2011; McDougall et al. 2013; 2014c; Barth and Anderson 2015). This same pattern has also been observed, to a lesser degree, for adult stages (Labadie 2011; McDougall et al. 2013; 2014c). In larger reservoirs (e.g., the 41 km Seven Sisters reservoir), if larvae do not, or rarely, drift into lower reaches and/or through the downstream dam, the rate of inter-reach upstream-to-downstream dispersal would likely be low, no matter what density of fish were present in upstream subsections.

On the Nelson River in the vicinity of the Kelsey GS, high-resolution genetic results indicate downstream dispersal occurred historically and, based on the presence of apparent first-generation migrants, also in the recent past (Gosselin et al. 2015). In the middle-Nelson River, sibship assignment suggests juveniles present within Stephens Lake (and also the Long Spruce Reservoir) were spawned farther upstream in Gull Lake (where some of their siblings still remain); downstream redistribution through Gull Rapids and, to a lesser degree, the Kettle GS has occurred. This observation is particularly notable because it is also apparent, based on genetic results, that the middle-Nelson River (from Gull Rapids downstream to the site of the Limestone GS) did not support a year-round resident population; otherwise transitional genotypes would be expected in the Lower Nelson River (Gosselin et al. 2015).

Therefore, contemporary dispersal into altered habitats may actually be resulting in the establishment of a new contemporary population, consistent with the Gull Lake genetic signature.

Inter- and intra- watershed dispersal of Lake Sturgeon is also occurring as a result of stocking. In the United States, Lake Winnebago-strain fish have been implanted in numerous locations. In the St. Louis River, large quantities of fry and age-0s (fingerlings), and some age-1 (yearlings) were stocked (Schram et al. 1999). In 2011, 28 years after stocking began, reproduction of those stocked into the St. Louis River, Michigan, was confirmed (J. Lindgren, MDNR, pers. comm.). On the upper Nelson River, redistribution and subsequent survival of hatchery-reared age-1s has been observed, with cumulative evidence indicating dispersal has consistently occurred shortly after stocking, but also after post-stocking establishment, the fish exhibit restricted movement patterns consistent with wild juveniles (McDougall and Pisiak 2014; McDougall et al. 2014d; McDougall and Nelson 2015).

POPULATION SIZES AND TRENDS

By designatable unit, known sampling effort and methods, abundance, and fluctuations and trends are provided for each management unit identified by Cleator et al. (2010a).

DU1: WESTERN HUDSON BAY

The Churchill River drainage is found in the Western Hudson Bay ecozone (Figure 1; COSEWIC Freshwater Ecozone 5; COSEWIC 2006). The Churchill River flows from its origin on the eastern edge of Alberta to its terminus in Hudson Bay, draining an area approximately 281,300 km^2 over 1,609 km of river (COSEWIC 2006). In Saskatchewan the Churchill River winds through the Canadian shield, where it widens into several lakes (Iskawatam, Wapumon, Wintego, Pita, Pikoo, and Reeds) eventually entering Sokatisewin Lake approximately 82 km downstream of its confluence with the Reindeer River. Sokatisewin Lake was formed by the Island Falls HS that inundated 18.3 km^2 of the Churchill River and 23.3 km^2 of land. Downstream of Island Falls HS, the Churchill River flows through Wasawakasik Lake at Sandy Bay, Saskatchewan, and into Manitoba though several large lakes (Sisipuk, Pukatawagan, Granville, and Southern Indian) interspersed with relatively short riverine sections. The Missi Falls Control Structure (CS), at the eastern end of Southern Indian Lake, went into operation in 1976 causing the lake to increase about 3 m (9.8 ft) in depth and worked to divert about 85% of the water that normally flowed out of the lake through the Churchill River, into the Burntwood and Nelson rivers system (FEMP 1992). Although this development had large impacts to Southern Indian Lake, the areas where Lake Sturgeon had been historically harvested in Manitoba (i.e., upstream of Opachuanau Lake and the backwater effect of Missi Falls) were not materially affected. Downstream of Southern Indian Lake the Churchill River flows through Partridge Breast, Thorsteinson, Northern Indian, Fidler, and Billard lakes as it transitions from Boreal Shield into the Hudson Bay Lowlands eventually emptying into Hudson Bay at Churchill, Manitoba.

The Churchill River is the northern boundary of Lake Sturgeon distribution. Cleator et al. (2010a) identified three Lake Sturgeon management units (MUs) in the Churchill River delineated by natural river features and/or dams (Figure 2). MU1 spans 112 km from Atik Falls on the Reindeer River and

Kettle Falls on the Churchill River downstream to Island Falls GS; MU2 spans 430 km from Island Falls HS downstream to Missi Falls CS; and MU3 spans 440 km from the Missi Falls downstream CS to the Churchill River estuary. The only known recruiting DU1 population occurs in a small stretch of the lower Churchill River in MU3. Population sizes and trends of Churchill River populations are discussed by MU below.

Kettle Falls to Island Falls GS (MU1)

There is little known about historical populations in the Saskatchewan portion of the Churchill River, however, it was reported that the species was found as far upstream as Kettle Falls on the Churchill River and Atik Falls on the Reindeer River (Sawchyn 1975). According to Cleator et al. (2010a), Lake Sturgeon may have declined by as much as 98% in the Churchill River from 1920–1939 due to over-harvest. Stewart (2009) noted uncertainty regarding the origin of Lake Sturgeon catches in Saskatchewan as Churchill River harvests may have erroneously been reported as being from the Saskatchewan River.

Focused Lake Sturgeon investigations have not been conducted upstream of Wintego Rapids. However, with the exception of potential climatic constraints (the Churchill River being essentially the northern extent of the species range), the in-stream habitat appears to be ideal. It is characterized by alternating sequences of rapids/falls and short riverine reaches flowing into shield lakes, much like the upper Winnipeg River. In the reach between Wintego Rapids and Island Falls GS, despite considerable gillnetting effort (using 1, 2, 3, 5, 6, 8, 9, 10 and 12" mesh) in ideal habitats, no juvenile or adult Lake Sturgeon were captured during studies conducted in 2010 and 2011 and the population is considered remnant (Johnson and Nelson 2011; Nelson and Barth 2011). The last reported capture of Lake Sturgeon in this MU occurred in 2001/2002 when two large individuals were captured in the vicinity of Wintego Rapids (Mark Duffy, Saskatchewan DNR, pers. comm.).

Island Falls GS to Missi Falls CS (MU2)

Little information exists regarding the historical abundance of Lake Sturgeon from the Saskatchewan portion of MU2. Harvest is known to have occurred during, and after, the construction of Island Falls GS (Morin 2002). While there are no definitive records of a commercial fishery operating in the area, there is evidence that Lake Sturgeon were harvested and transported to The Pas and Flin Flon by truck and plane (Morin 2002). In Manitoba, the earliest record of Lake Sturgeon in this MU comes from a report describing the commercial fishery resources of Manitoba. Skaptason (1926) reported commercial fishing occurred between Duck and Pukatawagan lakes in the winter of 1924–1925. Small commercial harvests were reported again in 1938 and 1946 (Stewart 2009). Commercial harvest of Lake Sturgeon was closed province wide from 1946 to 1952, and when the fishery re-opened in 1953, the reported harvest from the upper Churchill River in Manitoba was approximately 8,500 kg, the highest commercial harvest ever recorded from this area (Stewart 2009). Small quantities of harvest, likely from this MU, were reported annually from 1953–1961, after which the fishery was closed for 11 years (Stewart 2009). In 1976, the year the Missi Falls CS was completed, water levels increased on Southern

Indian Lake, and considerable flow volumes were diverted down the Churchill River Diversion (CRD) route to the Nelson River. Small quantities of harvest (<1,600 kg annually) were periodically reported from the Churchill River from 1972 to 1990, but the majority of this harvest is believed to have been taken in MU3 (Stewart 2009).

Reported Lake Sturgeon harvest was consistently low from the Churchill River in Manitoba, suggesting populations were never as large as those in the Nelson River or Lake Winnipeg, and even while fisheries were underway, it was noted the Churchill River did not have a population large enough to yield production levels comparable to the Nelson River (Kooyman 1955).

Over the past twenty years, reports of Lake Sturgeon from the Churchill River in Manitoba upstream of Southern Indian Lake have been rare. Large Lake Sturgeon (weighing over 150 kg) were reportedly taken from Granville and Pukatawagan lakes in 1986 and 2003, respectively (Manitoba Hydro and the Province of Manitoba 2015). In Hughes Lake, a single juvenile was captured in a gillnet that measured 457 mm in length (MCWS unpubl. data). The capture of this fish suggests that natural reproduction may be occurring in the Hughes Lake/Eden Lake section of the Churchill River drainage. Don Macdonald (MCWS, pers. comm. 2014) attributes the relatively low numbers of Lake Sturgeon in MU2 either to low productivity, as Kooyman (1955) suggested, or possibly to a large harvest event that was never recorded.

Missi Falls CS to Churchill River Estuary (MU3)

The Lower Churchill River (MU3) extends from the Missi Falls CS to the Churchill River Estuary and includes a number of lakes (Partridge Breast, Thorsteinson, Northern Indian, Fidler, and Billard). Due to natural breaks in habitat, and distinct changes to the abundance of Lake Sturgeon, this area was divided into three distinct reaches for the purposes of this assessment. These include: i) the upper reach: Missi Falls CS to Redhead Rapids (a.k.a. 'The Fours'); ii) the middle reach: Redhead Rapids to Swallow Rapids, which includes the confluence with the Little Churchill River; and iii) the lower reach: Swallow Rapids to the estuary (Figure 2).

Missi Falls CS to Redhead Rapids (The Fours) (MU3)

There is a near absence of Lake Sturgeon data from the lower Churchill River prior to 1976. Unpublished Manitoba Fisheries Branch (MFB) records note attempts were made in 1957 to harvest Lake Sturgeon from the upper reach but the catch was described as 'small' (MFB 1958 unpubl. data). In 1975, fishermen were issued licenses to salvage Lake Sturgeon from the Lower Churchill River prior to the drawdown caused by the Churchill River Diversion (MFB 1976 unpubl. data). The reach of the river where fishing was attempted is unknown, however, the abundance of Lake Sturgeon was found to be low (54 kg harvested) (Manitoba Hydro and the Province of Manitoba 2015).

Recent information suggests that the Missi Falls CS to Redhead Rapids reach does not support a reproducing population of Lake Sturgeon. In 2008 and 2009, Lake Sturgeon were absent from the index gillnetting catch in Partridge Breast, Northern Indian, Fidler, and Billard lakes (CAMP 2014). Further,

only one sturgeon was captured at the outlet of Billard Lake during a focused adult and juvenile Lake Sturgeon inventory conducted in a 45 km-long (28 mi) stretch of the Churchill River that included Billard and Fidler lakes (NSC 2011; Manitoba Hydro and the Province of Manitoba 2015).

Redhead Rapids to Swallow Rapids (including the Little Churchill River confluence) (MU3)

One commercial fisherman harvested periodically in the Lower Churchill River at the confluence with the Little Churchill River between 1977 and 1987 (MFB unpubl. data). In 1977, the fisherman did not report a harvest, however, in 1980, 1,202 kg were harvested with harvest quantities declining in subsequent years (Manitoba Hydro and the Province of Manitoba 2015). In October 1989, a single fisher was interested in assessing the Lake Sturgeon fishery of the Lower Churchill River; however, reports indicate 'there was virtually no catch to be had' and further attempts were abandoned (MFB unpubl. data).

Lake Sturgeon are known to be recruiting and are considered moderately abundant in the Churchill River between Redhead Rapids and Swallow Rapids (MacLean and Nelson 2005; CAMP 2014; Blanchard et al. 2014; Ambrose and McDougall 2016). Larval sturgeon have been captured drifting out of the Little Churchill River suggesting that some Lake Sturgeon spawn near the river's confluence with the Churchill River (NSC 2012). Further, juvenile Lake Sturgeon CPUEs are considered high in the thalweg of the Churchill River between the Little Churchill River and Swallow Rapids (CAMP 2014; Ambrose and McDougall 2016), indicating habitat is suitable for the early life stages. Growth of juvenile Lake Sturgeon is relatively slow in this section, with individuals reaching 800 mm FL by approximately 17 years of age (Ambrose and McDougall 2016). Lake Sturgeon are also known to utilize the Little Churchill River and movements have been reported between Recluse Lake and the Churchill River (D. Macdonald, MCWS, pers. comm. 2014; Manitoba Hydro and the Province of Manitoba 2015). A Lincoln-Peterson population estimate conducted in 2005 estimated the quantity of Lake Sturgeon > 800 mm present in the reach to be 2,005 (95% CI: 1,441–2,569) (MacLean and Nelson 2005). The estimate based on 2014 and 2015 data was 1,573 (range: 1,401–1,745) (Ambrose and McDougall 2016).

Swallow Rapids to Churchill River estuary (MU3)

Similar to the upper reach of MU3, Lake Sturgeon are considered rare in the lower reach. In 2013, small quantities of adults and juveniles were captured downstream of Swallow Rapids, but it is unclear whether recruitment is occurring or if these fish are the result of downstream redistribution from the high-density Churchill River confluence area (Blanchard et al. 2014).

Information collected from resource users in the town of Churchill circa 1993 indicated that small numbers of Lake Sturgeon could be captured in deep holes of the Churchill River proximate to town (Remnant and Bernhardt 1994; Manitoba Hydro and the Province of Manitoba 2015). In addition, juvenile and/or adult Lake Sturgeon were rarely captured during fisheries investigations conducted near the Churchill River Weir prior to, and following, weir construction (Remnant 1995; Peake and Remnant 2000; Bernhardt 2000; 2001; 2002; Bernhardt and Holm 2003; Bernhardt and Caskey 2009; Hertam et al. 2014).

Summary

The historical abundance of Lake Sturgeon in this DU is poorly understood. The species was present historically along much of the river in Saskatchewan and Manitoba but, based on commercial catch records, and reports from commercial fishers, may not have been as abundant as other nearby rivers, such as the Nelson River. It is possible small recruiting populations still exist in the Eden Lake system, or in the Churchill River in Manitoba upstream of Southern Indian Lake, however, focused studies have not been conducted to confirm this assertion. Downstream of the Missi Falls CS, a population comprised of approximately 1,500 adults, is the only known sizeable population that remains in this DU.

DU2: SASKATCHEWAN-NELSON RIVER

For the purposes of this assessment, DU2 is a combination of five previously separate DUs from the 2006 assessment (Figure 3): Saskatchewan River populations (formerly DU2), the Nelson River populations (formerly DU3), the Red-Assiniboine Rivers and Lake Winnipeg populations (formerly DU4), the Winnipeg River-English River populations (formerly DU5), and the Lake of the Woods-Rainy River populations (formerly DU6).

Saskatchewan River Drainage

The Saskatchewan River proper begins at the confluence of the South Saskatchewan and North Saskatchewan rivers in the province of Saskatchewan and flows approximately 550 km prior to emptying into Lake Winnipeg (Figure 4). Its watershed drains the majority of southern and central Alberta and a considerable portion of Saskatchewan, covering an area of approximately 335,900 km^2 (Rosenberg et al. 2005). The North and South Saskatchewan rivers originate in the Montane Cordillera ecozone in western Alberta, flow into the Prairie ecozone in Alberta and western Saskatchewan, transition into the Boreal Plain ecozone, and then merge to form the Saskatchewan River proper west of Prince Albert, Saskatchewan (Figure 3). Locations of naturally occurring falls and rapids are restricted to the Montane Cordillera in the upper watershed, in the Boreal Plain ecozone upstream of the confluence of the North and South Saskatchewan rivers and in the vicinity of Cumberland House upstream of the Manitoba and Saskatchewan border. The Saskatchewan River is shallow (mostly <10 m) with moderate to swift flows. Meandering is the dominant habitat feature throughout most for the drainage with characteristic alternating sequences of shallow inside bends and deeper outside bends when flowing through finer glacial deposits. The upper watershed has reaches of coarse substrates marked with gravel shoals. As the North and South Saskatchewan rivers flow through Saskatchewan there are extensive islands and channel braiding as the rivers transition from the Prairie to Boreal Plain ecozones. Historically, the Saskatchewan River mainstem had rapids located at Nipawin, Tobin, and Bigstone.

The South Saskatchewan River is formed from the confluence of the Bow and Oldman Rivers, near Grassy Lake, Alberta. The Oldman Dam on the Oldman River is approximately 320 km upstream of the confluence while the Bow River is dammed approximately 170 km upstream of the confluence. These dams mark the upstream extents of Lake Sturgeon movement in the system. The Red Deer River enters

the South Saskatchewan River near the AB-SK border, and is dammed at the Dickson Dam, located 50 km southwest of the town of Red Deer, Alberta. Further down the South Saskatchewan River, approximately 90 km due south of Saskatoon, the Coteau Creek HS forms Lake Diefenbaker (Figure 4). The North Saskatchewan River has one dam, the Bighorn Dam, located in the upper reaches near Rocky Mountain House, AB. In addition, flows on one of the tributaries, the Brazeau River, are controlled by the Brazeau Dam.

The Saskatchewan River proper is currently dammed in three locations: at the Nipawin and E.B. Campbell hydroelectric stations in Saskatchewan, and at the Grand Rapids GS in Manitoba. The Saskatchewan River is broken into four Lake Sturgeon management units (MUs) and encompasses parts of Alberta, Saskatchewan, and Manitoba:

- North Saskatchewan River (Bighorn GS to Forks ~1,195 km)/South Saskatchewan River (Coteau Creek HS to The Forks ~358 km)/Saskatchewan River proper (The Forks to Nipawin HS ~103 km) (MU1). Provides a total of about 1,656 barrier-free river kilometers;
- South Saskatchewan River upstream of Coteau Creek HS (MU2). Provides about 602 km of habitat from the confluences of the Bow and Oldman rivers in Alberta to the northern outlet of Lake Diefenbaker in Saskatchewan;
- Saskatchewan River: Nipawin HS to E.B. Campbell HS (MU3). Provides about 70 km of combined riverine and lacustrine habitat of which Tobin Lake occupies the final 75%; and
- Saskatchewan River: E.B. Campbell HS to Grand Rapids GS (MU4). Provides about 427 km of combined riverine and lacustrine habitat of which Cedar Lake occupies the final 23%, before entering Lake Winnipeg at Grand Rapids GS.

Based on commercial harvest records, Lake Sturgeon were once abundant in the Saskatchewan River drainage. Commercial Lake Sturgeon harvest was first reported from the Saskatchewan River in 1898 and over the next century 511,698 kg was harvested, primarily at the onset of the fishery (Stewart 2009). Little is known with respect to specific harvest locations in the Saskatchewan River drainage with the exception of a few reports. A substantive harvest was reported on the South Saskatchewan River, suggesting that '2,000 lbs of bladder flat' was harvested at the confluence of the Red Deer and South Saskatchewan rivers in the late 1700s or early 1800s (Stewart 2009). Stewart (2009) notes this would require a harvest amount of 257,588 kg of Lake Sturgeon. In Alberta, small commercial harvests were reported between 1880 and 1940, but there is little data available, as no formal records were kept (McLeod et al. 1999).

North Saskatchewan River, South Saskatchewan River Downstream of Coteau Creek HS, Saskatchewan River from the Forks to Nipawin (MU1)

In the North Saskatchewan River, Lake Sturgeon have been observed as far as 10 km upstream of Rocky Mountain House, Alberta, but are most commonly found in the lower 475 km in Alberta (Nelson and

Paetz 1992). There are also historical records of sturgeon in the Brazeau River, southwest of Edmonton (Saunders 2006). Captures of Lake Sturgeon by anglers have been reported in various locations between the Saskatchewan border and the Forks, most commonly from Lloydminster, Battleford, and Prince Albert (Smith 2003). Despite these records and reports, little is known about their historical abundance.

There is no historical information about Lake Sturgeon abundance in the South Saskatchewan River between Coteau Creek HS and The Forks, a stretch of 359 river km (Cleator et al. 2010b). The 100 km reach immediately downstream of the Coteau Creek HS is presently not considered suitable Lake Sturgeon habitat because of low temperatures and scarcity of suitable food (Smith 2003). Lake Sturgeon have been captured at a few locations from Saskatoon downstream to the Forks, but do not seem to be as common as in the North Saskatchewan River (Smith 2003). Lake Sturgeon are known to move extensively among the North Saskatchewan, South Saskatchewan, and Saskatchewan rivers. (Pollock 2012; Wishingrad 2014) and have been tracked as far upstream as Drayton Valley west of Edmonton (Owen Watkins, pers. comm.).

In the Saskatchewan River, Lake Sturgeon are known to be abundant at the Forks all year round, and have been detected as far downstream as Codette Lake, upstream of the Nipawin HS (Pollock 2012; Wishingrad 2014; Henderson et al. 2015d; 2016a). Lake Sturgeon implanted with radio tags at the Forks made long migrations (i.e., average >90 km) into the North and South Saskatchewan rivers, but returned to the Saskatchewan River to overwinter downstream of the Forks (Pollock 2012; Wishingrad et al. 2014). Other studies have noted movements in these MUs of >800 km (ALSRT 2011; DFO 2016). Juvenile Lake Sturgeon have been found in high abundances in the Saskatchewan River at the upstream end of Codette Lake at Wapiti Provincial Park. Targeted juvenile Lake Sturgeon studies conducted during the fall of 2014 and 2015 captured 321 Lake Sturgeon in 11 overnight sets (Mean CPUE: 29.2 LKST/overnight set) (Henderson et al. 2015d; 2016a). Acoustic tagging data indicates the same area provides significant overwintering habitat for Lake Sturgeon of all sizes (Henderson et al. 2016a).

Studies undertaken in the vicinity of the Forks, found the Saskatchewan River downstream of the Forks was heavily used by Lake Sturgeon, including over the winter period. There is also evidence of Lake Sturgeon spawning in the North Saskatchewan River approximately 12 km upstream of the Forks (Environnement Illimité Inc. 2012a). In the North Saskatchewan River, four additional potential spawning sites have been identified (Smith 2003). Low temperatures and unsuitable habitat below Coteau Creek HS in the South Saskatchewan River make it an unlikely spawning location for Lake Sturgeon (Smith 2003). The South Saskatchewan River immediately upstream of the Forks appears to have suitable habitat, but studies conducted in 2015 found no evidence of spawning (Henderson et al. 2016a).

The most current population estimate (derived from angler recapture data) in the North Saskatchewan River in Alberta comes from 2012 and splits the North Saskatchewan in two sections: the upstream reach from Drayton Valley to Smoky Lake where the population was estimated at 2,681 individuals, and the downstream reach from Smoky Lake to the Alberta border where the population was estimated at 3,673 individuals (Hegerat and Paul 2013). White (2015) noted these population estimates, derived from

the North Saskatchewan River mark-recapture data, should be interpreted with caution because of the relatively low recapture rate. The most recent population estimate in 2011 from the vicinity of the Forks including the lower stretches of the North and South Saskatchewan rivers and the Saskatchewan River up to Codette Lake was 4,197 adults (Pollock 2012).

South Saskatchewan River upstream of Coteau Creek HS (MU2)

Little historical abundance information is available from this MU. Lake Sturgeon are currently found throughout this MU in the South Saskatchewan River, the Oldman River, Red Deer River and the Bow River up to the dams that prevent upstream passage (Saunders 2006). A Lake Sturgeon was captured in a golf course pond in Red Deer, Alberta in 2010, but it is unknown if this fish came from the Red Deer river near this location; if so, this would represent the farthest upstream location of Lake Sturgeon occurrence recorded in this river (ALSRT 2011). In the Saskatchewan portion of the South Saskatchewan River, most reports of Lake Sturgeon come from the area near Leader, Saskatchewan (Smith 2003).

The most recent population estimate for the South Saskatchewan River from the confluence of the Bow and the Oldman rivers to the Alberta border was 6,464 in 2012, using tagging information obtained by angling from 2003–2012 (Paul 2013). However, similar to above, White (2015) cautions interpretation of these data given the low recapture rate.

Saskatchewan River Nipawin HS to E.B. Campbell (MU3)

There is no historic information specific to Lake Sturgeon from the 70 river km between the Nipawin HS and the E.B. Campbell Dam, however, this reach has been used as a source for eggs and milt for stocking initiatives (Ron Hlasny, pers. comm.).

There have been no population estimates derived for this MU, and the population trajectory was classified as unknown in 2010 by Cleator et al. (2010b). A spawning study was conducted immediately downstream of the Nipawin HS in 2014 which indicated Lake Sturgeon spawn downstream of the dam (Gillespie et al. 2015). Movements of 12 adult Lake Sturgeon were monitored from 2013–2015 in this reach. Lake Sturgeon were detected as far upstream as the Nipawin HS and moved only as far downstream as 15 km upstream of E.B. Campbell Spillway (McDougall et al. 2016).

E.B. Campbell to Cedar Lake (MU4)

Lake Sturgeon were historically found in Saskatchewan at Cumberland Lake, the Torch River, the Tearing River, and at Namew Lake. Downstream, in Manitoba, Lake Sturgeon were present from the border to the Grand Rapids GS at Lake Winnipeg (Cleator et al. 2010b). Populations were thought to be large prior to the commercial fishery.

Telemetry and mark-recapture studies have suggested Lake Sturgeon used the entire 240 km long stretch of this MU (Wallace 1999). Lake Sturgeon are known to spawn in the E.B. Campbell tailrace (Gillespie et al. 2015) and other suspected spawning locations include the Bigstone Rapids, the Torch River, the

Missipuskiow River, the Mossy River, and islands in the north end of Cumberland Lake (Wallace 1999; Smith 2003). The Saskatchewan River between E.B. Campbell dam and Lake Winnipeg (Grand Rapids GS) has been managed since 1994, and there is an extensive mark-recapture study which suggests the population is increasing. The population estimate based on mark-recapture data from 1994 to 2014 indicates the population increased over the 20 year period with a current estimate of 3,099 adults (Nelson 2015). Nelson (2015) also suggested that juveniles may be more abundant in the downstream reaches of this MU based on the spatial distribution of the Lake Sturgeon catch (i.e., juveniles more frequently captured in the downstream reach). A focused juvenile assessment during fall of 2015 found more juveniles in the vicinity of Cumberland House, however, juveniles were captured all the way downstream as far as Cedar Lake with annual, but variable recruitment similar to other Lake Sturgeon populations (Nelson and Johnson 2016).

In summary, Lake Sturgeon abundance in the Saskatchewan River has been extensively studied over the last few decades. Population estimates have been derived annually in the North and South Saskatchewan rivers in AB as part of a province-wide Lake Sturgeon management initiative. Although little is known about the historical abundance, it is clear that populations in AB are increasing. In Saskatchewan, between AB and Tobin Lake Sturgeon have been studied annually since 2009 and data suggest a robust and highly mobile population inhabits MU1 with evidence some of the Lake Sturgeon migrate as far upstream as Drayton Valley, west of Edmonton, AB on the North Saskatchewan River. The Saskatchewan River between E.B. Campbell dam and Lake Winnipeg has been managed since 1994, and there is an extensive mark-recapture study which suggests the population is increasing. Microsatellite genetics analysis suggests that prior to fragmentation there was extensive mixing among the MUs. The current distribution appears to have been affected by fragmentation, with evidence of juvenile concentrations in the upper extents of reservoirs where riverine habitat transitions to a slower, more lacustrine environment.

Assiniboine and Red River Drainages

Based on barriers to upstream Lake Sturgeon movement, the Red and Assiniboine river drainages were divided into three distinct MUs (Figure 5):

- Assiniboine River and tributaries upstream of the Portage la Prairie Diversion Control Structure (MU1);
- Red River and tributaries upstream of Lockport, including the Assiniboine River to Portage la Prairie Diversion Control Structure (MU2); and
- Red River downstream of Lockport (MU3)

Assiniboine River upstream of the Portage la Prairie Diversion Control Structure (MU1)

The Assiniboine River flows approximately 1,270 km from its origin in Preceville, Saskatchewan to its confluence with the Red River in Winnipeg, Manitoba (Andres and Thompson 1995). Substantive

tributaries such as the Qu'Appelle, Little Saskatchewan, and Birdtail rivers all have dams which prevent fish movement from the lower reaches to the upstream reaches (MCWS 2012). The Shellmouth Dam (est. 1970) controls the base flow of the Assiniboine River for the last 966 km from Shellmouth Dam to Winnipeg and forms the upstream boundary of MU1 as it prevents fish movement into the upper Assiniboine River. The Portage la Prairie Diversion (est. 1970) was built for flood control, diverting water from the Assiniboine River into Lake Manitoba, providing Lake Sturgeon a one-way direct route into Lake Manitoba, where they were not historically known (MCWS 2012). The Assiniboine River is generally shallow (depths <10 m), with sections of high and moderate velocities restricted to areas where the river flows over the glacial till plain. The dominant habitat feature is alluvial substrates with alternating sequences of shallow inside bends and deeper outside bends. For the purposes of this assessment, the river classifies as Prairie habitat.

Historically, Lake Sturgeon were found in the Assiniboine River and its tributaries (Cleator et al. 2010d). It is thought commercial harvest occurred in the river in the late 1800s to early 1900s, however, harvest quantities were likely recorded as Lake Winnipeg production. The dam constructed at Lockport in 1910 may also have influenced Lake Sturgeon abundance in the river, assuming individuals moved between Lake Winnipeg and the Assiniboine River prior to its construction.

Lake Sturgeon were believed to be completely extirpated from the Assiniboine River circa 1970 (Cleator et al. 2010d). In efforts to establish a population, approximately 16,683 Lake Sturgeon (4,000 fry; 12,416 fingerlings; 205 yearlings; 55 juveniles; 7 adults) were stocked into the Assiniboine River near Brandon (upstream of the Portage Diversion) between 1996 and 2008. Angler reports suggest the stocked fish have dispersed throughout much of the river, having been captured as far upstream as the Qu'Appelle River in Saskatchewan, and downstream as far as Spruce Woods Provincial Park (MCWS 2012). In addition, two incidental captures of Lake Sturgeon have been reported from Lake Manitoba in the past few years, which likely moved into the lake from the Assiniboine River via the Portage la Prairie Diversion channel. From 1998 to 2002, anglers fishing in the Assiniboine River reported 280 capture events to MCWS (COSEWIC 2006). In 2013, a Lake Sturgeon inventory was conducted in the Assiniboine River to determine the success of the stocking effort. Twenty-three juveniles (427–531 mm fork length) and 7 adults (820–1,040 mm) were captured in two deeper (2.5–6.0 m) areas of the river downstream of the Brandon industrial sector (Aiken et al. 2013).

In summary, the abundance of Lake Sturgeon in the Assiniboine River is largely unknown, however, it is believed to be increasing in the lower reaches due to stocking efforts in Minnesota (discussed below) and in the upper reaches due to stocking in Manitoba. To date, there is no conclusive evidence of stocked fish reproducing in the river; however, based on size, at least some of the fish stocked into the upper Assiniboine River are nearing sexual maturity.

Lower Assiniboine River and Red River (MU2 and MU3)

The last approximately 160 km of the Assiniboine River is very shallow and dominated by long shallow stretches of sand, with a few localized reaches of exposed till. The headwaters of the Red River are

located in North Dakota. The river flows 885 km north from the confluence of the Bois de Sioux and Otter Tail rivers (Rosenberg et al. 2005), crossing the border at Emerson, Manitoba, before emptying into Lake Winnipeg. The St. Andrews Lock and Dam (est. 1910) is the only dam on the Red River mainstem in Canada. It likely acts as a barrier to upstream movement, as the fishway does not facilitate upstream sturgeon passage (MCWS 2012). Red River thalweg depth is highly variable, with shallower depths generally characteristic of the upstream portions of the river. The river contains sections of high, moderate and low velocities, with habitats (inside and outside bend) characteristic of a meandering Prairie River. The river carries a high sediment load and as such, fine silt/clay substrates are common with interspersed reaches of exposed till.

Little historical information exists for the Assiniboine River between Portage la Prairie Dam and its confluence with the Red River at Winnipeg. Lake Sturgeon have recently been caught by anglers on the Assiniboine River within the Winnipeg city limits, and it is believed that at least some of these fish have dispersed into Canada from annual stocking efforts in the Minnesota portion of the Red River. Similar to the Assiniboine River, the historical abundance of Lake Sturgeon in the Red River is poorly understood, as commercial catch data were not recorded specifically from the Red River. Cleator et al. (2010d) suggested that historically Lake Sturgeon from Lake Winnipeg moved up the Red River to spawn at Lister Rapids, and other smaller tributaries such as the Roseau River. The construction of St. Andrews Lock and Dam, located approximately 40 km upstream from Lake Winnipeg, restricted movements of Lake Sturgeon upstream of St. Andrews. Lake Sturgeon were considered extirpated from the Red River by the mid-1900s (Cleator et al. 2010d).

The current abundance of Lake Sturgeon in the Red River is poorly understood as there has been no directed Lake Sturgeon research conducted in the Manitoba portion of the Red River (MU2 and MU3) in recent years. Since 1997, stocking has been undertaken throughout the Red River system in Minnesota by the Minnesota Department of Natural Resources (MN DNR) and the White Earth Nation. Between 1997 and 2013 there were a total of 375 juveniles, 4,402 yearlings, 344,593 fingerlings, and 1,616,945 larvae stocked into 15 waterbodies with 791,550 of the larvae being stocked into the Roseau River immediately upstream of the Canadian border (MN DNR unpublished data). Recaptures of tagged individuals linked to stocking events in Minnesota have occurred in the Red River in Manitoba, both upstream and downstream of Lockport, and in Lake Winnipeg (MCWS 2012). In 2005, two juvenile Lake Sturgeon were captured in hoop nets set at the City of Winnipeg floodway inlet control gates (Graveline and MacDonell 2005). A large adult-sized Lake Sturgeon was observed during electrofishing at St. Vital Park boat launch in spring 2012 (Doug Watkinson, DFO, pers. comm.). Angler reports of Lake Sturgeon captures in the Red River both upstream and downstream of Lockport have also increased over the last decade. Some of these are known to be fish that were stocked into Minnesota waters.

In summary, the abundance of Lake Sturgeon in the Red River is largely unknown, however, it is apparent the stocking efforts in Minnesota over the last two decades have increased encounters of Lake Sturgeon both upstream and downstream of Lockport. To date, there is no conclusive evidence of

stocked fish reproducing in the river; however, there is evidence stocked fish are nearing the size associated with sexual maturity.

Lake Winnipeg East Side Tributaries Upstream of Impassable Barriers

Several unregulated tributaries flow east into Lake Winnipeg and are known to contain Lake Sturgeon populations. These include the Bloodvein, Pigeon, Berens and Poplar rivers (Figure 5; Cleator et al. 2010d). These tributaries are typified by a mixture of riverine and lacustrine habitats that contain numerous falls and rapids (Figure 5). With the exception of the Ontario portion of the Berens River system, these rivers have not been subject to commercial harvest or affected by industrial development (MCWS 2012). According to Dick (2006) subsistence harvest is known to occur in each tributary, however, the only population estimate comes from the Round Lake portion of the Pigeon River which was estimated to have a population of 800–1,000 fish, with very few spawning females. The only recent information comes from a small section of the Pigeon River, 8 km upstream of Lake Winnipeg, where two juvenile sturgeon (4 and 7 years of age) were captured as part of a fisheries assessment conducted in 2015 (NSC unpublished data). These two captures indicate recruitment due to spawning in the upper reaches of the Pigeon River is occurring, however, the low catch-per-unit-effort (CPUE) value (0.01 sturgeon/100 m/24 hr) suggests low abundances at least in the river section sampled (NSC unpublished data). Finally, Haxton et al. (2014b) sampled the upper Berens River in Ontario with large and extra-large mesh in 2010. In total, 11 Lake Sturgeon were captured, in 11 and 9 overnight sets in large mesh and extra-large mesh, respectively.

In summary, very little is known with respect to Lake Sturgeon abundance and population trajectories in Lake Winnipeg's east side tributaries.

Winnipeg River-English River

The Winnipeg River has a drainage basin of 135,800 km^2, the majority of which lies in the province of Ontario and the state of Minnesota (Figure 6; Rosenberg et al. 2005). Originating at the outlets at Lake of the Woods, Ontario, it flows 260 km prior to emptying into Lake Winnipeg. Historically, the river was defined by a series of deep shield lakes, connected by riverine sections of varying length. The Winnipeg River plunges 105 m over its course, and much of the drop occurrs at the sites of large falls and rapids (Johnston 1915). Nine hydroelectric stations have been built on the Winnipeg River, three in Ontario: the Norman Dam, Kenora Dam, and the Whitedog Falls GS and six in Manitoba: the Pointe du Bois, Slave Falls, Seven Sisters, MacArthur Falls, Great Falls and Pine Falls GSs.

The English River joins the Winnipeg River in Tetu Lake, flowing 615 km from its headwaters near Thunder Bay, Ontario, draining an area of 52,000 km^2 (Rosenberg et al. 2005). The entirety of the English River system lies in the heart of the Boreal Shield, so the character of the river is largely consistent with that of the Winnipeg River. Hydroelectric stations on the English River include Caribou Falls, Manitou Falls and Ear Falls. The Wabigoon River is a tributary to the English River.

For the purposes of this assessment, the Winnipeg River was partitioned into nine MUs. These are consistent with the recovery potential assessment for the Winnipeg/English rivers (Cleator et al. 2010e). MUs 1–6 are within the heart of the Boreal Shield, and are defined by stepped gradient habitat due to the presence of both falls/rapids, and hydroelectric generating stations. In these systems, a diversity of aquatic habitats tend to occur over small spatial scales. MUs 7–9 are located further downstream, in the transition zone between Boreal Shield and the Interior Plains, and while their riparian character is somewhat different than the MUs located farther upstream in the watershed, they still classify as stepped-gradient habitat. Hydroelectric generating stations generally delineate the following Winnipeg/English River MUs (Figure 6):

- Wabigoon River (MU1) – the main tributary of the English River;
- English River: Manitou Falls GS–Caribou Falls GS (MU2). Includes a chain of seven lakes and spans a distance of 142 km;
- Winnipeg River: Norman GS–Whitedog Falls GS (MU3). A 45 km reach that contains a mixture of riverine and lake/reservoir habitats;
- Winnipeg/English River: Caribou Falls GS and Whitedog Falls GS–Pointe du Bois GS (MU4). An 81 km reach of river/lake/reservoir of which 46 km is located in Manitoba and 35 km in Ontario;
- Winnipeg River: Pointe du Bois GS–Slave Falls GS (MU5). A small reservoir reach 10 km long;
- Winnipeg River: Slave Falls GS – Seven Sisters GS (MU6). A 41 km reach defined by a series of upstream lakes and a downstream reservoir separated by hydraulic gradients of low to moderate severity;
- Winnipeg River: Seven Sisters GS – MacArthur GS (MU7). A 35 km reach, riverine at first and then widening to form Lac du Bonnet;
- Winnipeg River: MacArthur GS–Great Falls GS (MU8). A small reservoir reach, only 8.5 km long; and
- Winnipeg River: Great Falls GS–Pine Falls GS (MU9). A 20 km reach consisting of a mix of riverine and reservoir habitat.

Although specific harvest locations are largely unknown, the Manitoba portion of the Winnipeg River was subject to a large commercial harvest (Stewart 2009). Stewart (2009) reported an initial Lake Sturgeon harvest of 78,835 kg taken from the Winnipeg River in 1910/11, and Harkness (1980) reported that this catch came from Lac du Bonnet. Harvest was also reported from 1930 to 1948 (135,437 kg), and again from 1957 to 1960 (28,799 kg) (Stewart 2009). A conservation closure on sturgeon harvest (including for subsistence) was invoked from the Manitoba/Ontario border downstream to the Pine Falls

GS in 1994. Although contemporary poaching is known within Manitoba, the rate is believed to be relatively low (D. Kroeker, MCWS, pers. comm.).

There are no records of historical harvest from the English River (D. Brunner, OMNRF, pers. comm.).

English and Wabigon rivers upstream of Caribou Falls GS (MU1 and MU2)

The Wabigoon River flows 235 km from Raleigh Lake to its confluence with the English River, passing through several lakes including Dinorwic, Wabigoon, Clay, and Ball. The Wainwright GS (est. 1925), near Dryden, Ontario is located downstream of Wabigoon Lake.

Focused Lake Sturgeon studies have not been conducted in the Wabigoon River (MU1) and, there are no confirmed current or historical records of Lake Sturgeon occurring in the river.

Little information exists for MU2, although Lake Sturgeon are known to be present. The reach was sampled briefly by the OMNRF in 2011 and 2012 for the purpose of collecting genetic samples; Lake Sturgeon were captured with relative ease and both juveniles of several age classes and older fish were represented in the catch (J. Peacock, OMNRF, pers. comm).

At present, minimal sampling related to Lake Sturgeon has been conducted in MU1 and MU2. Although Lake Sturgeon are recruiting in MU2, little can be said about adult or juvenile abundance, and the trajectory of the population.

Norman/Kenora dams to Whitedog Falls GS (MU3)

The reach of the Winnipeg River between Norman and Kenora Dams to the Whitedog Falls GS is approximately 45 km long and contains a mixture of lotic and lentic habitats. Flows leave Lake of the Woods via two channels; the east channel is the site of the Kenora Dam and the west channel is the site of the Norman Dam. No significant falls or rapids occur contemporarily between the outlets of the Lake of the Woods and the Whitedog Falls GS.

Extensive gillnetting surveys were conducted in MU3 during 2008 to assess adult and juvenile abundance; only one adult Lake Sturgeon was captured (Duda 2008). More recently, in 2014, the reach was once again sampled using standard gillnet methods for adults and juveniles. Despite considerable effort, only two Lake Sturgeon were captured (Johnson et al. 2014). Another Lake Sturgeon approximately 600 mm FL was reported captured by a commercial fisherman. Ceremonial releases of hatchery reared Lake Sturgeon have occurred within the reach, and therefore it is possible that this fish linked back to those stocking events (J. Peacock, OMNRF, pers. comm.). This lone juvenile aside, there have been no signs to suggest contemporary recruitment within MU3, and the adult stock appears to be at remnant levels (COSEWIC 2017).

Whitedog Falls GS and Caribou Falls GS to the Pointe du Bois GS (MU4)

The Whitedog Falls GS is located on the Winnipeg River approximately 65 km downstream of Lake of the Woods. The Caribou Falls GS is located on the English River approximately 8 km upstream of Tetu

Lake, the location where the Winnipeg and English rivers converge. From Whitedog Falls GS, the river moves slowly for 48 km, through Tetu Lake and Eaglenest Lake prior to hastening at the Pine Island narrows. It continues as river proper for approximately 16 km, prior to slowing immediately downstream of Lamprey Rapids (formerly Lamprey Falls) as the backwatering from the Pointe du Bois GS, located 12 km further downstream, becomes influential. All told, MU4 measures approximately 80 km, and provides a diversity of aquatic habitats.

While harvest records are largely uninformative on the MU scale, Eaglenest Lake was at one time reported to be the best sturgeon fishing ground in southern Manitoba (McLeod 1943). Furthermore, as recently as the 1970s, large quantities of Lake Sturgeon were domestically harvested from Eaglenest Lake (B. Burgess, Pine Island Lodge owner, pers. comm.).

Lake Sturgeon studies focused on both spawning adults and juveniles were conducted on the Ontario side of MU4 from 2007–2012 (Duda 2008; 2009; Peacock 2014), and 2014 and 2015 (McDougall and Barth 2015; Henderson et al. 2015c). Numerous studies have also been conducted on the Manitoba side since 2007 (McDougall et al. 2008a; 2008b; McDougall and MacDonell 2009; Koga and MacDonell 2011; CAMP 2014; Henderson and McDougall 2015). The synthesis of data suggests that a population is actively recruiting as a result of spawning downstream of the Caribou Falls GS, with minimal contribution resulting from spawning below the Whitedog GS, Boundary Falls or Lamprey Rapids (Peacock 2014; McDougall and Barth 2015; Henderson and McDougall 2015). Adult population estimates have never been derived for the reach, but cumulative results from the past 10 years indicate adult abundance is low, while juvenile abundance is low-moderate, owing to a few strong year-classes produced since 2002 (Peacock 2014; McDougall and Barth 2015; Henderson and McDougall 2015). In a recent spawning study conducted in spring 2015, non-spawners of borderline adult size dominated the catch, suggesting that significant gains to the adult population may be imminent, likely related to the recruitment of the strong 2002 cohort (Henderson et al. 2015c).

At present, adult and juvenile abundance within the MU are believed to be low and moderate, respectively (COSEWIC 2017).

Pointe du Bois GS to the Slave Falls GS (MU5)

The Pointe du Bois GS to Slave Falls GS reach of the Winnipeg River is approximately 10 km long. The reach is characterized by three basins, each 2–6 km in length, separated by two shallow narrow constrictions that occur at the sites of now inundated falls (Eight Foot Falls and Old Slave Falls; Johnston 1915). In general, low-moderate velocities and deep water dominate the reach. Little is documented about Lake Sturgeon abundance and population trends in this reach prior to the early-1990s, and it is unknown if sturgeon were commercially harvested from the reach. It is suspected access would have been limited prior to construction of the railway leading to the Pointe du Bois GS in approximately 1900; further, the reach would have been historically difficult to navigate prior to backwatering from the Slave Falls GS (est. 1928).

The first population estimate was conducted during the mid to late 1990s, and although confidence intervals were wide, mean annual estimates suggested that 360–1,100 adults existed in the reach (Block 2001). Since then, Lake Sturgeon have been the focus of extensive environmental monitoring in relation to the Pointe du Bois GS Spillway Replacement Project (e.g. McDougall et al. 2008a; 2008b; 2014c; McDougall and MacDonell 2009; Koga and MacDonell 2011; 2012; Gillespie and MacDonell 2013; 2015; Koga et al. 2013; Henderson et al. 2014a; Lacho et al. 2015b). In addition, academic research within the reach has focused on susceptibility of Lake Sturgeon to Slave Falls GS entrainment (McDougall 2011a; McDougall et al. 2013; 2014a; 2014c; 2014d). Mark-recapture gillnetting targeted the adult population between 2006 and 2009. The most recent POPAN analysis produced mean annual estimates of 2,323–2,929 adults (>800 mm FL) for 2008 and 2009 (Table 1; McDougall et al. 2017a). Juveniles are abundant within the reach, and the most recent POPAN analysis based on juvenile gillnetting conducted from 2012–2015 yielded mean estimates of 6,962 and 7,547 fish <800 mm FL (juvenile) being present in 2013 and 2014, respectively (McDougall et al. 2017a).

At present, abundance of adult and juvenile Lake Sturgeon in MU5 is high and very high, respectively (COSEWIC 2017). It is suspected that the small reservoir may be at or near carrying capacity.

Slave Falls GS to Seven Sisters GS (MU6)

The Slave Falls GS to Seven Sisters GS reach is approximately 41 km long, and is characterized by a series of shield lakes separated by short riverine sections. Backwatering from the Seven Sisters Falls GS has caused some flooding in the lower 16 km, however, the character of the river (alternating riverine and lacustrine sections) is similar to what it was historically (Johnston 1915). The Whiteshell River is a significant tributary entering the middle of the reach with habitat in the upstream portion of the reach largely unaltered.

A long-term monitoring program was initiated in this reach by Manitoba Fisheries Branch during the early 1980s. Focusing exclusively on Nutimik and Numao Lakes during early summer, Jolly-Seber estimates based on Lake Sturgeon susceptible to capture in 5.5, 9 and 12” meshes from 1993 to 1999 ranged from 3,333 to 10,571 fish (Block 2001; MCWS 2012). Contemporary estimates based on POPAN models have examined all fish captured in the same gear, as well as only Lake Sturgeon >800 mm. From 2007 to 2014, mean estimates for fish >800 mm FL have ranged from 4,391 to 9,919 (D. Kroeker, MCWS, pers. comm.). Wide confidence intervals are assumed to be influenced by the relatively low rate of recaptures, as opposed to actual dramatic fluctuations in adult population sizes (McDougall et al. 2017a). Considering all fish susceptible to 5.5, 9 and 12” meshes (consistent effort and locations sampled since the 1990s), mean annual estimates for 2007 to 2014 have ranged from 21,418 to 34,960 Lake Sturgeon (D. Kroeker, MCWS, pers. comm.). It should be reiterated long term monitoring focuses exclusively on Nutimik and Numao Lakes, but Lake Sturgeon are known to utilize other sections. Much academic research has been conducted within the reach (Barth 2011; Barth et al. 2009; 2011; 2013; Labadie 2011; Sparks 2011; Henderson 2013; Klassen 2014; Barth and Anderson 2015; McDougall et al. 2017a; 2018). The cumulative results corroborate Lake Sturgeon abundance is high and that there is ongoing recruitment. For example, Barth et al. (2011) captured and tagged >2,400

individuals in the Slave Falls GS to Scott Rapids section from 2006 to 2008. Given juvenile Lake Sturgeon display highly restricted movement patterns within the Winnipeg River (Barth et al. 2011; McDougall et al. 2013), and these fish are outside the area sampled by Manitoba Fisheries Branch , large quantities of fish have not been accounted for in the long term population estimates presented above.

At present, abundance of both adult and juvenile Lake Sturgeon within MU6 is very high (COSEWIC 2017). Recent increases in population estimates seem to largely be attributable to the Conservation Closure invoked in 1994 (D. Kroeker, MCWS, pers. comm.).

Seven Sisters GS to MacArthur GS (MU7)

The Seven Sisters GS to McArthur GS reach of the Winnipeg River is approximately 35 km long. The upper 20 km is riverine. Lac du Bonnet, a large lake of moderate depth, dominates the lower portion of the reach. Two significant tributaries, the Whitemouth River and Bird River, as well as the Pinawa Channel (a semi-natural diversion) empty into the reach. As previously discussed, Harkness (1980) reported the 1910/1911 commercial harvest of 78,835 kg came from Lac du Bonnet, suggesting a very large population existed in this MU historically.

Although a formal population estimate has never been derived, based on angler captures, academic research, and results of unpublished MCWS experimental netting programs, the adult population is likely comprised of at least several hundred individuals (Hrenchuk 2011; Struthers 2016; D. Kroeker pers. comm.). For example, during spawning studies conducted at the base of the Seven Sisters GS and juvenile studies conducted within the riverine portion of the reach between 2010 and 2011, over 500 adults and 550 juveniles were captured (C. Hrenchuk, North/South Consultants, pers. comm.). Gillnetting conducted in MU7 during summer 2015 using 1.5, 5, 9, and 12” meshes yielded >200 captures in 48 overnight sets, with a wide variety of size and age classes being represented (D. Kroeker, pers. comm.).

At present, abundance of adult and juvenile Lake Sturgeon within MU7 is believed to be moderate and high, respectively (COSEWIC 2017).

MacArthur Falls GS to Great Falls GS (MU8)

The McArthur HS–Great Falls GS reach of the Winnipeg River is approximately 8.5 km long, making it the smallest Winnipeg River impoundment. Habitat is somewhat more riverine upstream of the now inundated Grand du Bonnet Falls, but the backwatering influence of the Great Falls GS extends to the base of McArthur Falls. Deepwater habitat is abundant, but perhaps most notably, no large sand dominated patches were located during recent habitat surveys (Murray and Gillespie 2011).

Little is known about the abundance of Lake Sturgeon in this reach historically.

Experimental gillnetting below McArthur Falls in 2003 yielded a total of two Lake Sturgeon in five net sets (D, Kroeker, MCWS, pers. comm.). More recently, general inventories, spawning studies, and targeted juvenile investigations have been conducted (McDougall 2011b; Murray and Gillespie 2011;

Henderson and McDougall 2012; McDougall and Gillespie 2012). Twelve adults were captured in 13 large mesh (8, 9, 10 and 12") sets during summer/fall 2010 (Murray and Gillespie 2011), and 14 adults were captured in nine overnight sets downstream of the McArthur Falls GS during the 2011 spawning period (Henderson and McDougall 2012). During fall 2011, 88 juveniles representing several cohorts were captured in 16 juvenile gangs set in deep-water habitats (McDougall 2011b; McDougall et al. 2014c). While immigration from upstream is possible, it was reasoned that in-situ recruitment is probably occurring. In fall 2015, 9 and 12" meshes were set for the purposes of collecting genetic samples; 10 net sets yielded three adults, including one tagged upstream in Lac du Bonnet (K. Kansas, pers. comm.).

At present, the abundance of adult and juvenile Lake Sturgeon within MU8 is believed to be very low and moderate, respectively (COSEWIC 2017).

Great Falls GS to Pine Falls GS (MU9)

The Great Falls to Pine Falls GS reach of the Winnipeg River is 20 km long. The backwater influence from the Pine Falls GS extends approximately 16 km upstream, to the base of White Mud Falls, upstream of which the reach is highly riverine. Significant hydraulic gradients still occur at Silver Falls and White Mud Falls under high-flow conditions, but not at Maskwa Rapids. The upper 4 km of the reach is riverine.

Little is known about Lake Sturgeon populations in this reach historically. Gillnetting investigations conducted at White Mud Falls in 2003 found some evidence successful reproduction and recruitment was occurring (K. Kansas, pers. comm.). As noted by Cleator et al. (2010e) gillnetting conducted upstream of the Pine Falls GS as part of environmental monitoring also captured several Lake Sturgeon.

Studies conducted since 2010 have improved the understanding of populations within the MU9 reach of the Winnipeg River (McDougall 2011b; Murray and Gillespie 2011; Henderson and McDougall 2012; McDougall et al. 2014b). Twenty-seven Lake Sturgeon were captured in 20 large-mesh gangs set during summer/fall 2010 (Murray and Gillespie 2011), while investigations during the 2011 spawning season produced 109 adults in 20 sets (Henderson and McDougall 2012). In fall 2011, 17 juvenile gangs were set yielding 88 juveniles and eight adults (McDougall 2011b).

At present, abundance of adult and juvenile Lake Sturgeon within MU9 is believed to be low and high, respectively (COSEWIC 2017).

In summary, Lake Sturgeon populations are highly variable in the Winnipeg River drainage. In MU1 and MU2, little is known about present or historical populations. In MU3, the population is virtually extirpated. In MU4, Lake Sturgeon exist at low abundances and may only spawn at one location in the MU. In MU5 and MU6, populations are large and appear to be increasing. Finally, in MU's 7, 8 and 9, Lake Sturgeon exist at low abundances and little is known about the trajectory of these populations.

Lake of the Woods/Rainy River

The Rainy River – Lake of the Woods system consists of numerous lakes and rivers located throughout northwestern Ontario and parts of northern Minnesota (Figure 7). Large lakes include Lac la Croix, the Namakan Reservoir, Rainy Lake, and Lake of the Woods. The region is connected via two main rivers: the Namakan River which connects Lac la Croix with the Namakan Reservoir and Rainy Lake, and the Rainy River which connects Rainy Lake with Lake of the Woods. Previously referred to as DU6, the Rainy River – Lake of the Woods system is broken into five management units for the purpose of this assessment:

- Sturgeon Lake–Lac la Croix system (MU1) – includes the Maligne River connecting Sturgeon Lake and Lac la Croix;
- Namakan River (MU2) – a 30 km long stretch of river including three small lakes connecting Lac la Croix and the Namakan Reservoir;
- Namakan Reservoir (MU3) – the 260 km^2 reservoir includes five lakes: Kabetogama, Namakan, Sand Point, Crane, and Little Vermilion lakes as well as their associated tributaries;
- Rainy Lake–Seine River (MU4) – Rainy Lake from the dam at the outlet of the Namakan Reservoir to the Fort Frances GS at the Inlet of the Rainy River. This MU also includes the Seine River from Sturgeon Falls GS to Rainy Lake; and
- Rainy River from Fort Frances GS to the outlet of Lake of the Woods (MU5) – the 3,850 km^2 Lake of the Woods including the 131 km long Rainy River downstream of Fort Frances GS.

Lake Sturgeon within the Rainy River – Lake of the Woods system were subjected to high commercial fishing pressures in the late 1800s and early 1900s. The commercial fishery on Lake of the Woods alone accounted for 39% of the total sturgeon catch in Ontario in 1895. Fisheries on the other major lakes and rivers in the region (Lac la Croix, Namakan Reservoir, Rainy Lake) were not as large but still had major impacts on Lake Sturgeon stocks (Harkness and Dymond 1961). Commercial harvest is no longer permitted in the region and the level of subsistence fishing is unknown.

Sturgeon Lake – Lac la Croix System (MU1)

Sturgeon Lake has a surface area of 41 km^2 and is connected to Lac la Croix by the Maligne River. It is a large mesotrophic lake in the boreal shield characterized by deep basins and shallow bays (Solomon and Baljko 2011). Two dams were constructed on the Maligne River (in 1873 and 1930), with only one remaining presently. There are no records of commercial harvest on Sturgeon Lake, however, the lake did support a small subsistence fishery (Solomon and Baljko 2011). Although commercial harvest did not occur on Sturgeon Lake, licenses were issued for the Maligne River from 1959 to 1968, which may have affected the population. CPUE data suggest that adults were moderately abundant, while work on the juvenile segment of the population has not been conducted (Solomon and Baljko 2011). A population estimate suggests the population is comprised of 2,048 individuals. Based on the age

composition of captured Lake Sturgeon, recruitment is considered to have occurred fairly consistently over the last 50 years (Solomon and Baljko 2011). Sturgeon have also been found in nearby Wolsey and McAcree lakes but abundance is unknown (Solomon and Baljko 2011).

Lac la Croix, located downstream of Sturgeon Lake, supported a commercial sturgeon fishery from 1959 to 1968 that peaked at 5,105 kg in 1960 (catches were combined with those from Maligne River) (Solomon and Baljko 2011). The abundance of Lake Sturgeon in Lac la Croix is unknown, but the lake is believed to support a self-sustaining population (Solomon and Baljko 2011).

Namakan River (MU2)

The Namakan River is a boreal shield river (30 km long) that flows between Lac la Croix and the Namakan Reservoir. The River drains 8,860 km^2 and has a mean discharge of 109 m^3/s (McLeod 2008a). Flow from the Namakan River accounts for approximately 75% of the inflow to the Namakan Reservoir (McLeod 2008a). There are three smaller lakes located along the 30 km long river, Little Eva, Bill and Three Mile. Several sets of rapids that are potential barriers to upstream sturgeon movement exist along the Namakan River, including Snake Falls, Myrtle Falls, Ivy Falls, Twisted Rapids, Quetico Rapids, High Falls, Back Channel, Hay Rapids, and Lady Rapids (McLeod and Martin 2015).

Lake Sturgeon are known to occur throughout the Namakan River system from the outlet of Lac La Croix downstream to the Namakan Reservoir (McLeod 2008a). There is no record of commercial fishing on the Namakan River proper, however, according to Pearson (1963), a commercial pound-net fishery for Lake Sturgeon existed on both the Namakan Reservoir and Lac La Croix in the 1890s.

CPUE data from the Namakan River suggests the number of adults and juveniles in the river is high (McLeod 2008a). A population estimate was developed for Little Eva Lake in 2007 using a Chapman adjusted Peterson estimate. Little Eva Lake was estimated to have a total of 2,729 individuals measuring >1,000 mm total length (TL) with a density of 7.9 to 11.9 fish/ha (McLeod 2008b). Trembath (2013) captured 133 juvenile Lake Sturgeon in 56 net sets in Bill Lake, suggesting juveniles are moderately abundant in this section of the Namakan River. Further, Haxton et al. (2014b) captured 90 Lake Sturgeon in 106 large and 45 extra-large mesh overnight sets in the Namakan River during sampling in 2010 and 2011.

Namakan Reservoir (MU3)

The Namakan Reservoir is located downstream of Quetico Provincial Park and upstream of Rainy Lake. The 260 km^2 reservoir includes five lakes: Kabetogama, Namakan, Sand Point, Crane, and Little Vermilion as well as their associated tributaries (McLeod and Martin 2015). The Namakan Reservoir is separated from Rainy Lake by two control dams at Kettle Falls and Squirrel Falls which both regulate the water level in the reservoir (McLeod and Martin 2015).

Commercial fishing licenses existed in the Namakan Reservoir from 1916 to 2001 and harvest data was collected from 1924 to 1999 (McLeod 2008a). Total harvest from 1924 to 1999 was 33,090 kg (McLeod

2008a). A population estimate has not been developed for the Namakan Reservoir, however, gillnets set in the reservoir have been successful in capturing adult Lake Sturgeon at low abundances (Shaw et al. 2012; 2013).

Rainy Lake–Seine River (MU4)

Rainy Lake is a 920 km^2 waterbody shared between Ontario and Minnesota consisting of three large basins: the North Arm, Redgut Bay, and the South Arm (Adams et al. 2006). Of the three basins, the South Basin is the largest, covering an area of approximately 492 km^2 of which 55% is located in Canada. Dams constructed in the 1900s on the outflow of Rainy Lake and the Namakan Reservoir isolated Lake Sturgeon populations within the two waterbodies and prevented upstream movement from the Rainy River into Rainy Lake (Adams et al. 2006).

Historically, commercial harvest of Lake Sturgeon occurred throughout Rainy Lake in both Canadian (until 1990) and U.S. (until 1940) waters with catches peaking at 2,762 kg in 1959 (Canadian waters only). By 1964, harvest had declined to 1,007 kg and was almost zero from 1974–78. In Canada, from 1979–1990 catches averaged 345 kg until the closure of the fishery in 1990 (Adams et al. 2006).

A population of Lake Sturgeon still exists within Rainy Lake but it has not been studied extensively. Between 2002 and 2004, Adams et al. (2006) captured 322 Lake Sturgeon in the South Arm of Rainy Lake using gillnets (4, 4.5, 5, 6, and 7" mesh). Lake Sturgeon recruitment was found to be inconsistent, as cohort strength was variable (Adams et al. 2006). Although Adams et al. (2006) focused their work in the South Arm of Rainy Lake, Lake Sturgeon are also known to be present in Redgut Bay and the North Arm in low-moderate abundance; there has been no focused work conducted on the juvenile segment of the Rainy Lake population (Adams et al. 2006).

The Seine River originates in the Mille Lacs headwaters and flows 240 km through numerous small lakes before emptying into Rainy Lake. The Sturgeon Falls GS (est. 1926) located 45 km from Rainy Lake is the farthest downstream dam on the Seine River (McDougall and Cooley 2013). Lake Sturgeon upstream movement is restricted by Sturgeon Falls GS and focused sturgeon studies have been conducted downstream of the GS. Lake Sturgeon from Rainy Lake are known to move upstream into the Seine River in the spring to suspected spawning sites at the base of Sturgeon Falls GS. Adams et al. (2006) observed movements of adult Lake Sturgeon from the South Arm of Rainy Lake to the Seine River. In the spring of 2013, large-mesh gillnets set in the Seine River, captured 16 Lake Sturgeon with relatively little effort (McDougall and Cooley 2013). Successful recruitment is occurring due to spawning downstream of the Sturgeon Falls GS as 279 juvenile Lake Sturgeon were caught during focused juvenile studies conducted between 2012 and 2015; ages ranged from 1–8 years with several strong year-classes (Groening et al. 2015).

Rainy River from Fort Frances GS to the outlet of Lake of the Woods (MU5)

The Rainy River runs 131 km from Fort Frances, Ontario to the southeastern end of Lake of the Woods. The outflow of Rainy Lake is controlled by the Fort Frances GS which regulates the Rainy River

(Heinrich and Friday 2014). Several tributaries in both Minnesota and Ontario flow into the Rainy River and include the Big Fork, Little Fork, Black, and Rapid rivers on the Minnesota side and the Pinewood, Sturgeon, and La Vallee rivers in Ontario (Heinrich and Friday 2014). Lake of the Woods spans the Ontario/Manitoba border and is the headwaters of the Winnipeg River system. The total surface area of Lake of the Woods is 3,850 km^2 with over two thirds of the lake located in Canada (Mosindy 1987). Hydroelectric development on the Rainy River began in the early 1900s when a dam was constructed at the outlet of Rainy Lake in 1909. Further development included a pulp and paper mill at International Falls in 1907 and at Fort Frances in 1914. All pulp and paper mills discharged their effluents into the Rainy River until the 1970s (Mosindy 1987). Mosindy (1987) also cites increasing runoff, soil erosion, and siltation resulting from agriculture as having a significant impact on sturgeon spawning sites, especially in tributaries of the Rainy River.

Lake Sturgeon in Lake of the Woods were once extremely abundant and the lake was once described as the greatest sturgeon pond in the world (Evermann and Latimer 1910). Carlander (1942) summarized the commercial fishing yields from Ontario and Minnesota portions of Lake of the Woods. Commercial harvests were very large, peaking at 809,000 kg in 1893 and totalling >4 million kg from 1892–1898. Lake of the Woods accounted for 39% of all Lake Sturgeon caught in Ontario in 1895 (Harkness and Dymond 1961). However, similar to the Great Lakes, catches were not sustainable, and by the 1930s sturgeon populations declined to the point where sturgeon were virtually non-existent (Mosindy 1987). Commercial fishing for Lake Sturgeon on the American side of Lake of the Woods was closed in 1941 but continued in Canada until 1995 (OMNR 2009).

Mosindy (1987) suggested increases in the annual commercial harvest (circa 1987) provided evidence Lake Sturgeon were making a gradual recovery in Lake of the Woods. Mosindy and Rusak (1991) estimated the Lake Sturgeon population in 1990 to be 16,910 individuals >999 mm. Stewig (2005) estimated the population at 59,050 in 2004. The Chapman modification of the Petersen estimate was used by Heinrich and Friday (2014) in 2014 to estimate the abundance of adults measuring >999 mm in the Rainy River/Lake of the Woods population. For the third consecutive estimate, the abundance estimate increased to 92,286 individuals >999 mm. In addition, the number of spawning adults downstream of Fort Frances and International Falls on the Rainy River was estimated in 2012 and 2013. It was determined that fairly high numbers of Lake Sturgeon were spawning at this location with estimates of 2,635 individuals in 2012 and 3,157 (95% CI: 1,139–6,210) in 2013 (T. Pratt, pers. comm.). Heinrich and Friday (2014) suggested the Lake Sturgeon population within Lake of the Woods/Rainy River is in a continued state of recovery and the population is increasing steadily.

In summary, one large Lake Sturgeon population remains in the Rainy River watershed between Fort Frances dam and the outlet of Lake of the Woods. The population in this region appears to be increasing steadily according to population estimates carried out in the area (Mosindy and Rusak 1991; Stewig 2005; Heinrich and Friday 2014). Upstream of the Fort Frances dam, Lake Sturgeon abundance is highly variable, with moderate to high abundances occurring only in a few locations. Mostly, populations are at low abundances upstream of the Fort Frances dam and several populations have been fragmented by

hydroelectric developments, where populations no longer exist upstream of the furthest downstream development.

Nelson River Drainage

The Nelson River drainage basin has a catchment area of approximately 1,093,442 km^2 (Figure 3; Rosenberg et al. 2005) stretching from the Rocky Mountains in the west, to Ontario in the east, and to South Dakota in the south. The Nelson River originates at the north end of Lake Winnipeg and flows 660 km, dropping 217 m in elevation, to its outlet at Hudson Bay (Cleator et al. 2010c). It flows through the Boreal Shield transitioning into Hudson Plain northeast of Gillam, MB (Figure 3). The Boreal Shield habitat is dominated by the alternation of riverine and lacustrine reaches separated by falls and rapids (Figure 3). The habitat in the Hudson Plain changes to strictly large riverine with a few mainstem rapids.

The Nelson River is impounded by five hydroelectric generating stations which from upstream to downstream include: Jenpeg (est. 1976); Kelsey (1957); Kettle (1966); Long Spruce (1971); and Limestone (1985) (Figure 8). An additional station is currently under construction at Gull Rapids (Keeyask GS) located between the Kelsey GS and Kettle GS. For the purposes of this assessment, the Nelson River was divided into six MUs, similar to Cleator et al. (2010c), with boundaries occurring at natural and man-made barriers:

- Playgreen Lake–Whitemud Falls (MU1);
- Whitemud Falls–Kelsey GS (MU2);
- Kelsey GS – Kettle GS; lower Burntwood River between First Rapids and Split Lake (MU3);
- Kettle GS–Long Spruce GS (MU4);
- Long Spruce GS–Limestone GS (MU5); and
- Limestone GS–Hudson Bay (MU6)

Based on Aboriginal Tradition Knowledge (ATK), early reports, and a fisheries survey from the early 1900s (Comeau 1915 in Skaptason 1926; Lytwyn 2002; FLCN 2008), Lake Sturgeon were historically abundant throughout the Nelson River. Sturgeon fishing for isinglass became an important part of regional trade economy of Aboriginal communities circa 1832 (Holzkamm and McCarthy 1988; Northern Lights Heritage 1994). The Norway House District of the Hudson's Bay Company purchased an average of 142 kg of isinglass per year for the period 1832 to 1891 (Northern Lights Heritage 1994). Given an estimated 284 kg of headless dressed sturgeon was required to produce 1 kg of isinglass (Holzkamm and McCarthy 1988), an average annual harvest of 40,450 kg sturgeon was needed to supply the isinglass trade during this period (Manitoba Hydro and the Province of Manitoba 2015).

Commercial harvest of Lake Sturgeon for shipment south began in the Nelson River in 1902 (Stewart 2009). From 1902–1905, 297,199 kg was harvested, with the largest harvest occurring in 1903 (Stewart 2009; Manitoba Hydro and the Province of Manitoba 2015). In subsequent years (1906–1910), the

Nelson River Lake Sturgeon harvest declined substantially. In 1910, a federal Royal Commission announced that sturgeon in MU1 were near extinction, resulting in complete closure of the fishery (Manitoba Hydro and the Province of Manitoba 2015). The fishery was reopened and closed several times over the next eight decades, with harvests declining in each successive opening. The Nelson River commercial fishery was closed for the last time in 1991. It should be noted the early reported harvest from the Nelson River likely came from MU1, the most upstream reach.

Upper Nelson River–Outlet of Lake Winnipeg to Kelsey GS (MU1 and MU2)

The uppermost reach of the Nelson River between Lake Winnipeg and the Kelsey GS is approximately 380 km long (Figure 14). This reach contains Playgreen and Cross lakes, two large relatively shallow lakes. Downstream of Playgreen Lake, the Nelson River branches into two channels; a western channel and an eastern channel (referred to as 'Sea River'). The eastern channel is unregulated, and contains numerous rapids including Sea (River) Falls and Sugar Falls. The eastern channel flows through Pipestone Lake, prior to merging with the western channel in Cross Lake. Two channels exit Cross Lake, and significant hydraulic gradients occur at Whitemud Falls and Eves Falls. Downstream of Whitemud and Eves falls, the two channels flow swiftly through shield bedrock, with several sets of rapids occurring prior to the channels merging in Sipiwesk Lake. Sipiwesk is a large lake characterized by irregular shorelines and a multitude of bedrock islands and reefs. Downstream of Sipiwesk, the Nelson River runs long and straight along the Molson Dyke for about 150 km prior to reaching the Kelsey GS, the furthest downstream extent of MU2. Habitat in this reach of the Nelson River is typical of large stepped-gradient rivers. MU1 and MU2 are regulated by two hydroelectric generating stations: Jenpeg GS which was built in 1976 in the western channel outlet of Playgreen Lake, immediately upstream of Cross Lake and the Kelsey GS which was completed in 1961.

Given the commercial harvest data presented above, it is clear Lake Sturgeon abundance was high in MU1 and MU2 prior to the start of the commercial fishery in 1903. The population was then subjected to three openings and subsequent closures of the commercial fishery over the next five decades. Immediately after opening for the fourth time in 1953, the first biological data (size, sex, maturity and age) were collected from the commercial harvest (McTavish 1954; Kooyman 1955; Sunde 1959). Based on these data, Kooyman (1955) believed the outlook for the population (referring to MU1 and MU2) was 'perilous'. Kooyman (1955) reported Lake Sturgeon numbers were, at best, at a quarter of their historical levels and hypothesized if Lake Sturgeon continued to be harvested at the current levels, then the fishery would quickly collapse and take a long time to recover. The fishery was subsequently closed for a fourth time in 1961.

The fishery re-opened in 1969 with reduced quotas, and it remained a marginal fishery until permanent closure in 1991. By the 1990s, it was clear the Nelson River sturgeon stocks were on the verge of collapse; MU1 populations were believed nearly extirpated, while MU2 populations were declining. For example, in MU2, a substantive Lake Sturgeon spawning run in the Landing River, a tributary to the Nelson River located downstream of Sipiwesk Lake, had been so reduced by harvest only a few adults were observed during the annual spawning run. Hundreds had been observed only a few years previous

(D. Macdonald, MCWS, pers. comm.). A Conservation Closure was invoked in the Landing River area of MU2 in 1994 to conserve sturgeon stocks (MCWS 2012).

More recently, Lake Sturgeon are believed to be virtually extirpated throughout most of MU1. For example, during fish community assessments conducted in Cross Lake between 1992 and 2008 only one Lake Sturgeon was captured despite considerable effort (Henderson et al. 2015e). To recover Nelson River populations, a stocking program was initiated in 1994 using wild brook stock captured near the mouth of the Landing River. Between 1994 and 2013, 2,444 age-1, 32,052 fingerlings and 87,700 larvae were stocked in the Sea Falls to Sugar Falls reach of the Nelson River (McDougall and Pisiak 2012). The effectiveness of the stocking program was evaluated during studies conducted in three consecutive years (2012, 2013 and 2014) (McDougall and Pisiak 2012; 2014; McDougall and Nelson 2015). Results indicated that all fish captured could be linked back to stocking events (i.e., wild fish were not captured). McDougall and Nelson (2015) suggested that although densities were low, stocking has led to the re-establishment of juvenile Lake Sturgeon in the reach of the Nelson River between Sea Falls and Sugar Falls. Also in MU1, a Lake Sturgeon spawning assessment was conducted downstream of the Jenpeg GS during spring 2014. Lake Sturgeon abundance was found to be low (mean CPUE 0.12 LKST/100m/24h) (Henderson et al. 2015e) suggesting a small population may exist downstream of the Jenpeg GS.

Farther downstream in MU2, data collected from 1993–2000 and 2006–2014 were used to derive a Peterson population estimate for adults in the vicinity of the Landing River. The population showed a decreasing trend from 1993 to 2000, but since 2006, the population appears to be rebounding, with the most recent estimate at 3,257 adult individuals (D. Macdonald, MCWS, pers. comm.). The relative abundance of juveniles in the vicinity of the Landing River was also studied in 2013 (Groening et al. 2014). Results indicated erratic recruitment was occurring in the reach, and that juvenile abundance was relatively low (mean CPUE was 1.8 LKST/100m/24 h).

In summary, Lake Sturgeon were abundant in MU1 and MU2 prior to the establishment of the commercial fishery in the early 1900s. Stocks declined over the next several decades. In 1991, the commercial fishery was closed permanently, but harvest continued to deplete populations, especially in MU2 where the spawning population in the Landing River was decimated. Hydroelectric developments were constructed in these MUs in the 1960s and 1970s; however, sturgeon populations were already so depleted by harvest the impacts these developments had on sturgeon could not be determined (Manitoba Hydro and the Province of Manitoba 2015). By 1994, efforts were initiated to recover sturgeon stocks in the Sea Falls area of MU1. Recent study has indicated a small juvenile population has been established due to stocking in this area. Further, a small reproducing population appears to be present downstream of the Jenpeg GS. In the vicinity of the Landing River (MU2), the most recent population estimate suggests an increasing population of approximately 3,300 individuals. Juveniles are also present in the Landing River reach at low abundances.

Kelsey GS to Kettle GS (MU3) includes the Burntwood River to First Rapids

The Kelsey GS to Kettle GS reach of the Nelson River is approximately 150 km in length (Figure 8). It is dominated by several large lakes (Split, Clark, Gull and Stephens) separated by high-gradient riverine sections, typical of Boreal Shield rivers. Downstream of the Kelsey GS, the Nelson River splits into two channels before emptying into Split Lake. The Burntwood and Odei rivers empty into the western arm of Split Lake. Clark Lake occurs just downstream of Split Lake and is separated from Gull Lake by an approximately 25 km long riverine section which includes a significant hydraulic drop at Long and Birthday rapids. Downstream of Gull Lake, the Nelson River again pitches at the site of Gull Rapids (the site of the Keeyask GS currently under construction), before entering Stephens Lake (the Kettle GS reservoir). Kelsey GS prevents upstream movement of Lake Sturgeon, as will the Keeyask GS once constructed.

As previously discussed, commercial harvest of Lake Sturgeon in the Nelson River began in 1902. Commercial harvest of lower Nelson River stocks (between the Kelsey GS and the Nelson River estuary) however, did not begin until the rail line was extended to Gillam in 1917 (MacDonell 1997a). The Nelson River fishery opened and closed several times until 1970, however, the proportion of the harvest that came from the different MU's of the Nelson River is not clear. In 1970 more detailed records were maintained and catches were recorded by area. From 1970–1982, only 4,305 kg were commercially harvested in the reach of the Nelson River between the Kelsey GS and Kettle GS (Patalas 1988; MacDonell 1997b).

It is now clear from Lake Sturgeon genetic analyses that three distinct populations are present in MU3 including one in the Burntwood River, one in the Nelson River below the Kelsey GS, and one in the Nelson River between Clark Lake and Gull Rapids (Gosselin et al. 2015). The study also revealed Lake Sturgeon populations in the Nelson River likely did not move upstream over the site of the Kelsey GS and the reach where the Kettle GS was built prior to hydroelectric development at these sites (Manitoba Hydro and the Province of Manitoba 2015).

Adult population estimates have been derived for all three of these populations based on mark-recapture data collected since 2001 (Nelson and Barth 2012; Hrenchuk et al. 2015; Henderson et al. 2016b). The 2015 population estimate for the Nelson River in the vicinity of the Kelsey GS was 426 individuals (Henderson et al. 2016b). For the Burntwood River, the population estimate in 2015 was 570 individuals (Henderson et al. 2016b). For the Nelson River between Clark Lake and Gull Rapids, the 2014 population estimate was 596 individuals (Hrenchuk et al. 2015). There is no clear increasing or decreasing trend for any of these populations.

Studies focused on juvenile Lake Sturgeon from each of these three populations suggest juveniles are present at low-moderate abundances (MacDonald 2008; 2009; Michaluk and MacDonald 2010; Henderson et al. 2011; 2013; 2015a; Henderson and Pisiak 2012). Juveniles were found to be moderately abundant in the Nelson River between Birthday and Gull Rapids, and considered to be in low abundance in the Nelson River in the vicinity of the Kelsey GS, the Burntwood River and in

Stephens Lake. Recruitment to Nelson River populations is considered erratic based on the finding that only one strong year class (2008) has been observed over an 11-year period from 2002–2012 in Gull and Stephens lakes (Henderson et al. 2015a). A stocking program (25 year commitment) was initiated in 2013 to mitigate potential effects of the construction of the Keeyask GS (Klassen 2015).

In summary, the Lake Sturgeon populations in MU3 are among the most well studied populations in Canada. Adult abundance is considered to be low for each population, with low-moderate numbers of juveniles. Recruitment is occurring within each population, however, recruitment is highly erratic especially in the Clark Lake-Stephens Lake population where one strong cohort (2008) has dominated the catch since 2008 (COSEWIC 2017). The populations have been assessed as stable, with no clear trend in abundance being evident (Nelson and Barth 2012).

Long Spruce and Limestone reservoirs (MU4 and MU5)

The Long Spruce and Limestone reservoirs, MU4 and MU5, are 16 and 23 km long, respectively. Both reservoirs are characterized by a riverine upstream section and downstream portions that are more lacustrine-like due to backwatering from the downstream GS. Little is known about Lake Sturgeon in either reservoir reach prior to 1985, but based on the high gradient of the reaches and habitat preferences of Lake Sturgeon, it would be expected numbers would be small.

Based on considerable data collected from 1985–2013, the abundance of Lake Sturgeon in each of MU4 and MU5 is small (Baker 1990; Swanson et al. 1991; Kroeker and Horne 1993; MacDonell and Horne 1994; Bretecher and Horne 1997; Bretecher and MacDonell 2000; Johnson et al. 2004; Holm et al. 2006; Ambrose et al. 2008; 2009) and it is unknown if recruitment has occurred within each reservoir since the GSs were built. Lake Sturgeon younger than each reservoir have been captured, however, downstream movement from upstream populations has been documented (tagged fish from upstream have been tracked into these MUs) and is known to occur based on results of genetic analyses (Gosselin et al. 2015; Lacho et al. 2015a).

Recently, focused studies re-assessed the adult spawning and juvenile segments of the population in MU4 (Lavergne and Barth 2012a; 2012b). In spring 2012, with considerable gillnetting effort, six adults and one juvenile were captured near the base of the Kettle GS powerhouse and spillway, while in fall 2012, ten juveniles were captured in the middle portion of the reach. Three of the adult fish captured during spring were classified as male and were in spawning condition; one of these (a fish tagged with an acoustic transmitter) survived passage through the Kettle GS the previous winter (Lavergne and Barth 2012a). In addition, of eight juveniles captured in MU4 during fall 2012 (Lavergne and Barth 2012b) five were age four, indicating either recruitment occurred in the reservoir in 2008, or downstream movement of juveniles/larvae through the Kettle GS. Indeed, genetic analyses conducted by Gosselin et al. (2015) on these fish determined they were closely related to fish further upstream in MU3.

In summary, the abundance of adult and juvenile Lake Sturgeon in MU4 and MU5 is low (COSEWIC 2017). It is unknown if recruitment from spawning in either MU has occurred since construction of the Kettle or Long Spruce GSs.

Limestone GS to Hudson Bay (MU6)

The Limestone GS–Hudson Bay section of the Nelson River (MU6) consists of approximately 100 km of moderate gradient riverine habitat, prior to entering the Nelson River estuary. Short-term flow and water level fluctuations are common in this stretch of river and extensive dewatering may occur daily. Historical harvest was likely minimal from this reach, primarily due to access difficulties. More accurate harvest records from after 1970 show almost no harvest from MU6 (Stewart 2009).

Environmental studies beginning in the mid-1980s and continuing until present have revealed the Lake Sturgeon population in this section of river is the most abundant population in the Nelson River, and one of the largest populations in Manitoba (MacDonell 1995; 1997a; 1998; Barth and MacDonell 1999; Holm et al. 2006; Ambrose et al. 2008; 2009; 2010a; 2010b; Pisiak et al. 2011). Population estimates for adults (i.e., those greater than or equal to 800 mm FL) were derived in 2005 and 2013; the 2005 estimate was 5,595, while the more recent estimate (2013) was 8,413 (Henderson et al. 2014b) (COSEWIC 2017). The substantial increase in abundance between 2005 and 2013 was attributed to relatively high numbers of unmarked small adults and sub-adults (750–849 mm FL) in the 2013 catch.

The abundance of juveniles in MU6 is difficult to estimate as fishing conditions throughout most of the MU are difficult. However, a single area where juveniles can be captured in high abundances has been located in the vicinity of Jackfish Island, which is essentially the only large area (~3 km^2) in the lower Nelson River where deep water (>10 m) and lower water velocities predominate (Ambrose et al. 2010a). A single juvenile (age-2) captured in the Hudson Bay estuary with limited effort suggests this area may be nursery habitat (Holm and Bernhardt 2011).

In summary, the abundance of both adult and juvenile Lake Sturgeon in MU6 is high with the 2013 population estimate suggesting the population may be increasing (COSEWIC 2017).

DU3: SOUTHERN HUDSON BAY-JAMES BAY

DU3 watersheds are found within the Southern Hudson Bay-James Bay aquatic ecozone (Figure 9; COSEWIC 2006). This area includes all drainages of northwestern Québec, northern Ontario and northeastern Manitoba that drain to Hudson and James bays (Figure 9). Relative to the other DUs included in this assessment, information on Lake Sturgeon is rather sparse for many of the watersheds in DU3. In general, the watersheds contain long rivers (> several hundred km in length) with several substantive tributaries, and the information available on Lake Sturgeon often comes from only a small section of the watershed. The only historical population data available are from commercial harvest records. Harvest amounts were relatively low compared to other systems discussed in this document.

Hayes River System

The Hayes River system (Figure 10) originates in Molson Lake in north-eastern Manitoba. It flows northeast, draining an area of 108,000 km^2 before emptying into Hudson Bay (Environment Canada Water Surveys, unpubl. data). The Hayes River proper flows 485 km with a mean annual discharge of

694 m^3/s (Environment Canada Water Surveys, unpubl. data). The drainage area includes several substantive tributaries that support Lake Sturgeon populations including the Fox, Bigstone, Echoing, Gods and Pennycuttaway rivers. The upper reaches of the Hayes and its various tributaries feature pool/riffle streams, and deep shield lakes, the lower portion of the system is fast flowing and shallow, cutting through the Hudson Bay lowlands. The system is entirely unregulated, supporting no hydroelectric development. The tidal influence from Hudson Bay can be observed as far as 25 km upstream from the river mouth. Habitat in the Hayes River and its tributaries is typical of low-gradient rivers in the Hudson Bay lowlands which tends to be relatively homogeneous compared to stepped-gradient rivers.

Historically, relatively little is known about Lake Sturgeon in the Hayes River system. Productivity and carrying capacity of rivers in the Hayes system are expected to be low (MCWS 2012). Lake Sturgeon populations in the Hayes River were commercially harvested, but were never depleted to the same extent as other Manitoba river systems (MCWS 2012). Commercial harvest was reported from the Fox/Bigstone/Hayes rivers combined for the first time in 1939 and again two years later in 1941 (Stewart 2009). Harvest was not reported again until 1956 when it peaked at 6,546 kg. Harvest continued until 1960 (annual amounts < 2,500 kg) when the fishery was closed. After reopening in 1971, periodic annual harvests below 1,500 kg were reported until 1991 (Stewart 2009). The commercial fishery was officially closed on the river in 1999 (Stewart 2009).

As noted previously, Lake Sturgeon are known to move between the lower Nelson River and the Hayes River system (Ambrose et al. 2010b; Klassen 2012). Recent high-resolution genetic results indicate despite the mixing of populations, the Nelson and Hayes River populations are distinct (Gosselin et al. 2015). These results suggest, although sturgeon move between the two rivers, Lake Sturgeon return to their natal river to spawn. Further, results presented in Gosselin et al. (2015) indicate Lake Sturgeon in the lower Hayes River and those captured in the lower Gods River are not genetically different.

There is little quantitative information on Lake Sturgeon abundance in the Hayes River watershed, but populations are generally thought to be healthy (MCWS 2012). The only population estimate produced from the watershed comes from a stretch of the Fox River between Great Falls and Rainbow Falls. Pisiak and Maclean (2007) reported the population was comprised of 646 adults, based on the Petersen single census estimate in 2004.

Other Lake Sturgeon focused studies have attempted to identify spawning locations in the system. One spawning study was carried out near Red Sucker Rapids on the God's River in the spring of 2011. Gillnets were set over a 9-day period and a total of 59 Lake Sturgeon were captured, however, of these only three males were identified as current year spawners (Klassen 2012). Ambrose et al. (2010a) reported on a gillnetting study conducted in the Pennycuttaway River during spring 2008 where CPUE data suggested Lake Sturgeon abundance was low and two of the fish captured were identified as spawning males. Other studies have been conducted in the Hayes watershed to identify spawning locations, however, few fish in spawning condition have been captured. These studies were conducted in the Gods River at the mouth of the Opuskiamishes River, in a short reach of the Echoing River, in the

Hayes River at Whitemud Falls and in the Fox River below Rainbow Falls in 2013 and 2014 (Koga and MacDonell 2014, Ambrose and MacDonell 2015).

The abundance of juvenile fish in the Hayes River watershed is also poorly understood. Small quantities of juveniles were captured in experimental standard gang index gillnets set in the vicinity of Seal Island (10 km from the Hudson Bay estuary) in September 2005 (Mota and MacDonell 2008). All 24 Lake Sturgeon caught were smaller than 750 mm and five were smaller than 365 mm. In 2006, two small juveniles were captured in large mesh gillnets set in the same area. Based on their size these fish were considered one year olds (Mota and MacDonell 2008).

In summary, although several studies have been conducted, the Hayes River watershed is very large and likely contains several populations (D. Macdonald, MCWS, pers. comm.). As such, limited data exists on the size of historical or current populations, or population trends across the watershed. Given the information that is available however, and considering the commercial fishery was not as extensive as other rivers across the province, populations are thought to be healthy (D. Macdonald, MCWS, pers. comm.).

Sturgeon River, Severn River, Winnisk River, Ekwin River

The Sturgeon, Severn, Winisk and Ekwin rivers flow north, beginning in the Boreal Shield, transitioning into Hudson Bay lowlands, before entering into James Bay or Hudson Bay (Baldwin et al. 2009). Along the length of these rivers, a transition occurs from well-drained bedrock to very poorly drained organic deposits (Baldwin et al. 2009). To date there are no hydroelectric developments on any of these rivers or their tributaries in the watershed.

Based on anecdotal reports and ATK, Lake Sturgeon are known to exist in each of these rivers, however, no quantitative information, including commercial harvest data, has ever been collected (T. Haxton, OMNRF, pers. comm.). Each river is unregulated, and with the exception of the Ekwin River, where a natural barrier exists near its mouth, there are no known barriers to fish movement (T. Haxton, OMNRF, pers. comm.).

Attawapiskat River

The Attawapiskat River (Figure 10) is formed by the confluence of the Pineimuta, Trading and Otoskwin rivers at Attawapiskat Lake. This river runs 748 km into James Bay, draining an area of 50,500 km^2 (Natural Resources Canada, unpublished data). It is the third largest river entering the western side of James Bay, after the Albany and Moose rivers (Glooschenko and Martini 1983). Several sets of rapids and falls occur along its length. The Attawapiskat River is located primarily within the Hudson Bay Lowland, and passes through very poorly drained organic deposits along its length (Baldwin et al. 2009). To date, there has not been hydroelectric development on the Attawapiskat River; mining occurs in the area.

Similar to the Sturgeon, Severn, Winisk and Ekwin rivers, there is no quantitative data (contemporary or historical) from this system other than a Lake Sturgeon assessment conducted in 2015 (T. Haxton, OMNRF, pers. comm). During this assessment, three 50 km reaches of river were sampled during summer/early fall following the protocol developed by Haxton et al. (2014b) for sampling sturgeon in Ontario rivers. The three reaches sampled included an upper reach from river kilometer (rkm) 442 to rkm 414, the middle reach from rkm 387 to rkm 346, and the lower reach from rkm 223 to rkm 189. Similar to other rivers discussed in this assessment, relative abundance estimates suggested Lake Sturgeon abundance varied by river reach. CPUE of adults was 0.06, 0.21 and 1.27 per net night in the upper, middle and lower reach, respectively. Although the abundance of adults increased in a downstream direction, juvenile abundance decreased, with CPUE values of 0.95, 0.63 and 0.0 sturgeon per net night in the upper, middle and lower reaches, respectively (total sample size 112). Qualitatively, these data suggest a low to moderate abundance of Lake Sturgeon in the Attawapiskat River.

Kenogami/Albany River Watershed

The Albany River flows 982 km from Lake St. Joseph to James Bay, draining an area of 135,200 km^2 (Natural Resources Canada, unpublished data) and is tied with the Severn River as the longest river in Ontario. The Albany River begins in the Boreal Shield, transitioning to Hudson Bay Lowlands (Baldwin et al. 2009). The main tributaries of the Albany River include the Ogoki and Kenogami rivers. The Lake St. Joseph diversion was built in 1935 to redirect water from the Albany River into Lac Seul for hydropower generation on the Winnipeg River system. Overall, it adds 80 m^3/s of discharge annually (Lake of the Woods Control Board 2002). In 1937, the Long Lake Diversion was constructed with the aim of redirecting the flow of the Kenogami River south to Lake Superior (Peet and Day 1980).

Historically, it is unknown if Lake Sturgeon in the Kenogami/Albany River watershed were harvested commercially. Sandilands (1987) suggested by the mid-1980s commercial harvest was not occurring and relatively small numbers of sturgeon were taken by subsistence harvesters. The abundance of Lake Sturgeon in this system was not quantified until the late 1980s when Sandilands (1987) conducted a mark-recapture study in 1984 and 1985 on the Kenogami River upstream of the confluence with the Albany River. The study area was divided into three distinct reaches, separated by long stretches of river that were difficult to navigate due to shallow water depth. The reaches sampled included Kapeesawatan Lake and 15 km of the river immediately downstream; a 5 km stretch in the vicinity of Ogahalla rapids (located approximately 5 km downstream of the upstream reach) and an approximate 25 km stretch of the main river at Mammamattawa. Similar to other rivers, Lake Sturgeon abundance varied among the three different stretches of the river included in the study. Abundance, calculated using the modified Schnabel estimate, was lowest in the upstream reach, Kapeesawatan Lake, (1984 pop. est. 55; 1985 pop. est. 10); followed by the Ogahalla Rapids reach (1984 pop. est. 55; 1985 pop. est. 48), and Mammamattawa (1985 only, pop. est. 1,314). Relative abundance of Lake Sturgeon was also measured in three distinct reaches of the Kenogami River in 2011 using large mesh and extra-large mesh gillnets (Haxton et al. 2014b). The three reaches included: between the Kabinagami and Drowning River, Ogahalla Lake and Chipman Lake. Lake Sturgeon CPUE values in large mesh nets were 2.3, 0.0 and 0.20, and 0.67, 1.73 and 0.59 in extra-large mesh nets, in the three river reaches from upstream to

downstream, respectively (total n=78). Lake Sturgeon abundance in this system was qualitatively assessed as low for adults and juveniles (Haxton et al. 2014b; T. Haxton, OMNRF, pers. comm.).

Moose River Basin

The Moose River Basin drains an area of roughly 109,000 km^2 and includes Canadian Shield and Hudson Bay Lowland habitats. The major tributaries of the basin include the Missinaibi, Mattagami, Groundhog, and Abitibi rivers. Lake Sturgeon were historically found throughout the Moose River basin but are now confined to the lower reaches of the watershed in the Hudson Bay Lowland regions and are no longer found within the Canadian Shield (Seyler 1997a). A number of man-made obstacles to upstream fish movement have been constructed in the basin, particularly in the Mattagami and Abitibi rivers, which are heavily fragmented. Upstream in the watershed, six small generating stations have been built on the Abitibi River, four in the upper Mattagami River, while four generating stations operate in series as part of the Mattagami River hydro-electric complex further downstream, including, from upstream to downstream, the Little Long, Smoky Falls, Harmon and Kipling GSs. The Little Long GS is located 30 km downstream of the confluence of the Kapuskasing and Mattagami rivers. The Little Long Reservoir is the largest reservoir on the Mattagami River stretching 45 km upstream of the Little Long GS. The Kapuskasing and Groundhog rivers represent major tributaries of the Mattagami River and drain areas of 9,111 km^2 and 13,913 km^2, respectively (OPG 2009). The Adam Creek spillway was constructed in 1963 and is 37 km long. It works to divert water from the Little Long Forebay into the Mattagami River downstream of the Kipling GS when river flow exceeds 583 m^3/s. Sturgeon are frequently entrained into the Adam Creek spillway and each spring recovery programs are conducted to remove sturgeon from the diversion and place them back into the Little Long Reservoir (OPG 2009).

Kapuskasing, Ground Hog, and Upper Mattagami Rivers Downstream to the Little Long GS

Commercial and subsistence harvest of Lake Sturgeon in the Mattagami River started in the early 1900s but by the 1980s catches had declined dramatically and the commercial fisheries were closed (OMNR 2008). Commercial harvest from the Mattagami River was highly variable ranging from 5,518 kg in 1948 to 190 kg in 1967 (Seyler 1997b). Mean annual commercial harvest from the lower Mattagami and Groundhog rivers from 1961–1971, was 2,352 kg (Seyler 1997b). Angling for Lake Sturgeon was prevalent in the 1980s on the Groundhog and Mattagami rivers but it is unknown what affect it had on population size.

The upper Mattagami River is fragmented by a series of three generating stations: Wawaitin, Sandy Falls and Sturgeon Falls (from upstream to downstream). Lake Sturgeon were believed to have been extirpated in the 35 km reach between the Wawaitin and Sandy Falls GSs, and consequently, 52 adult Lake Sturgeon from the Little Long Reservoir were translocated into the reach in 2002. The success of the translocation effort was unknown until studies conducted in 2011, 2013 and 2015, captured 10 adults and 103 juveniles, of which 85 were taken from between the Wawaitin GS and Sandy Falls GS and 18 were captured in the section of river further downstream between the Sandy Falls and Sturgeon Falls GS (M. Boothroyd, unpublished data). Parentage analysis revealed the juvenile fish in the system were

related to the translocated adults, indicating some of the translocated fish had successfully reproduced (M. Boothroyd, unpublished data). These results suggest adult translocation is a potential mitigation option to recover extirpated populations where suitable habitat remains.

Further downstream, a Lake Sturgeon population estimate has been derived on several occasions over three decades in the reach of the Mattagami River that includes the Groundhog and Kapuskasing rivers and the Little Long GS and Little Long Reservoir. The study area includes the Groundhog River from LaDuke Rapids (a barrier to upstream movement) to its confluence with the Mattagami River; the lower Kapuskasing River; and the Mattagami River from Cypress Falls (also a barrier to upstream movement) to the Little Long GS. The first estimate in the 1980s suggested a population of 8,429 individuals (Nowak and Jessop 1987). In 1991, Sheehan and McKinley (1992) estimated the population to be much higher at 24,772 individuals. A subsequent estimate using similar methods from 2002 suggested the population was comprised of 12,395 individuals. The most recent estimate derived in 2012 using a modified Schnabel model yielded a population of 9,894 individuals (Hatch 2014). Despite the differences in estimates over three decades, the Lake Sturgeon population in the Little Long Reservoir appears to be comprised of at least several thousand individuals and may be one of the largest populations in northeastern Ontario.

The Groundhog River is known to support a Lake Sturgeon population of unknown abundance. Haxton et al. (2014b) sampled the river in 2010 with large mesh and extra-large mesh gillnets. Only three Lake Sturgeon were captured, and based on low CPUEs, Lake Sturgeon abundance is thought to be low in the reach of river sampled (T. Haxton, OMNRF, pers. comm.).

Little Long GS to Kipling GS

This 17 km reach of the Mattagami River is bounded by the Little Long GS on the upstream end and the Kipling GS on the downstream end. The Smokey Falls GS and Harmon GS lie within the reach dividing it into three distinct sections. Recently, mature Lake Sturgeon were captured in the vicinity of possible spawning grounds downstream of the Smoky Falls GS, suggesting a spawning population may exist in the Harmon GS headpond (Hatch 2009). Lake Sturgeon have also been caught in the Smoky Falls GS headpond but it is unknown if spawning occurs below Little Long GS (OPG 2009). The abundance of Lake Sturgeon within these fragmented reaches is poorly understood.

Lower Mattagami and Moose Rivers, Including the Abitibi and Frederick House Rivers

The Abitibi River, flows into the Moose River 30 km from James Bay and drains an area of approximately 28,700 km^2 (AWMP 2004). Commercial harvest occurred in the Abitibi River, with records dating back to 1935. Reported harvest was as high as 2,414 kg in 1936 and as low as 3.56 kg in 1978 (Payne 1987).

A study that examined biological characteristics, population size, biomass and production in the Mattagami, Frederick House and Abitibi rivers of northeastern Ontario was conducted in the early 1980s (Payne 1987). Population estimates were developed using an adjusted Peterson estimate for a 14 km

stretch below Neeland's Rapids and extending to Carters Rapids on the Frederick House River. The population estimate was 125 fish in 1981 and 186 fish in 1983 (numbers likely represented the spawning population only). In the Abitibi River, a Schnabel population estimate of 994 individuals was derived for the Island Falls to Abitibi Canyon reach in 1984 (Gibson et al. 1984).

More recently, Haxton et al. (2014b) sampled three reaches of the Abitibi River (Long Sault Rapids GS to Island Falls HS; Island Falls HS to Abitibi Canyon GS; and Abitibi Canyon GS to Otter Rapids GS) with large mesh and extra-large mesh in 2010. A total of 49 Lake Sturgeon were captured (from all three reaches combined) yielding CPUE values <0.6 sturgeon/net night in both large mesh and extra-large mesh from each of the three river sections. Based on these data, Lake Sturgeon abundance in these three reaches of the Abitibi River is thought to be low (T. Haxton, OMNRF, pers. comm.). Further, in the southern reaches of the Abitibi River and Abitibi Lake, Lake Sturgeon are considered scarce or no longer present (OMNR 2008).

The Moose River starts at the confluence of the Mattagami and Missinabi rivers and flows in a northeast direction 106 km towards James Bay. The Moose River is characterized as being a wide and fairly shallow river with numerous rapids and rock/sand shoals (Threader and Brousseau 1986). Threader and Brousseau (1986) investigated the abundance of Lake Sturgeon in the Lower Moose River system between 1980 and 1982 using gillnets and long-lines. A total of 2,346 Lake Sturgeon were captured yielding a mark recapture population estimate of 7,088 individuals (Threader and Brousseau 1986).

In summary, the abundance of Lake Sturgeon within the Moose River Basin varies by location. The population in the Little Long GS Forebay has an estimated adult population of approximately 10,000–12,000 individuals and is considered to be the largest Lake Sturgeon population in northeastern Ontario (OMNR 2008; Hatch 2014). Within the Abitibi and Frederick House rivers, Lake Sturgeon are thought to be present at low abundances. In the Lower Moose River downstream of the Kipling GS, a population estimate in the 1980s suggested approximately 7,000 individuals, however, no recent work has been conducted.

Harricana River

The 533 km Harricana River (Figure 10) runs through western Québec and northeastern Ontario. It drains an area of 29,300 km^2, and has a mean annual discharge of 570 m^3/s (Natural Resources Canada, unpublished data). Closer to its outlet, the Harricana River becomes fast flowing, with many sets of rapids. The majority of the river flows through Boreal Forest, which transition to wetlands of the Hudson Bay Lowlands near its outlet. Tributaries of the Harricana River include the Turgeon and Kesagami rivers. The southern portion of the river is heavily logged while mining operations are significant in the north. The river is also subject to impacts from urbanization and agriculture.

Nottaway River

The Nottaway River runs 776 km from Mattagami Lake to James Bay at Rupert Bay. It drains an area of 65,800 km^2 and has a mean discharge of 1,190 m^3/s (Natural Resources Canada, unpublished data). The

Nottaway River runs north from Lac Parent to Lac Mattagami, where it is joined by the Waswanipi River. The Nottaway River has numerous sets of and rapids and falls. The majority of the river flows through the Boreal Shield, and transitions to Hudson Bay Lowlands near its outlet. Its main tributary is the Kitchigama River. Historically, Lake Sturgeon were considered rare in the Nottaway River (Ferguson and Duckworth 1997). Commercial fishing for Lake Sturgeon on the river was carried out from 1989–1994 by the Cree communities of Mistissini, Waswanipi, and Ouje-Bougoumou (Fortin et al. 1992; Environnement Illimité Inc. 2012b).

In the Nottaway River there are four stretches of rapids which are believed to be suitable locations for Lake Sturgeon spawning (Environnement Illimité Inc. 2012b). Fishing surveys conducted in the Nottaway River in 1991 yielded an average CPUE of 0.4 Lake Sturgeon/net-day.

Broadback River

The Broadback River (Figure 10) flows 450 km from Lac Frotet to Rupert Bay, a small bay at the south end of James Bay. It drains an area of 20,800 km^2 and has an average discharge of 350 m^3/s (Natural Resources Canada, unpublished data). The Broadback River flows through several lakes including Labeau, Evans, and Giffard. The river becomes more confined towards James Bay, and has many sets of rapids and falls along its length. The majority of the river flows through the Boreal Shield, and transitions to Hudson Bay Lowlands near its outlet.

Lake Sturgeon spawning in the Broadback River is believed to occur at the first set of impassable rapids (Tupatukasi Rapids), approximately 59 km upstream of James Bay. A fisheries survey conducted in the Broadback River in 1991 yielded CPUE values of 1.3 sturgeon per net (Environnement Illimité Inc. 2012b).

Rupert River

The Rupert River (Figure 10) flows 763 km from the head of the Temiscamie River at Mistassini Lake to Rupert Bay, north of the outlet of the Broadback River. It drains an area of 43,400 km^2 and has an average discharge of 900 m^3/s (Natural Resources Canada, unpublished data). Its main tributary is the Nemiscau River. The majority of the river flows through the Boreal Shield, and transitions to Hudson Bay Lowlands near its outlet.

Damming and diverting of the Rupert River, along with the Nottaway and Broadback rivers, was considered during predevelopment planning of the James Bay Project. Although this did not occur, the Rupert River was partially diverted (a total of 450 m^3/s a year, on average) in 2009 to increase the energy output of the La Grande complex (Environnement Illimité Inc. 2012b). The hydroelectric installations were constructed on the Rupert River in late 2006 and included a dam (the Rupert dam) as well as five weirs, two spur dikes and one rock blanket located downstream of the main dam.

Historically, Lake Sturgeon were abundant in the Rupert River and surrounding tributaries (Ferguson and Duckworth 1997). Subsistence fishing in the Rupert River (including Lac Mesgouez and Lac

Nemiscau) is known to occur by members of the communities of Waskaganish and Nemaska. A commercial fishery operated upstream of Lac Mesgouez between 1989 and 1994 but is no longer active (Environnement Illimité Inc. 2012b). According to Environnement Illimité Inc. (2012b), although commercial fishing no longer occurs on the Rupert River, it is likely the active subsistence fishery is operating near the maximum sustainable limit and any additional fishing pressure would need to be monitored closely.

In a study carried out between 2002 and 2003, before impoundment of the Rupert River, Lake Sturgeon eggs were found at five spawning sites along the Rupert River (Environnement Illimité Inc. 2012b). An additional three sites were believed to be suitable spawning locations, but were not confirmed. After the diversion, it was suggested the reduction in flow may have improved spawning conditions at certain sites on the Rupert River. Ideal nursery habitat appears to be present at two locations with catches as high as 117 juveniles/100 net days in 2009.

The size of Lake Sturgeon captured from the Rupert River (800–1,300 mm) was smaller than from other rivers in the region (e.g., Eastmain and Opinaca rivers: 1,000–1,400 mm) (Environnement Illimité Inc. 2012b). The size of spawning adults in the population was also small suggesting harvest may be impacting the spawning population.

Eastmain River

The Eastmain River (Figure 10) flows 756 km from Lac Bréhat to James Bay, draining an area of 46,400 km^2 (Natural Resources Canada, unpublished data). The Eastmain River flows largely through Boreal Shield, but enters James Bay near the Hudson Bay Lowland's eastern boundary.

The Eastmain River has undergone significant hydroelectric development as part of the James Bay Project. In July 1980, 80% of the discharge of the Eastmain River was diverted to the La Grande complex (Roy and Messier 1989). Flows of the river were reduced from an average of 700 m^3/s to 95 m^3/s (Roy and Messier 1989). Construction of the Eastmain-1 hydroelectric development began in 2002, upstream of Opinaca reservoir. Impoundment of Eastmain-1 reservoir began in November 2005 and was completed in May 2006 (Environnement Illimité Inc. 2012b). In addition to the powerhouse, the development includes a dam across the Eastmain River, a spillway, and 32 dikes. The reservoir covers a surface area of 603 km^2. Eastmain-1-A powerhouse construction began in 2007 and was completed in 2012 (Environnement Illimité Inc. 2012b). In 2009, flow was increased in a section of the river (including Eastmain-1 reservoir) by the diversion of the Rupert River.

Unlike the Rupert River, subsistence fishing in the Eastmain River is much less extensive and not well documented (Environnement Illimité Inc. 2012b). Subsistence fishing locations on the Eastmain River are located primarily upstream of the Opinaca Reservoir and downstream of OA-11 dam. There is currently no commercial fishery for Lake Sturgeon in the Eastmain River and although it is likely current harvests are below the maximum sustainable level, recorded catches from 1992, 1993, and 1996 likely exceeded potential yields (Environnement Illimité Inc. 2012b).

The main spawning site in the Eastmain River prior to construction of the Eastmain-1 dam was located 215 km upstream of James Bay (Environnement Illimité Inc. 2004). Once the dam became operational, the spawning site was no longer suitable. As a result three separate artificial spawning sites were created. Since their creation spawning has been observed at only one of the three new sites and has not been consistent every year (Environnement Illimité Inc. 2012b). Since the beginning of operation of the Eastmain-1 dam, larval production in the Eastmain River has decreased from an estimated 167,109 larvae in 2003 to 7,485 larvae in 2009. The abundance of Lake Sturgeon in the Eastmain River has not been quantified by a population estimate but three sections of the Eastmain River (lower, middle, and upper reaches) were sampled for Lake Sturgeon in 2004 (Burton et al. 2006). The lower, middle, and upper reaches of the river yielded catches of 0.03, 0.11, and 0.36 sturgeon/net-day, respectively, which were considerably lower than catch rates in the Rupert and Nottaway rivers.

Opinaca River

The Opinaca River is located in northwestern Québec and flows into James Bay. The river had an average annual discharge of approximately 263 m^3/s prior to diversion of water through the La Grande River Project in 1980 (Dery et al. 2005). Similar to the Eastmain River, no commercial Lake Sturgeon fishery currently exists in the Opinaca River and subsistence fishing is not well understood. Lake Sturgeon spawning occurs at a site 62 km from James Bay. Estimated larval production at the Opinaca River spawning site increased from 10,111 in 2003 to 45,820 in 2008 and may be the result of Lake Sturgeon moving from poor spawning sites in the Eastmain River to sites in the Opinaca (Environnement Illimité Inc. 2012b). Genetic analysis of Lake Sturgeon from the Eastmain and Opinaca rivers confirmed that the Eastmain River was colonized by sturgeon from the Opinaca River (Bernatchez and Saint-Laurent 2004; Environnement Illimité Inc. 2004).

La Grande River

La Grande River (Figure 10) runs 893 km from Lac Nichicun to the eastern side of James Bay. It drains an area of 97,600 km^2, and is the second largest river in Québec, other than the St. Lawrence (Natural Resources Canada, unpublished data). The La Grande River runs solely through the Boreal Shield region of northern Québec. It is highly regulated, with eight hydroelectric dams along its length, which are cumulatively known as the La Grande Hydroelectric Complex. Phase 1 of construction on the complex took place between 1973 and 1985. Three hydroelectric generating stations were constructed: La Grande-2, La Grande-3 and La Grande-4. The second phase of construction of the La Grande complex took place between 1987 and 1996 when five generating stations were added: La Grande-1, La Grande-2-A, Laforge-1, Laforge-2, and Brisay. In 2000, the La Grande complex had a total reservoir area of 12,954 km^2 (Hydro Québec, unpublished data).

DU4: GREAT LAKES – UPPER ST. LAWRENCE

The Great Lakes and St. Lawrence River basins cover 250,000 km^2 stretching from the northwest arm of Lake Superior to the upper St. Lawrence River estuary (Figure 11; Mailhot et al. 2011). The Great Lakes and St. Lawrence River ecozone, formerly referred to as DU8 in the COSEWIC 2006 report, is referred

to as DU4 for this assessment. The COSEWIC (2017) assessment stated Lake Sturgeon are widespread in this ecozone and were once extremely abundant in each of the Great Lakes, the St. Lawrence River and their tributaries. Lake Sturgeon, however, now exist in DU4 at a fraction of their historical abundance (Haxton et al. 2014a).

Within DU4, twelve management units (MUs) based on genetic structure and known barriers to movement were established by Pratt (2008). The MUs and their associated extant populations are as follows:

- MU1: Western Lake Superior (Pigeon and Kaministiquia rivers);
- MU2: Lake Nipigon;
- MU3: Northern Lake Superior (Black Sturgeon, Nipigon, Gravel, Pic, White, and Michipicoten rivers);
- MU4: Eastern Lake Superior (Batchawana, Chippewa, and Goulais rivers, Goulais Bay);
- MU5: Lake Huron north channel (St. Marys, Garden, Thessalon, Mississagi, and Spanish rivers);
- MU6: Lake Nipissing;
- MU7: Georgian Bay-Lake Huron (French, Key, Magnetawan, Naiscoot, Moon, Go Home, Severn, Sturgeon, and Nottawasaga rivers);
- MU8: Lake Huron/Erie Corridor (Main Basin Lake Huron, St. Clair River, Lake St. Clair, Detroit River, and Lake Erie);
- MU9: Lower Niagara River;
- MU10: Eastern Lake Ontario/upper St. Lawrence River;
- MU11: Ottawa River watershed population; and
- MU12: Lower St. Lawrence River.

Historically, the Great Lakes and their tributaries supported exceptionally large Lake Sturgeon populations (Haxton et al. 2014a). By 1860, Lake Sturgeon were becoming a valuable species for commercial fishermen as prices for smoked meat and caviar increased. The surge in demand led to a forty year period of unregulated harvest resulting in the collapse of Lake Sturgeon populations throughout the Great Lakes by 1910 (Harkness and Dymond 1961; Auer 1999). According to catch data recorded by the Great Lakes Fishery Commission, Lake Sturgeon harvest peaked in 1885 with approximately 3,175,146 kg of Lake Sturgeon taken (Baldwin et al. 2009). Two predictive models, used to estimate historic biomass in the Great Lakes suggested Lake Sturgeon biomass may have been as high as 25 million kilograms (37 kg per ha) in the late 1800s (Haxton et al. 2014a). Haxton et al. (2014a) however, also suggested this figure could represent an underestimate as populations may have already been in decline by the mid-1800s.

Similar to the Great Lakes, the St. Lawrence River and its tributaries were believed to have abundant Lake Sturgeon populations before hydroelectric development and overharvest reduced their numbers dramatically (Mailhot et al. 2011). Historic references to Lake Sturgeon abundance dating back to the mid-1600s by the French governor of Trois-Rivières suggested Lake Sturgeon were abundant upstream

of Québec City and reached sizes of 1.3–2.5 m in length (Boucher 1964 in Mailhot et al. 2011). In the mid-1900s industrialization led to increased pollution in the region and together with hydroelectric development and commercial harvest, Lake Sturgeon populations were dramatically affected. The lower St. Lawrence River Lake Sturgeon commercial fishery was one of the largest in North America reaching 150 tonnes annually in the 1980s. By 1987, the species was determined to be overfished and a management plan was implemented, but harvest continued to rise to over 250 tonnes by the mid-1990s (Mailhot et al. 2011). Currently, there is still a commercial fishery for Lake Sturgeon in the St. Lawrence River, but quotas have been reduced to 80 tonnes since 2002 and a size limit was implemented in 2012 with the revision of the management plan to increase the protection of juveniles and spawning adults (Dumont and Mailhot 2013).

Each of the twelve MUs in DU4 are discussed below.

Western Lake Superior (MU1)

Kaministiquia River

The Kaministiquia River (Figure 12) empties into the northwest portion of Lake Superior at the town of Thunder Bay, Ontario, and drains an area of approximately 7,800 km^2 (LRCA 2008). No specific historical harvest data exists for the Kaministiquia River but commercial harvest in Lake Superior may have impacted Lake Sturgeon populations assuming interchange between the river and Lake Superior. The Kakabeka Falls GS is the lower of two generating stations constructed on Kaministiquia River (LRCA 2008), located 2 km downstream of Kakabeka Falls (Friday 2006). The only major barrier to upstream movement is the naturally occurring Kakabeka Falls, a 39 m tall waterfall, 47 km from Lake Superior (Welsh et al. 2015). Spawning is known to occur at the base of Kakabeka Falls, and flow restrictions caused by the Kakabeka Falls GS have been shown to prevent migration to the historic spawning sites below the Falls (Friday 2013). Presently, a minimum flow of 14 m^3/s over Kakabeka Falls is maintained during the spawning period to allow sturgeon to reach the spawning grounds and prevent fish stranding.

Based on mark/recapture data, the Kaministiquia River Lake Sturgeon population was estimated at 196 individuals in 2001 (M. Friday, OMNRF, unpublished data). Larval drift data was used to estimate that 54 and 97 sturgeon spawned in the river in 2005 and 2006 respectively (M. Friday, pers. comm.). In 2010, Haxton et al. (2014b) caught a low number of Lake Sturgeon using large (CPUE: 0.29 fish per net night) and extra-large (CPUE: 0.38 fish per net night) mesh gillnets. Little is known about the abundance of juveniles in the population as a focused inventory has not been conducted in the river proper. Gillnetting was conducted at the mouth during a Lake Superior wide juvenile survey and juveniles were found to be present at low abundances (0.06 fish/net).

Lake Sturgeon in the Kaministiquia River, unlike many other Great Lakes populations, appear to be year-round river residents, with relatively few reports of adults being recaptured from other Lake Superior tributaries (Friday 2004; Friday 2005; M. Friday, OMNRF, pers. comm.). Additionally, Lake

Sturgeon from the Kaministiquia River appear to be genetically distinct from other Lake Superior spawning populations (Welsh et al. 2008; Friday 2013).

Pigeon River

The 80 km long Pigeon River (Figure 12) forms part of the Canada-United States border before draining into Lake Superior. It is characterized as having navigable reaches connecting steep waterfalls (LRCA 2008). High Falls is a natural barrier to fish movement, located approximately 3 km from the lake. Little is known about the historical Lake Sturgeon population within the Pigeon River. Contemporary surveys suggest small numbers of sub-adults and a very small number of adults are present or intermittently utilize the system, although nothing is known about these trends (E. Isaac, Grand Portage Band, pers. comm.).

Lake Nipigon (MU2)

Lake Nipigon is a large lake located entirely within Ontario and is connected to Lake Superior by the Nipigon River which is dammed by three hydroelectric generating stations (OMNR 2009; Figure 12). Spawning is suspected to occur in Lake Nipigon and its inflowing tributaries, however, few studies have been conducted. Commercial harvest in Lake Nipigon peaked in 1924 at 37,706 kg and by 1920 the population had collapsed (Swainson 2001). It is believed Lake Sturgeon populations within the lake have been significantly reduced due to overharvest (OMNR 2009).

Northern Lake Superior (MU3)

The tributaries of northern Lake Superior with historical Lake Sturgeon populations include the Wolf, Black Sturgeon, Nipigon, Gravel, Prairie, Pic, White, and Michipicoten rivers (Figure 12). Lake Sturgeon are believed to be extirpated in two of the eight tributaries (Wolf and Prairie rivers) and the population within a third (Gravel River) is considered unknown/extirpated (Pratt 2008). The remaining five tributaries (Black Sturgeon, Nipigon, Pic, White, and Michipicoten rivers) appear to support populations (Pratt 2008) and are discussed below.

Black Sturgeon River

The Black Sturgeon River is roughly 100 km in length, originating at Black Sturgeon Lake and emptying into Lake Superior at Black Bay (Swainson 2001). Substrate, flow, and gradient vary along the length of the river, with the majority of the river below Black Sturgeon dam (17 km from Lake Superior), consisting of slow moving deep water with a silt/clay substrate (Furlong et al. 2003). No historical harvest data exist for the river proper, but commercial harvest in Lake Superior likely affected the population, assuming historical interchange between the two waterbodies. Currently, spawning is believed to occur below the Black Sturgeon dam, which likely blocks access to up to 80% of the spawning habitat historically available for Walleye (*Sander vitreus*) and Lake Sturgeon in the river (Bobrowicz 2012). Unlike the population in the Kaministiquia River, Lake Sturgeon in the Black Sturgeon River are not river residents, as fish are known to leave the river after spawning and overwinter

in Lake Superior (Friday 2005). A population estimate carried out in 2003 and 2004 on the Black Sturgeon River estimated the abundance of adult spawning Lake Sturgeon to be 89 and 96, respectively (M. Friday, OMNRF, pers. comm.). In addition to studies below the Black Sturgeon dam, Haxton et al. (2014b) caught three Lake Sturgeon upstream of the dam with extra-large mesh gillnets for a CPUE of 0.16 fish per net night, suggesting a remnant population exists upstream. Recently, the 2015 spawning population of Lake Sturgeon in the Black Sturgeon River was estimated to be 24 (M. Friday, OMNRF, pers. comm.). In a juvenile survey conducted in 2011, a CPUE of 2.4 sturgeon/net was observed (T. Pratt, DFO, pers. comm.). By all indications, Lake Sturgeon abundance in the Black Sturgeon River is low.

Nipigon River

The Nipigon River has an average mean discharge of 370 m^3/s and flows from its origin at Lake Nipigon to its confluence with Lake Superior approximately 50 km downstream (Kelso and Cullis 1995). Currently three hydro-electric generating stations operate on the Nipigon River: the Pine Portage GS located approximately 50 km from Lake Superior, Cameron Falls GS, and the Alexander GS located 11.5 km from the outlet of the Nipigon River into Lake Helen (Avery 2015).

Little is known about Lake Sturgeon in the lower Nipigon River historically. Contemporary abundance in the lower reach of the river is believed to be very low and it is unknown if recruitment has occurred due to spawning in the river over the last decade. Three years of spring sampling (2013 to 2015), led to the capture of 17 Lake Sturgeon in the lower Nipigon River between the Alexander GS and Lake Helen, but CPUEs were very low (Avery 2015). One juvenile was captured in Lake Helen, but it is unknown if it immigrated from a nearby tributary or was a product of natural recruitment in the Nipigon River (Avery 2013). Egg deposition was reportedly observed immediately downstream of the Alexander GS spillway in 2013 (OMNRF unpublished data). A larval drift study conducted in 2015 did not yield any Lake Sturgeon eggs or larvae (Henderson et al. 2015b). A study sampling Lake Sturgeon in Lake Superior tributary mouths failed to capture juveniles at the mouth of the Nipigon River (DFO 2016).

Pic River

The Pic River empties into the northeastern arm of Lake Superior and encompasses a drainage area of roughly 4,270 km^2 (Figure 12; Ecclestone 2012a). Lake Sturgeon inhabit the lower 103 km of the river between Lake Superior and the naturally occurring Manitou Falls. The Black River and Kagiano River flow into the Pic River 4 km and 98 km upstream of Lake Superior, respectively. On the Black River a dam was constructed 10.2 km upstream of Lake Superior; on the Kagiano River an impassable set of falls exists 99.2 km from Lake Superior (Ecclestone 2012a).

Unlike most other Lake Superior tributaries there is no historical harvest information from the Pic River. However, it is likely the population was influenced by harvest on Lake Superior. Contemporarily, little is known about the abundance of adults or juveniles within the river, as a population estimate or focused juvenile study have not been conducted. The adult segment of the population is likely comprised of at

least several hundred individuals as over a three year period, from 2007–2010, a total of 159 Lake Sturgeon were captured within the Pic River (Ecclestone 2012a).

White River

The White River is located in Pukaskwa National Park on the northeastern edge of Lake Superior (Figure 12). Lake Sturgeon only have access to the lower 4.5 km of the river because of the naturally occurring Chigamiwinigum Falls which prevent upstream movement. Historical harvest records are not available from the White River, but the number of fish using the river to spawn may have been affected by harvest in Lake Superior (Ecclestone 2012b).

Given the proximity of the White River to the Pic River, Lake Sturgeon movement between the two rivers is common with the rate of immigration believed to be 15% annually (Ecclestone 2012b). In 2010, 10 Lake Sturgeon were captured in eight overnight gillnet sets which confirmed the presence of the species in the river. A subsequent two year study (2011–2012) conducted to assess the population characteristics of Lake Sturgeon in the White River yielded low CPUE values (Ecclestone 2012b). A total of 144 individual fish were captured including 24 recaptures. Ages of Lake Sturgeon ranged from 6–41 years with a total of 27 different year classes represented. Based on these data, a small number of Lake Sturgeon continue to utilize the lower 4.5 km of the White River.

Michipicoten River

The 110 km long Michipicoten River empties into the northeast arm of Lake Superior (Figure 12; Ecclestone 2012c). There are four generating stations on the river. The Hollingsworth GS is located at the southern end of Whitefish Lake and controls flow through all three downstream stations. The most downstream station on the river is the Scott Falls GS located 17 km upstream of Lake Superior, and acts as a barrier preventing upstream movement (A/OFRC 2014).

Several studies have suggested adult abundance in the Michipicoten River is low. In 2011, gillnetting carried out near the mouth of the river captured eight Lake Sturgeon yielding a CPUE of 0.33 sturgeon/304.8 m net night (Schloesser et al. 2014). An additional eight Lake Sturgeon (five juvenile/sub-adult and three ripe males) were captured in the 17 km reach from Scott Falls GS to Lake Superior in 2012; CPUE was very low (Ecclestone 2012c). The river was sampled again in 2013, but CPUE was even lower and only three Lake Sturgeon were captured with similar effort. CPUE values within the Michipicoten River indicate a very low abundance population is present. This is further corroborated by an absence of females in the catch during both years of study (A/OFRC 2014). Spawning habitat may exist below Scott Falls GS and at the naturally occurring Mission Falls but spawning has not been confirmed at either site (A/OFRC 2014).

Eastern Lake Superior (MU4)

Historically in MU4, the Batchawana, Chippewa, Harmony, and Goulais rivers as well as Stokely Creek supported Lake Sturgeon populations (Figure 12). Lake Sturgeon are believed to be extirpated in the

Harmony River and Stokely Creek and their status in the Chippewa River is unknown (Pratt 2008). Historical harvest data specific to MU4 does not exist.

Batchawana River

The Batchawana River is approximately 95 km in length, however, sturgeon are limited to the lower 11 km of river downstream of Batchawana Falls. Population estimates derived from data collected in the Batchawana River suggest the population is comprised of approximately 4,400 individuals (including juveniles) (T. Pratt, DFO, pers. comm; DFO 2016).

Goulais Bay/River

Goulais Bay is an approximately 80 km^2, shallow (mean depth <20 m) waterbody, located in the southeast corner of Lake Superior. The Goulais River is 67 km long and empties into Goulais Bay, draining an area of approximately 2,000 km^2 (Pratt et al. 2014). No hydroelectric development exists on the river and greater than 50 km of connected habitat exists before upstream movement is restricted by natural features (Pratt et al. 2014).

As of 2008, the spawning population of Lake Sturgeon in the Goulais River was considered extant with <50 individuals (S. Greenwood, pers. comm., in Pratt 2008). However, during a focused juvenile (<100 cm in length) mark/recapture study conducted in Goulais Bay from 2010 to 2012, 531 juvenile sturgeon were captured, yielding a juvenile population estimate of 4,977 individuals (Pratt et al. 2014). The majority of fish captured were between the ages of 4 and 10 and recruitment was suspected to have occurred each year since 1983 (Pratt et al. 2014). These data suggest the number of Lake Sturgeon using the Goulais River as a spawning location may be higher than previously thought.

Lake Huron North Channel (MU5)

The North Channel of Lake Huron is believed to have nine tributaries which historically supported Lake Sturgeon populations (Figure 13). Lake Sturgeon are considered extirpated in four of these (Serpent, Root, Echo, and Blind rivers) with the remaining five tributaries (St. Marys, Garden, Thessalon, Mississagi, and Spanish rivers) supporting populations (Pratt 2008). No historical data exists for Lake Sturgeon populations in MU5.

St. Marys River

The St. Marys River (112 km long) connects Lake Superior with Lake Huron. The river has been heavily impacted by anthropogenic factors such as shipping, pulp and paper mills, sewage treatment and shoreline development. Natural flow patterns within the river have been changed dramatically through the addition of several gates and locks that likely affect sturgeon movement.

Lake Sturgeon abundance in the St. Marys River is believed to be low. From 2000–2007, set lines captured 192 unique Lake Sturgeon (recapture rate of 16%) and the population was estimated at 505 sub-adult and adult individuals (95% CI = 388–692) (Bauman et al. 2011).

Garden River

The Garden River is a high-gradient river which flows through Lake George before entering the St. Marys River. Since 2012, focused Lake Sturgeon work has confirmed a small population exists in the river (Nahwegahbow 2015). Lake Sturgeon eggs and larvae have been captured confirming the presence of a spawning population (Nahwegahbow 2015). Additionally, 18 juveniles were captured in Lake George (CPUE low) suggesting recruitment is occurring due to spawning in the river (Nahwegahbow 2015). Little is known about the adult segment of the population.

Mississagi River

The 270 km long lower Mississagi River is a large, deep river which empties into the North Channel of Lake Huron and drains an area of approximately 11,000 km^2 (Zanatta and Woolnough 2011). The main barrier to upstream movement is the Red Rock GS located approximately 31 km upstream of the North Channel of Lake Huron.

Studies conducted in 2011 and 2012 have suggested a population consisting of at least several hundred individuals exists in the river (Tremblay 2013a). Although CPUE values were low, 154 and 140 individuals were captured in 2011 and 2012, respectively (Tremblay 2013a). Two spawning sites were identified, one immediately downstream of the Red Rock GS and the other at the Mississagi Chutes approximately 3 km upstream of Lake Huron. The reproducing Lake Sturgeon population within the Mississagi River is considered stable, and the river is an important tributary for spawning Lake Sturgeon within Lake Huron (Tremblay 2013a).

Serpent River

As of the 2006 COSEWIC report, the Lake Sturgeon population in the Serpent River was considered extirpated. A recent survey carried out in the summer of 2012 demonstrated juvenile Lake Sturgeon were present in the North Channel of Lake Huron within 10 km of the mouth of the Serpent River. However, there is no evidence of sturgeon spawning in the Serpent River and the 92 juveniles captured in the study are believed to be from other North Channel tributaries with known spawning populations such as the Mississagi and Spanish rivers (Kerr et al. 2011; Ecclestone 2013; Tremblay 2013a; 2013b).

Spanish River

The Spanish River flows into the North Channel of Lake Huron at Spanish Bay. The Spanish River has been heavily impacted by anthropogenic factors such as agricultural run-off, pulp and paper mills, and smelting activities (Dixit et al. 1998). The main obstacle to upstream movement is the Espanola pulp and paper dam located 52 km upstream of Spanish Bay. In addition to blocking upstream movement, the effluent was considered highly toxic and may have impacted Lake Sturgeon and their habitat within the river (Dixit et al. 1998). Historically, Lake Sturgeon in the Spanish River were harvested by members of the Sagamok Anishnawbek and a small number of sturgeon are still harvested annually (Gillies 2010).

Spawning studies in the Spanish River were carried out in 2003, 2005, 2006, 2008 and 2009 and although the amount of effort is unclear a total of 157 Lake Sturgeon were captured in gillnets, suggesting the Spanish River supports a spawning population (Gillies 2010). The age structure of captured Lake Sturgeon suggests a fairly young population (mean age approximately 12–13 years old) with sex ratios skewed heavily towards males (Gillies 2010).

Lake Nipissing (MU6)

Lake Nipissing covers an area of 873 km^2 and is the fifth largest inland lake within Ontario (OMNRF 2009; Figure 13). Lake Sturgeon commercial harvest from Lake Nipissing was first recorded in 1888 and annual catch peaked at 86,000 kg in 1903. Lake Sturgeon stocks were quickly diminished, but despite the population crashing, a small fishery remained on the lake from 1971–1982 with annual catches averaging 4,725 kg (OMNR 2009). Commercial and recreational fishing for Lake Sturgeon was completely closed on Lake Nipissing in 1991.

Lake Nipissing still supports a Lake Sturgeon population and spawning is believed to occur within the lake and in two of its tributaries (Sturgeon and South rivers) (Golder Associates Ltd. 2011). As evidence, a total of 144 Lake Sturgeon were captured in the Sturgeon River from 1991 to 2003, but no juveniles were present in the catch (McKee 2004). Over the past 20 years, Lake Sturgeon stock assessments have determined successful recruitment is occurring and sturgeon populations within the lake may be increasing (OMNR 2009; Pratt 2008).

Georgian Bay-Lake Huron (MU7)

There are 13 Canadian tributaries and one lake draining into Georgian Bay that historically supported Lake Sturgeon populations (Figure 13). The populations in five tributaries (Seguin, Go Home, Manitou, Saugeen, and Ausable rivers) and Lake Simcoe are considered extirpated (Pratt 2008). Tributaries believed to still have extant populations of Lake Sturgeon include: the French, Key, Magnetawan, Naiscoot, Moon, Severn, Nottawasaga, and Asauble rivers. Population sizes and status are unknown for the Key, French, Naiscoot, Severn, and Sauble rivers. Information for the remaining three tributaries (Magnetawan, Nottawasaga and Moon rivers) is sparse.

Magnetawan River

Lake Sturgeon are considered extant within the Magnetawan River, however, no evidence of spawning or successful recruitment has been documented (A/OFRC 2015). In the spring of 2014, 40 large mesh gillnets (6”–10”) were set in the Magnetawan River but no Lake Sturgeon were caught (A/OFRC 2015). Lake Sturgeon have reportedly been captured in the river by anglers but the last confirmed Lake Sturgeon capture was in 2009 (A/OFRC 2015).

Nottawasaga River

Adult spring assessments have been conducted from 2010 to 2015 in the Nottawasaga River. In excess of 350 individuals have been captured. Incidental catches of young juveniles in commercial gear

suggests recruitment is occurring. A radio-telemetry project focused on adult movement has documented movement of adults to spawning sites located in the upper portion of the river downstream of the Nicholson dam (OMNRF, unpublished data).

Moon River

The Moon River is approximately 35 km long and one dam has been constructed on the river. A major habitat enhancement project, creation of spawning shoals for Walleye and Lake Sturgeon, was completed in 2008. In 2009 and 2010, an observational spawning study was conducted immediately downstream of Moon Falls, a suspected spawning location and potential natural barrier to upstream movement (McIntyre 2010). Sixteen Lake Sturgeon were observed in 2009 and two were observed in 2010 (McIntyre 2010). In 2012, 2013 and 2014, a focused study was conducted to assess the effectiveness of the spawning shoals at providing habitat for Lake Sturgeon. During these studies, it was shown Lake Sturgeon eggs were deposited on the shoals; larvae were also captured indicating eggs had hatched (OMNRF, unpublished data). These observations suggest the river is still being used by sturgeon but the size of the population is unclear, and it is unknown if successful recruitment is occurring.

Lake Huron/Erie Corridor (MU8)

The Huron/Erie Corridor flows 160 km in a southward direction connecting Lake Huron and Lake Erie (Manny and Kennedy 2002). Water leaves Lake Huron via the St. Clair River before entering Lake St. Clair where water continues through the Detroit River and eventually into Lake Erie (Figure 14). Unlike in many of the Great Lakes tributaries, Lake Sturgeon movement is unimpeded in this system, and individuals can move freely from Lake Huron into Lake Erie (Thomas and Haas 2002). The discussion of MU8 below follows from upstream to downstream.

Main Basin – Lake Huron

Lake Huron is the fifth largest lake in the world with an estimated volume of 3,482 km^3 and a watershed of over 186,480 km^2 (Riley 2013). Lake Huron once supported large numbers of Lake Sturgeon, however, commercial harvest was extensive, peaking at 250 tonnes before collapsing in 1909. The contemporary population size was estimated based on mark-recapture data collected over a 14-year period (1995 to 2008) from the southern Bay of Lake Huron. Estimates suggested the population was comprised of approximately 30,000 individuals, making this population one of the largest populations in the Great Lakes (Boase and Mohr 2015).

St. Clair River

The St. Clair River stretches 64 km from Lake Huron to Lake St. Clair, with an average discharge of 5,100 m^3/s (Edsall et al. 1988; Boase et al. 2011). Historically, large quantities of Lake Sturgeon were harvested to supply a caviar factory located on the banks of the river in the town of Algonac, Michigan (Harkness and Dymond 1961).

Due to the lack of restrictions to movement in MU8, estimating the size of the population in the river is problematic, and as such, no accurate estimates are available (Boase et al. 2011). It is known Lake Sturgeon spawn in the St. Clair River, and the river is used as a nursery location (Boase et al. 2011). Lake Sturgeon spawn at two locations within the St. Clair River; the Bluewater Bridge in Port Huron and the North Channel near Algonac, Michigan (Manny and Kennedy 2002; Thomas and Haas 2002).

Lake St. Clair

The St. Clair River drains into Lake St. Clair, a large (1,114 km^2), relatively shallow (mean depth 3 m), lake connected to Lake Erie by the south flowing Detroit River (Bolsenga and Herdendorf 1993). Similar to the Great Lakes, commercial harvest within Lake St. Clair was high with mean annual harvest peaking at 2.4 million kg in 1870, but by the mid-1890s the population had declined dramatically (Baldwin et al. 2009). In addition to overfishing, habitat degradation and water quality also affected sturgeon populations within the lake and its tributaries (Thomas and Haas 2002).

As with the St. Clair River, estimating Lake Sturgeon abundance in Lake St. Clair is difficult given the lack of barriers to movement and the relatively large size of the population. Historically, estimates suggest the population was comprised of 354,000 individuals, but current estimates based on mark-recapture methods put the population at 20,000–40,000 individuals (Hay-Chmielewski and Whelan 1997; Thomas and Haas 2002). Lake Sturgeon from both the St. Clair and Detroit rivers are known to move into Lake St. Clair for the summer, where they have been found in relatively high densities (Thomas and Haas 2002).

Detroit River

The Detroit River (average discharge 5,300 m^3/s) represents the southern portion of the Huron-Erie Corridor and connects Lake St. Clair to Lake Erie via a 51 km long stretch of river (Edwards et al. 1989; Caswell et al. 2004). Several factories, power plants, and waste water treatment facilities have been built along the rivers banks. In addition, the Detroit River is an important route for tanker ships navigating through the Great Lakes and as such the habitat within the river has changed dramatically to allow passage of large vessels (Caswell et al. 2004).

Historically, the Detroit River and the Huron-Erie Corridor were believed to have had an abundant Lake Sturgeon population and may have supported one of the largest populations in the region (Harkness and Dymond 1961; Caswell et al. 2004). Relatively few studies have been conducted on Lake Sturgeon spawning in the Detroit River but recent attempts to locate and improve spawning locations have been undertaken (Caswell et al. 2004; Roseman et al. 2011). In 2008, the historical spawning grounds near Fighting Island were restored and deemed successful in promoting Lake Sturgeon spawning. Mature spawning adults, as well as eggs and larvae, were collected at the site in 2009 and 2010 (Roseman et al. 2011).

Lower Niagara River (MU9)

The Lower Niagara River connects Lake Erie and Lake Ontario and is 58 km long (Hughes et al. 2005; Figure 15). The shoreline is heavily populated and industrialized both on the US and Canadian sides of the border. The river accounts for 80% of the water draining into Lake Ontario (5,000 m^3/s) and Niagara Falls represents a barrier to upstream fish movement (Hayashida et al. 1999).

Historically, the Lower Niagara River had an abundant population of Lake Sturgeon. Commercial and recreational harvest occurred on the Lower Niagara River until the early 1940s, but by 1950, sturgeon abundance was deemed to be very low and the fishery collapsed (Hughes et al. 2005). Hughes et al. (2005) used gillnets, setlines, and scuba diving to assess Lake Sturgeon abundance in the Lower Niagara River. Although CPUE varied between methods, CPUEs were low, suggesting Lake Sturgeon are present in the river at low abundances. The majority of fish captured by Hughes et al. (2005) were younger than age 10, indicating juveniles are present in the Lower Niagara River.

Eastern Lake Ontario-Upper St. Lawrence River (MU10; Figure 15)

Trent River

The Trent River flows into the northeast side of Lake Ontario near the start of the St. Lawrence River. Lake Sturgeon are believed to be extant within the Trent River but current population size and trajectory are unknown (Pratt 2008). More recent data suggest the population is remnant; any individuals observed were considered migrants (Tim Haxton, OMNRF, pers. comm.).

Upper St. Lawrence River

The upper St. Lawrence River is separated from the lower reach of the river by the Moses-Saunders GS (completed in 1958) upstream and the Beauharnois-Les Cedres GS (completed in 1961) downstream (Figure 15; Mailhot et al. 2011). Before construction of the two generating stations, Lake Sturgeon could freely move from the St. Lawrence estuary to the outlet of Lake Ontario (Roussow 1955). The St. Lawrence River is the outflow of the Great Lakes and is one of the largest rivers in Canada; average flow at Québec City is 12,600 m^3/s (Mailhot et al. 2011).

Commercial fishing occurred in the upper St. Lawrence, with catches peaking in Lake St. Francis at 8,700 kg in 1964 (Robitaille et al. 1988). The population however, was considered depleted as of the 1940s (Mailhot et al. 2011; Dumont and Mailhot 2013). Low abundances of Lake Sturgeon in Lake St. Francis are still evident as CPUEs remain very low and the frequency of sampling stations with sturgeon has not exceeded 3.3% during three surveys conducted in 1996, 2004 and 2009 (Dumont and Mailhot 2013). Presently, the abundance of Lake Sturgeon remaining in Lake St. Francis is critically low and recruitment is virtually nonexistent (Dumont and Mailhot 2013).

Ottawa River Watershed (MU11)

The Ottawa River is a highly fragmented river stretching 1,130 km from Lake Capitmitchigama in Québec to its confluence with the St. Lawrence River (Legget 1975). The river drains an area of approximately 146,000 km^2 with an average annual flow rate of 1,968 m^3/s at the Carillon GS upstream of the river's confluence with the St. Lawrence (Telmer 1996). There are nine reaches of the lower Ottawa River separated by either naturally occurring rapids or hydroelectric generating stations, including (from upstream to downstream): Lake Temiscaming, Lac la Cave, Holden Lake, Allumette Lake, Lac Coulonge, Lac du Rocher Fendu, Lac des Chats, Lac Deschênes, and Lac Dollard des Ormeaux (Figure 16).

Historically, Lake Sturgeon were abundant in the Ottawa River and its many tributaries with commercial catches peaking at 28,780 kg in 1898 (Dymond 1939). In addition to high commercial catch rates, both poor water quality and hydroelectric development contributed to a substantial reduction in Lake Sturgeon abundance (Harkness and Dymond 1961). Between 1880 and 1964, seven hydroelectric generating stations (Otto Holden, Des Joachims, Bryson, Chenaux, Chats, Chaudiere, and Carillon) were built on the Ottawa River and a further 36 dams were built on its tributaries (Haxton 2002; 2011). Commercial fishing activities in the Ottawa River were closed completely in 2012–2013 (T. Haxton, OMNRF, pers. comm.).

Currently, Lake Sturgeon are known to exist in all nine major reaches of the Ottawa River from Lake Temiscaming to the Carillon GS with spawning believed to occur below most generating stations (Haxton 2008). Until recently, little research has been done to establish the status and trajectory of Lake Sturgeon populations within the different reaches of the Ottawa River. Lake Sturgeon populations in the Ottawa River are considered to be recovering although variations in population size have been observed (Y. Paradis, pers. comm.).

Lake Temiscaming

Lake Temiscaming is 93 km long with a surface area of approximately 25,507 km^2 and is controlled by the Public Works dam (Haxton 2011). A commercial fishery existed in the Québec portion of the lake which closed in 2012. From 1986 to 2009 commercial landings of Lake Sturgeon varied from year to year, likely due to variations in fishing effort but still averaged 118 individuals per year.

In 2008, 52 large-mesh (38–127 mm) gillnets were set in the lake, resulting in the capture of only two Lake Sturgeon. These data suggest Lake Sturgeon abundance and recruitment are low in Lake Temiscaming (T. Haxton, OMNRF, pers. comm.). Similarly, during Walleye monitoring conducted by the province of Québec, Lake Sturgeon were captured infrequently.

Lac la Cave

The 49 km long Lac la Cave stretches from the Public Works dam at the outflow of Lake Temiscaming downstream to the Otto Holden GS and has a surface area of 3,028 km^2 (Haxton 2011). The Lake

Sturgeon population within Lac la Cave is believed to be low as no sturgeon were caught during fall Walleye index netting in 1998 or during near shore community index netting in 2004 (18 and 16 net sets, respectively) (Haxton and Findlay 2008). In 2010, a single Lake Sturgeon was caught in 28 net sets further suggesting Lake Sturgeon abundance is low in the lake (Haxton 2011). Recruitment is believed to be minimal at present (Haxton and Findlay 2008).

Holden Lake

The Holden Lake reach stretches 90 km from the Otto Holden GS downstream to the Des Joachims GS (Haxton 2011). Similar to the other reaches of the Ottawa River, Holden Lake supported a commercial fishery for Lake Sturgeon. By 1987, a sturgeon harvest was not recorded despite a quota of 800 kg (Fortin et al. 1992). This suggests abundance was low in the lake by this time.

Holden Lake was historically believed to have several spawning locations near Mattawa. In 2006, twenty-six Lake Sturgeon were captured in gillnets below the Otto Holden GS, but none were captured at any of the other possible spawning sites (Haxton 2006). Studies carried out on Holden Lake in 1998, 2003, 2004, and 2009 were unsuccessful in capturing Lake Sturgeon (Haxton and Findlay 2008; Haxton 2011). Based on these results, the abundance of Lake Sturgeon in Holden Lake is likely low as recruitment is limited (Haxton and Findlay 2008), but a small spawning population may exist downstream of the Otto Holden GS.

Allumette Lake

The Allumette Lake reach is one of the few unimpounded reaches of the Ottawa River. The lake covers an area of 17,825 km^2 and is split into two zones by the Allumette Rapids (Haxton 2008). The two zones are known as upper (approximately 78 km long) and lower (approximately 22 km long) Allumette Lake (Haxton 2011).

Several population studies have been carried out in both reaches of Allumette Lake since 1999. Between 1998 and 2001, CPUE was highest in both lower (1999: 2.9 sturgeon/net set) and upper (2001: 2.13 sturgeon/net set) Allumette Lake when compared with the other reaches of the Ottawa River (Haxton 2002). Spawning assessments, conducted in 2001, 2004, and 2007, captured a total of 201 Lake Sturgeon (Haxton 2008). In a recent study conducted between 2008 and 2010, 58 Lake Sturgeon were caught in 44 overnight gillnet sets (Haxton 2011). According to Haxton and Findlay (2008), the relatively undisturbed nature of both upper and lower Allumette Lake has helped to create a robust Lake Sturgeon population within the reach.

Lac Coulonge

Similar to Allumette Lake, Lac Coulonge is not impounded and stretches a total of 18.1 km downstream from Allumette Lake to Lac Du Rocher Fendu (Haxton 2011). Little is known about spawning within Lac Coulonge but the lack of barriers preventing upstream movement suggests sturgeon have access to spawning sites within Lac Coulonge and potentially further upstream. Haxton (2011) found the

probability of catching Lake Sturgeon was higher in the unimpounded reaches of the Ottawa River (Allumette Lake and Lac Coulonge) when compared to impounded reaches. Data collected between 2008 and 2010, suggested CPUE was highest in Lac Coulonge (approximately 4.2 sturgeon/net set) when compared with other Ottawa River reaches (Haxton 2011). Within the three contiguous reaches of the Ottawa River (lower and upper Allumette Lake and Lac Coulonge) it appears Lac Coulonge may be an important juvenile nursery area with larger more mature sturgeon eventually migrating upstream (Haxton 2011). According to Haxton (pers. comm.), the population between Allumette Lake and Lac Coulonge is shared and robust.

Lac du Rocher Fendu

Lac du Rocher Fendu is controlled at the downstream end by the Chenaux GS and stretches approximately 31 km upstream with a surface area of 3,893 km^2 (Haxton 2011). Historical spawning grounds are believed to have existed upstream of Portage du Fort, but were flooded by the construction of the Chenaux GS in 1948. However, Lake Sturgeon abundance information prior to construction of the GS is limited (Haxton 2008).

It is believed recruitment within this stretch of the Ottawa River is low due to the lack of available spawning habitat (Haxton 2008). Low CPUE values from 1999 (0.44 sturgeon/net set), 2000 (0.38 sturgeon/net set), and 2009 (0.33 sturgeon /net set), suggest adult Lake Sturgeon abundance in the reach is low. Recruitment is also believed to be low in the reach at present (T. Haxton, OMNRF, pers. comm.).

Lac des Chats

Controlled at the downstream end by the Chats Falls GS, Lac des Chats stretches 40 km upstream to the Chenaux GS and covers an area of 7,513 km^2 (Haxton 2011).

Aggregations of high numbers of Lake Sturgeon below the Chenaux GS during the spawning season have been documented (Haxton 2008). In 2007, eighteen Lake Sturgeon were sampled below the Chenaux GS and three larvae were captured in drift traps suggesting successful spawning had occurred. CPUE in Lac des Chats has varied between study years going from 0.26 sturgeon/net set in 1998 to 0.03 sturgeon/net set in 2009, suggesting Lake Sturgeon exist at low abundances in the lake (Haxton 2002, Haxton 2011). More recently, in 2014, 41 Lake Sturgeon were captured during netting in spring and fall (CPUEs not provided) (D. Gibson, Ontario Power Generation, pers. comm.). Few juveniles are observed in this section of the Ottawa River (T. Haxton, OMNRF, pers. comm.). Based on collected data, Lake Sturgeon abundance in Lac des Chats, both adult and juvenile, is considered low (T. Haxton, OMNRF, pers. comm.).

Lac Deschênes

Lac Deschênes runs approximately 53 km downstream from the Chats Falls GS to the Chaudière Falls dam and covers an area of approximately 10,900 km^2 (Haxton 2011).

A spawning study carried out in the Lac Deschênes reach of the Ottawa River downstream of the Chats GS from 2001–2004 yielded a spawning population estimate of 202 individuals in 2003 (Haxton 2006). Despite the relative success at capturing spawning individuals in 2003 a study in 2009 only captured seven Lake Sturgeon in Lac Deschênes for a CPUE of 0.22 sturgeon/net set (Haxton 2011). Spawning habitat was created downstream of the Chats Falls GS in fall 2012 and monitoring was conducted from 2013 to 2015 to determine use of the created habitat. Adult Lake Sturgeon were observed each year, although data collection was met with several challenges. Larval fish were captured in 2015 confirming successful spawning occurred downstream of the GS (D. Gibson, OPG, pers. comm.). Abundance of Lake Sturgeon in the reach is thought to be low (T. Haxton, OMNRF, pers. comm.).

Lac Dollard des Ormeaux

The farthest downstream reach of the Ottawa River, Lac Dollard des Ormeaux is a approximately 113 km long stretch of river with a surface area of 14,414 km^2 (Haxton 2011). Lac Dollard des Ormeaux is controlled by the last dam on the Ottawa River, Carillon GS, before spilling into the St. Lawrence River. Commercial fisheries were shut down in the reach in 1987 due to concerns over mercury contamination.

Little is known about Lake Sturgeon populations in Lac Dollard des Ormeaux. In 2009, 41 Lake Sturgeon were captured in 28 over-night broad scale net sets (CPUE of 1.46 sturgeon/net set) (Haxton 2011). Based on these CPUE values, adult abundance is thought to be low, but juvenile abundance is thought to be moderate (T. Haxton, OMNRF, pers. comm.).

The Gatineau River is one of the main tributaries of the Lac Dollard des Ormeaux reach of the Ottawa River. It stretches 386 km from its headwaters in the Baskatong Reservoir to the confluence with the Ottawa River in Gatineau, Québec. The River is regulated by the Mercier dam located 25 km north of the St. Joseph Rapids.

Lake Sturgeon studies have been carried out on the upper Gatineau River and several of its tributaries located in the Kitigan Zibi Anishinabeg Algonquin First Nation Reserve (Dery 2012). Between 2006 and 2011, 33 Lake Sturgeon were radio tagged in the Hibou-Eagle-Desert-Gatineau river system in order to characterize habitat and to determine differences in seasonal movement patterns. There are many potential spawning sites in the upper Gatineau River system however, none have been confirmed (Kitigan Zibi Anishinabeg First Nation 2015). Recently, effort has been directed at assessing the population size within the system, and in 2015, 10 Lake Sturgeon were captured (CPUE: 0.011 sturgeon/net hours) (Kitigan Zibi Anishinabeg First Nation 2015).

Lower St. Lawrence River (MU12)

The lower St. Lawrence River stretches approximately 350 km from Lac St. Louis downstream of the Beauharnois-Les Cedres GS to the St. Lawrence estuary downstream of Québec City (Mailhot et al. 2011). This reach also includes the Ottawa River downstream of the Carillon Dam to the confluence with the St. Lawrence River (Figure 17). The St. Lawrence River and the Ottawa River converge in Lac Saint Louis and Lac des deux Montagnes, enlargements of each river, respectively. Lake Sturgeon

utilize the entire 350 km long reach and are known to spawn in the St. Lawrence River and lower sections of St. Lawrence River tributaries below the lower most barrier. At least 16 spawning sites have been identified. Spawning tributaries include the Des Prairies, des Mille-Îles, l'Assomption, Ouareau, Richelieu, Saint-François, Saint-Maurice, Batiscan, Chaudière and Montmorency rivers (Fortin et al. 1992; Valiquette 2016). Given the importance of the commercial and domestic fishery, a considerable amount of research has been conducted on this population making it one of the most well studied populations in Canada.

Commercial and domestic harvest has, and continues to be prevalent in this stretch of river. For example, people of Kahnawake still maintain a subsistence fishery at Lachine rapids, in front of Montréal, at the outlet of Lac Saint-Louis. In terms of the commercial fishery, from 1920 to 1984, commercial harvest remained fairly consistent in the lower St. Lawrence River which is considered atypical for commercial fisheries of this species (Mailhot et al. 2011; Dumont and Mailhot 2013). Dumont et al. (1987) suggested the ability of this stock to sustain harvest for 60+ years without collapse may be due in part to the high productivity of the system and management measures that imposed restrictions on fishing areas and the use of gillnets (19 to 20 cm stretched) that select for 'smaller' sized individuals. Circa 1987, this population was largely considered to be over-exploited (Dumont et al. 1987; LaHaye et al. 1992). A management plan was developed between 1987 and 1991 that was gradually implemented to reduce the catch, protect spawning adults and strengthen enforcement (Mailhot et al. 2011; Dumont and Mailhot 2013). Considerable amounts of data and research collected on this population during the early, mid and late 1990s (LaHaye et al. 1992; Fortin et al. 1992; Nilo et al. 1997) suggested the population continued to be overexploited, and the 1987 management plan was ineffective at protecting the population. As a result, new management measures were implemented during the 2000–2002 period which included the reduction of the quota to 80 tonnes where it has since been maintained. Other management actions included the shortening of the fishing season by two months, a minimum size limit of 800 mm total length, requirements for each sturgeon to be registered and a sustained effort to control poaching.

In 2013, a new diagnosis on the status of St. Lawrence River Lake Sturgeon was made to assess the effectiveness of management actions applied in the commercial fishery during the 2000–2002 period (Dumont and Mailhot 2013). Contemporarily, several indicators show the population has responded well to the last management plan. The species recovery is gradual and noticeable at all stages of the life cycle.

In the upstream portions of the river, the abundance of juveniles and sub-adults is increasing as their presence has been documented in a significantly higher proportion of sampling stations in the St. Lawrence River fish monitoring network. Annual variations in year class strength were in the range of 5:1; but variations have generally been in the range of 2:1 except in the case of very strong year classes of 1993, 1994 and 2002. These very large year classes have a noticeable influence on the state of the population. Thus, those of 1993 and 1994 are the source of the significant increase in the abundance of juveniles and sub-adults in Lac Saint Louis. Studies on Lake Sturgeon recruitment on the Des Prairies River spawning ground also show year class strength is dependent on the number of larvae produced and

hydrological and climatic factors (Nilo et al 1997; Dumont et al. 2011.). These observations strongly suggest an abundant larval production allows the appearance of a strong year class in high flow conditions (greater than 1,150 m^3/s) in June during the larval drift period. However, the analysis clearly demonstrates changes in the number of larvae produced are also strongly and inversely correlated to both the increase/decrease of commercial landings of the previous year. The decrease in the commercial fishing quota in 2000–2002 could therefore have effectively protected the spawning stock during the period of monitoring. In addition to the decrease in landings, an increase in egg to larva survival rate was observed after the improvement in surface area of the major spawning ground in 1996 (Dumont et al. 2011).

Recent studies have shown that the number of Lake Sturgeon spawning grounds is higher than previously expected (Valiquette 2016). Important spawning aggregations were recently observed in five rivers (Des Milles Îles, Richelieu, Chaudière, Montmorency and Du Sud). It is now thought this population has access to at least 16 spawning grounds mainly located in tributaries all along the St. Lawrence River up to the estuary. The surface area and substrate quality of several spawning grounds have been improved during the last 25 years (Dumont et al. 2011).

The current commercial fishing management plan was implemented in 2012 and included the following measures: a quota of 80 tonnes, a slot size limit of 800–1,305 mm for juveniles and spawning adult protection, mesh size of gillnets restricted to 19–20.3 cm, a fishing season from June 14 to July 31 and September 14 to October 31, the identification of each sturgeon captured with a numbered seal and fish weight on a barcode ticket and a sustained effort to control poaching in the main fishing sectors. The protection offered to the spawning stock by applying a maximum size limit to commercial catches has also been extended to sport fishing which is thought to be increasing in the St. Lawrence River with unknown impacts to Lake Sturgeon. For sport fishing, the new management plan includes the following measures: a daily bag limit of one sturgeon, a season from June 14 to October 31 and a slot size limit of 800–1,305 mm.

Large quantities of data have also been collected from several specific reaches within MU12 (i.e., Lac Des Deux Montagnes and several spawning tributaries). Some of these data are described by location below.

Lac Des Deux Montagnes

The Lake Sturgeon population of Lake Des Deux Montagnes was decimated in the late 1940s by a prolonged episode of anoxia under ice cover caused by excessive intakes of municipal and industrial effluents (pulp mills) in the Ottawa River (Dumont and Mailhot 2013). In 1964, the construction of the Carillon GS submerged spawning areas and prevented further upstream movement. Monitoring conducted in the 1960s and late 1970s suggested a complete lack of fish born prior to 1951. Mongeau et al. (1982) reported 30 years after the anoxic event, only seven age classes were detected in scientific sampling. However, during sampling conducted in 2010, Lake Sturgeon were caught at 41% of the sampling stations fished with standard gillnets and in 67% of sampled stations with large mesh gillnets

(20.3 to 30.5 cm mesh size). Sixty years after the anoxic event, the survey conducted in 2010 confirms the low relative abundance of Lake Sturgeon in Lac Des Deux Montagnes.

In 2011, a man-made spawning ground of 4,300 m^2 was built at the outlet of Lac Des Deux Montagnes, but no sturgeon eggs were captured during a three-year survey conducted in 2012, 2014 and 2016 (D. Hatin, Ministry of Forest, Wildlife and Parks, unpublished data). However, 10 Lake Sturgeon of adult size (TL: 833–1,178 mm) were captured on this new spawning ground in May 2016 (D. Hatin, Ministry of Forest, Wildlife and Parks, unpublished data).

Richelieu River

The Richelieu River is 124 km long and empties into the St. Lawrence River with an annual average discharge of 362 m^3/s (Thiem et al. 2013). Eggs and larvae were collected downstream of the St. Ours dam in 2011 (Thiem et al. 2013). The St. Ours dam once represented a barrier to upstream movement, but a vertical slot fish-way was built in 2001 and was used by a small number of Lake Sturgeon to move upstream of the dam (Thiem et al. 2011). No population estimate is available for the river but a daily estimate of the number of spawning individuals present at the base of the St. Ours dam in 2011 ranged from 285–1,282 (Thiem et al. 2013).

Des Prairies River

The Des Prairies River is a tributary of the St. Lawrence River with an average annual flow of 1,100 m^3/s (Dumont et al. 2011). Historically, Lake Sturgeon populations within the Des Prairies River and the associated reach of the St. Lawrence River experienced heavy commercial fishing pressure (Dumont et al. 1987).

Spawning occurs downstream of the Rivière-des-Prairies GS and represents the largest of 16 confirmed spawning sites on the St. Lawrence River system (Dumont et al. 2011; Valiquette 2016). Due to the importance of the site to the long term future of Lake Sturgeon in the reach the spawning site was expanded twice, once in 1985 (increased by 5,000 m^2) and again in 1996 (increased by 8,000 m^2). The estimated number of spawning Lake Sturgeon visiting the Rivière-des-Prairies GS spawning site on an annual basis from 1994 to 2003 varied from 9,657 in 1996 to 4,170 in 1999 (Dumont et al. 2011).

The L'Assomption River, of which the Ouareau River is a tributary, flows into the Des Prairies River near its confluence with the St. Lawrence River (LaHaye et al. 1992). The spawning grounds within the L'Assomption River, located near the city of Joliette, are a set of impassable rapids (LaHaye et al. 1992). Unlike the spawning site in the Des Prairies River the site in the L'Assomption River is relatively unaltered.

Saint François River

The Saint François River flows into the St. Lawrence River at the west end of Lac St. Pierre. There are three generating stations on the Saint François River: Chute-Burroughs GS (completed in 1929), Chute-Hemmings GS (completed in 1925), and the Drummondville GS (completed in 1910) the farthest

downstream generating station on the river located in the town of Drummondville, Québec (Hydro Québec unpublished data). Spawning within the river is known to take place below the Drummondville GS (DFO 2016). Using the Schnabel index, the abundance of spawners was estimated at 111 (57–418; CI 95%), including five (3–20; CI 95%) females (DFO 2016).

In summary, in the lower 350 km of the St. Lawrence River, the abundance of sub-adult and adult Lake Sturgeon are high and stable, with significant recruitment occurring annually; further, the number of known spawning sites has increased over the years and at least four spawning grounds are used by more than 1,000 spawners annually (Valiquette 2016). In 2013, a new management plan was released confirming the actual commercial fishing quota (80 tonnes per year) was sustainable and imposed a slot size of 800–1,305 mm to increase protection of the spawning stock (Dumont and Mailhot 2013). In the upstream sector specifically, the abundance of juveniles and sub-adults is increasing, and the frequency of occurrence is increasing at standard sampling locations. Further, the age of the specimens caught in the commercial fishery is widespread between the last 10 and 35 years. Recruitment, although variable, has been annual since at least 1984. Interestingly, commercial fishers who target the Atlantic Sturgeon (*Acipenser oxyrinchus*) in the estuary have noticed a higher abundance of Lake Sturgeon in their catch in the last few years. Catches have even occurred in habitats with quite high salinity where Lake Sturgeon have been historically absent (L. L'Italien pers. comm.).

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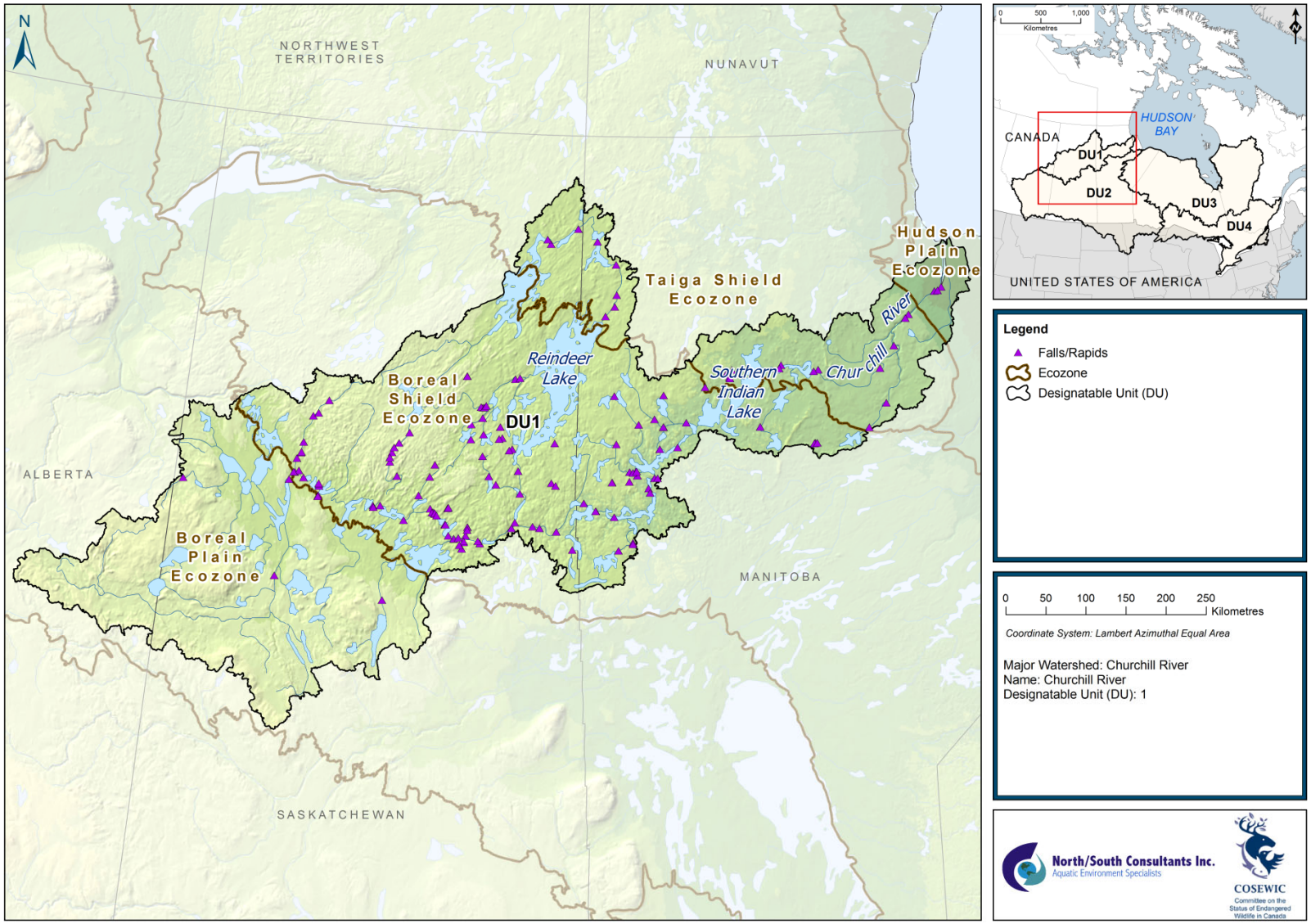

Figure 1. Western Hudson Bay aquatic ecoregion showing the terrestrial ecozones and locations of officially named rapids and falls.

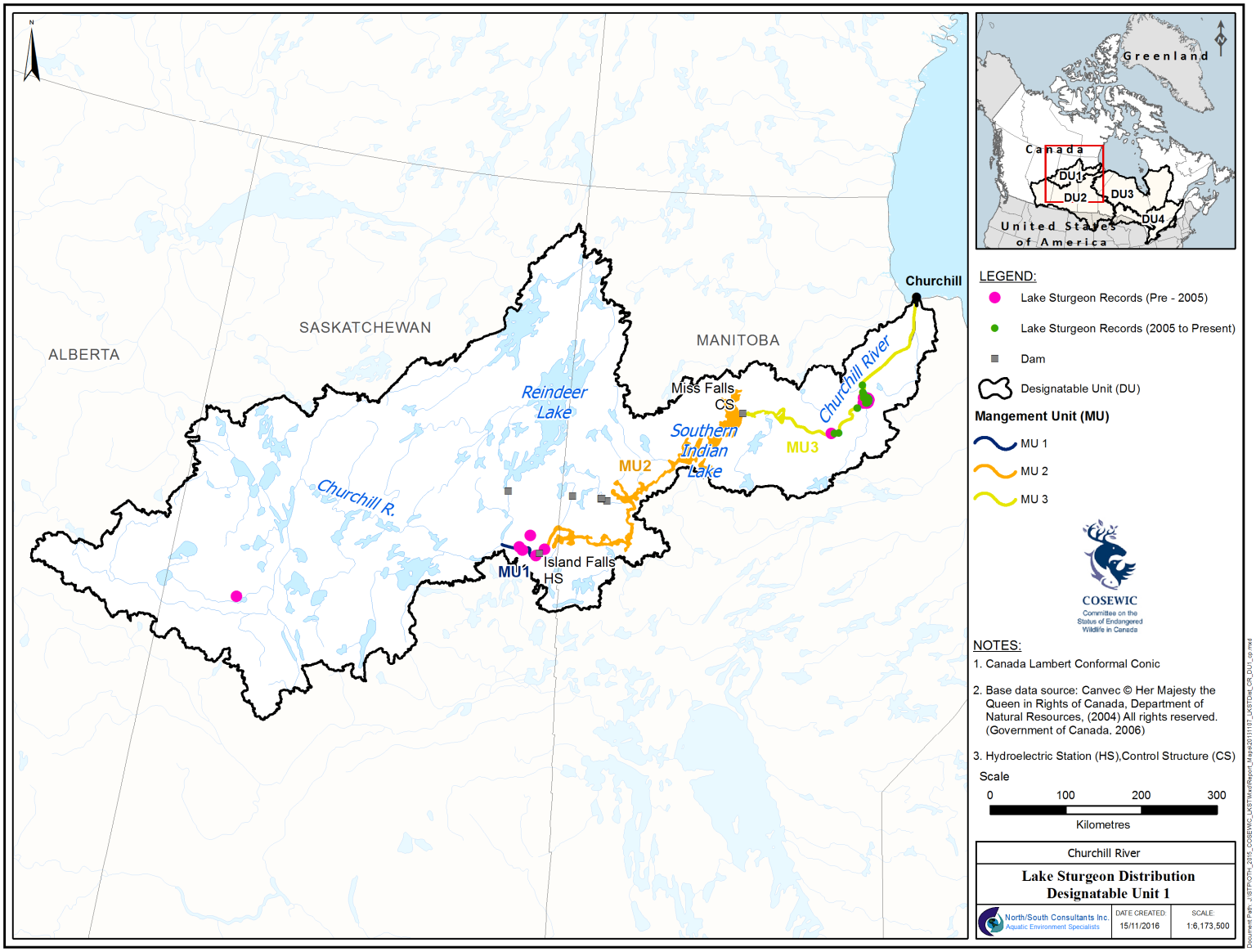

Figure 2. Historical and contemporary Lake Sturgeon distribution in the Churchill River (DU1), showing the location of current management units.

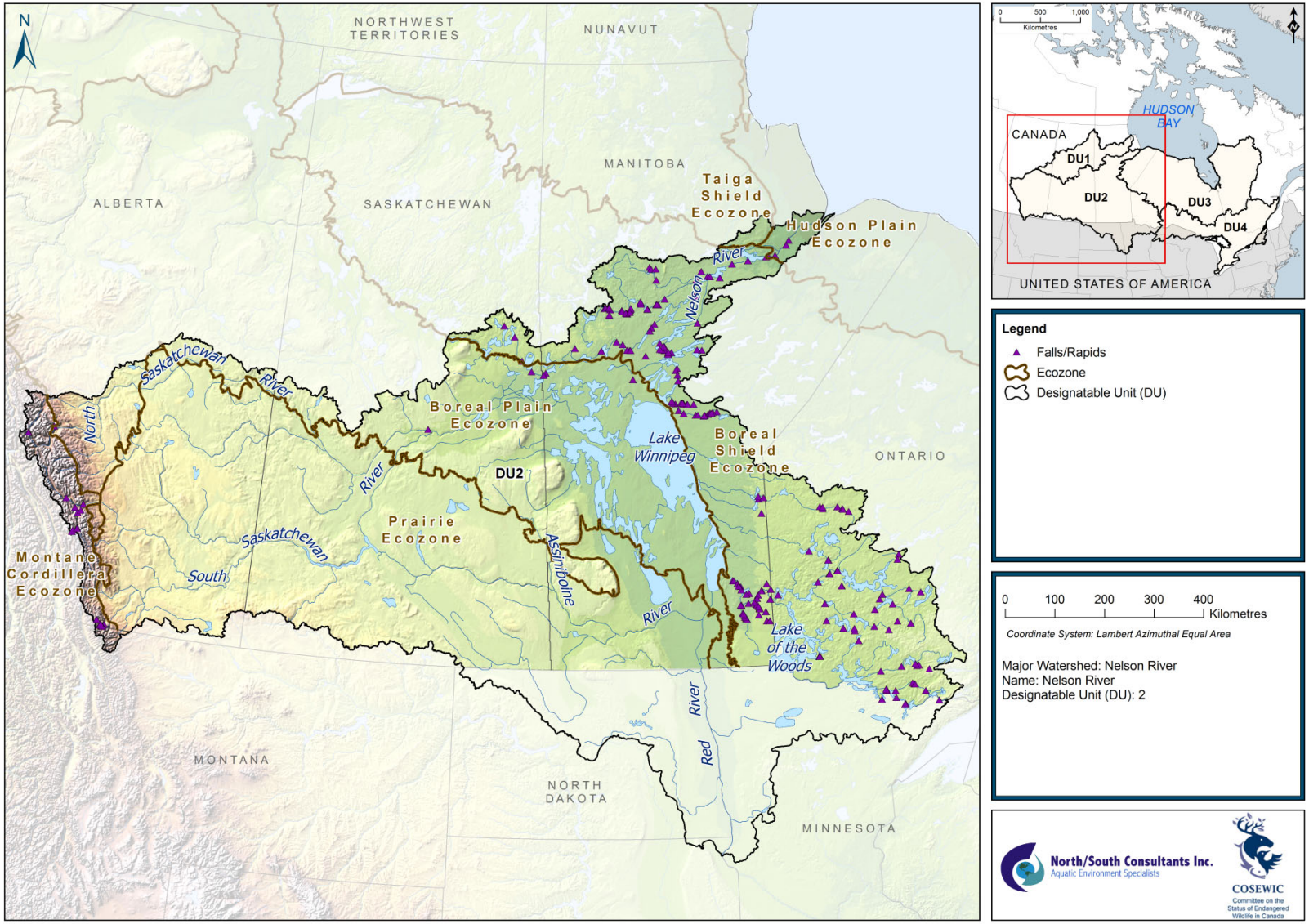

Figure 3. Saskatchewan-Nelson River (DU2) showing the terrestrial ecozones and locations of officially named rapids and falls.

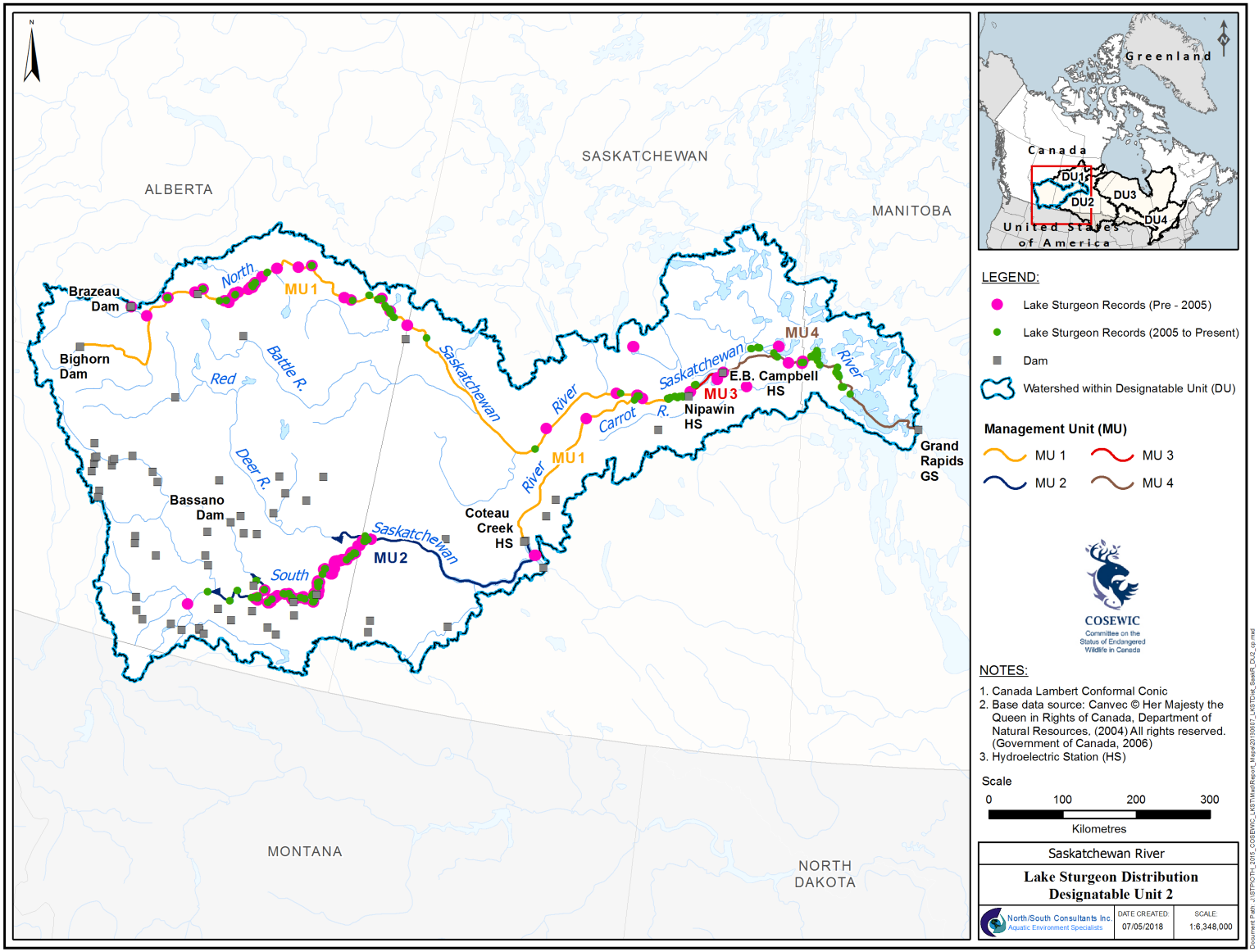

Figure 4. Historical and contemporary Lake Sturgeon distribution in the Saskatchewan River (DU2), showing the location of current management units.

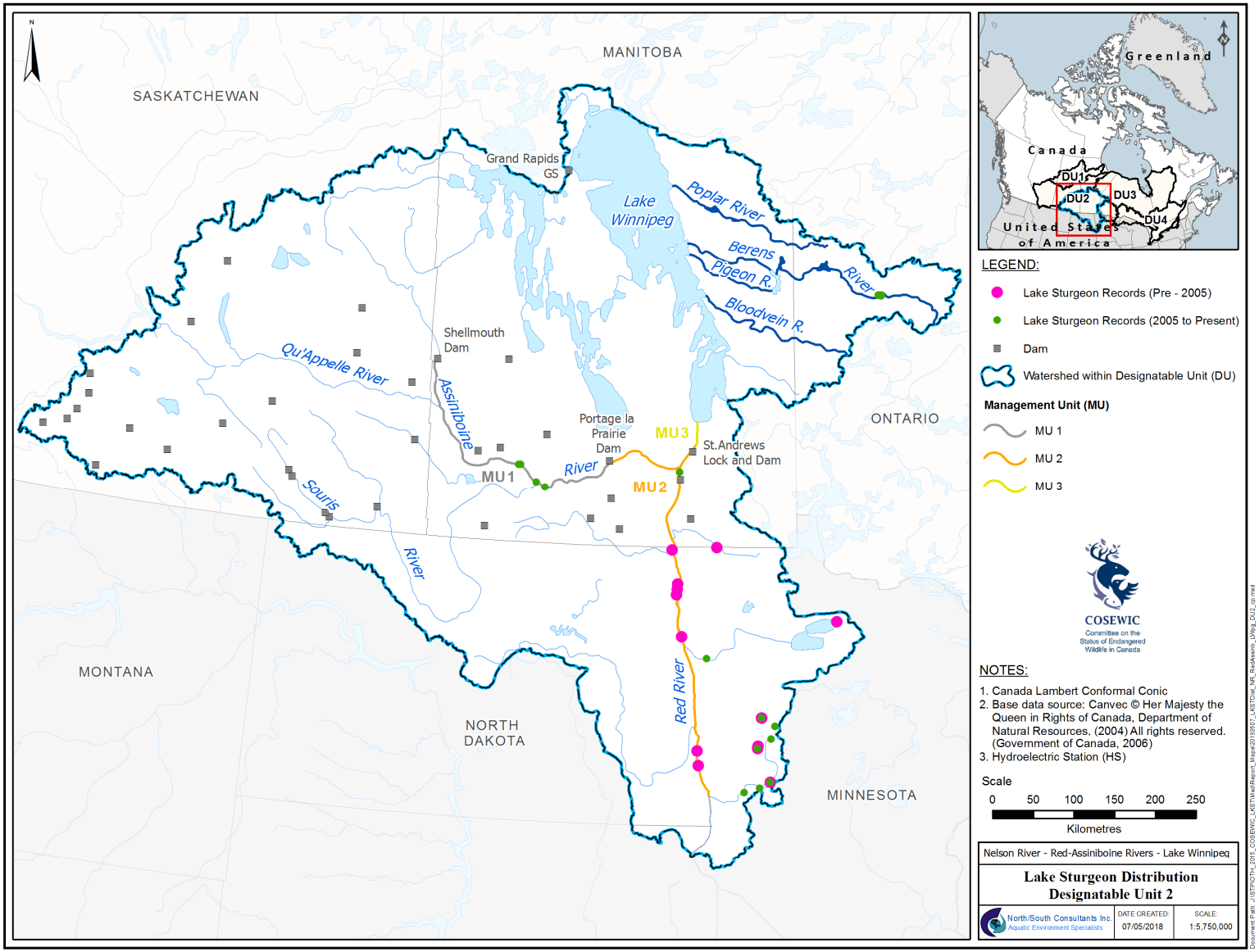

Figure 5. Historical and contemporary Lake Sturgeon distribution in the Red-Assiniboine Rivers-Lake Winnipeg (DU2), showing the location of current management units.

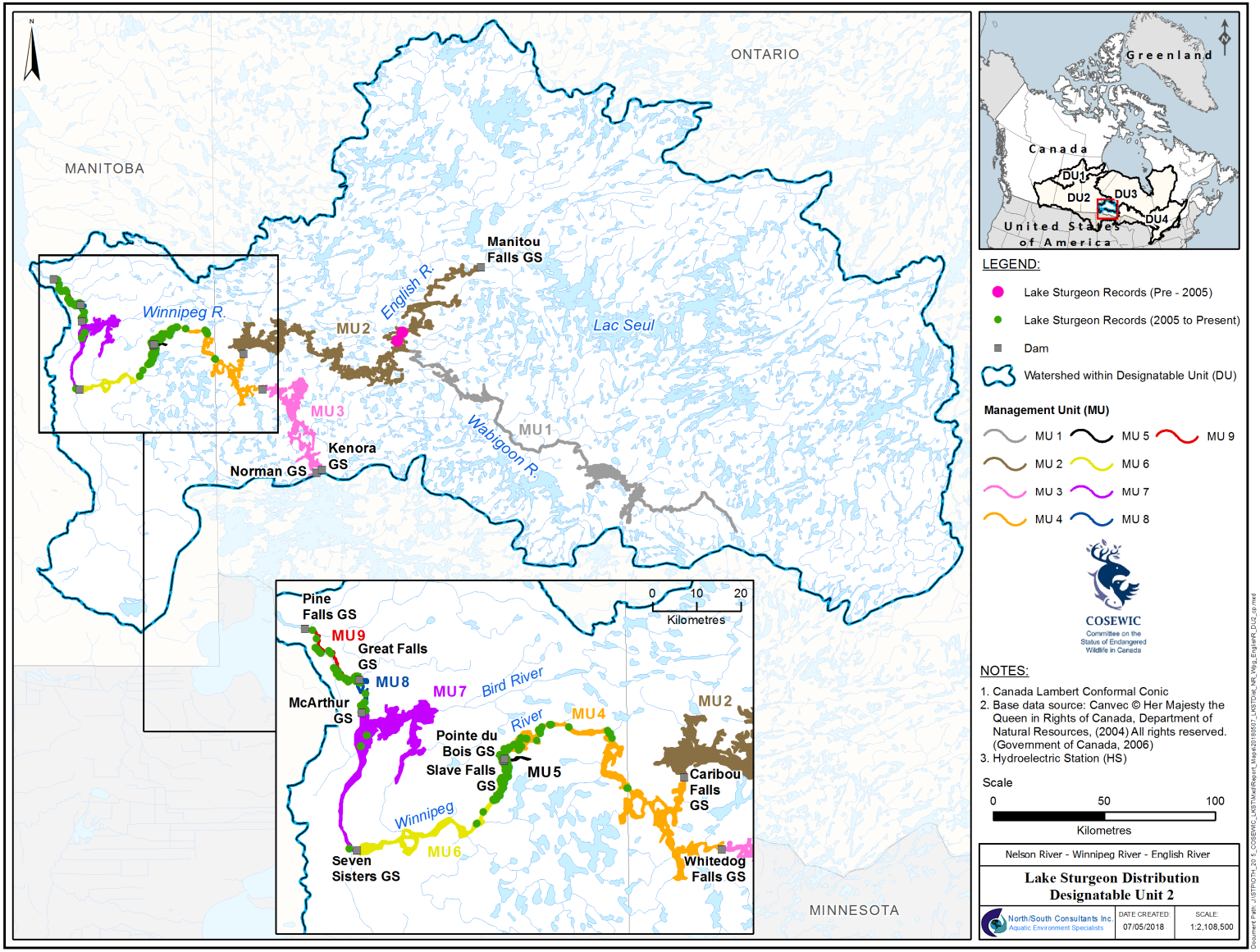

Figure 6. Historical and contemporary Lake Sturgeon distribution in the Winnipeg River-English River (DU2), showing the location of current management units.

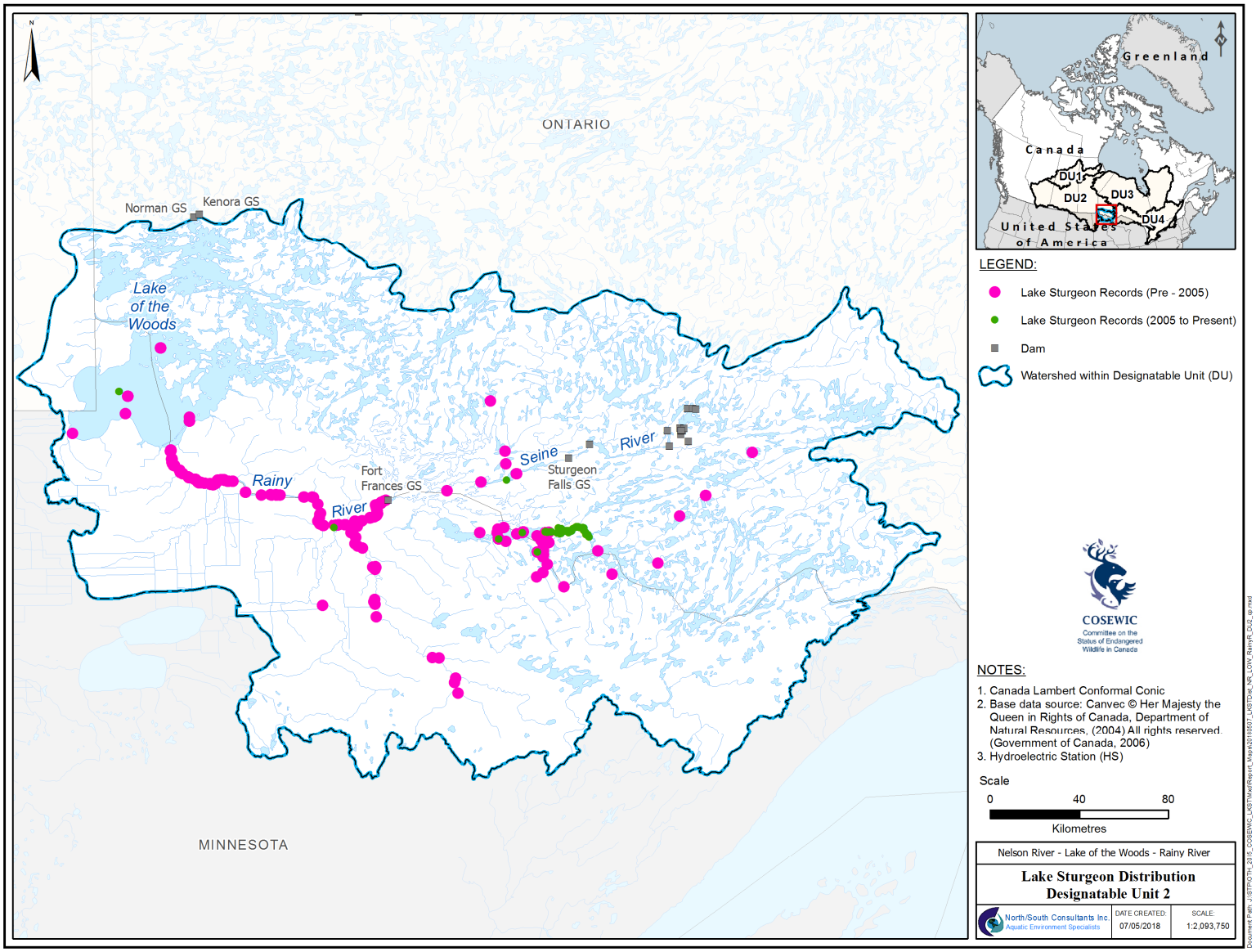

Figure 7. Historical and contemporary Lake Sturgeon distribution in the Lake of the Woods-Rainy River (DU2), showing the location of current management units.

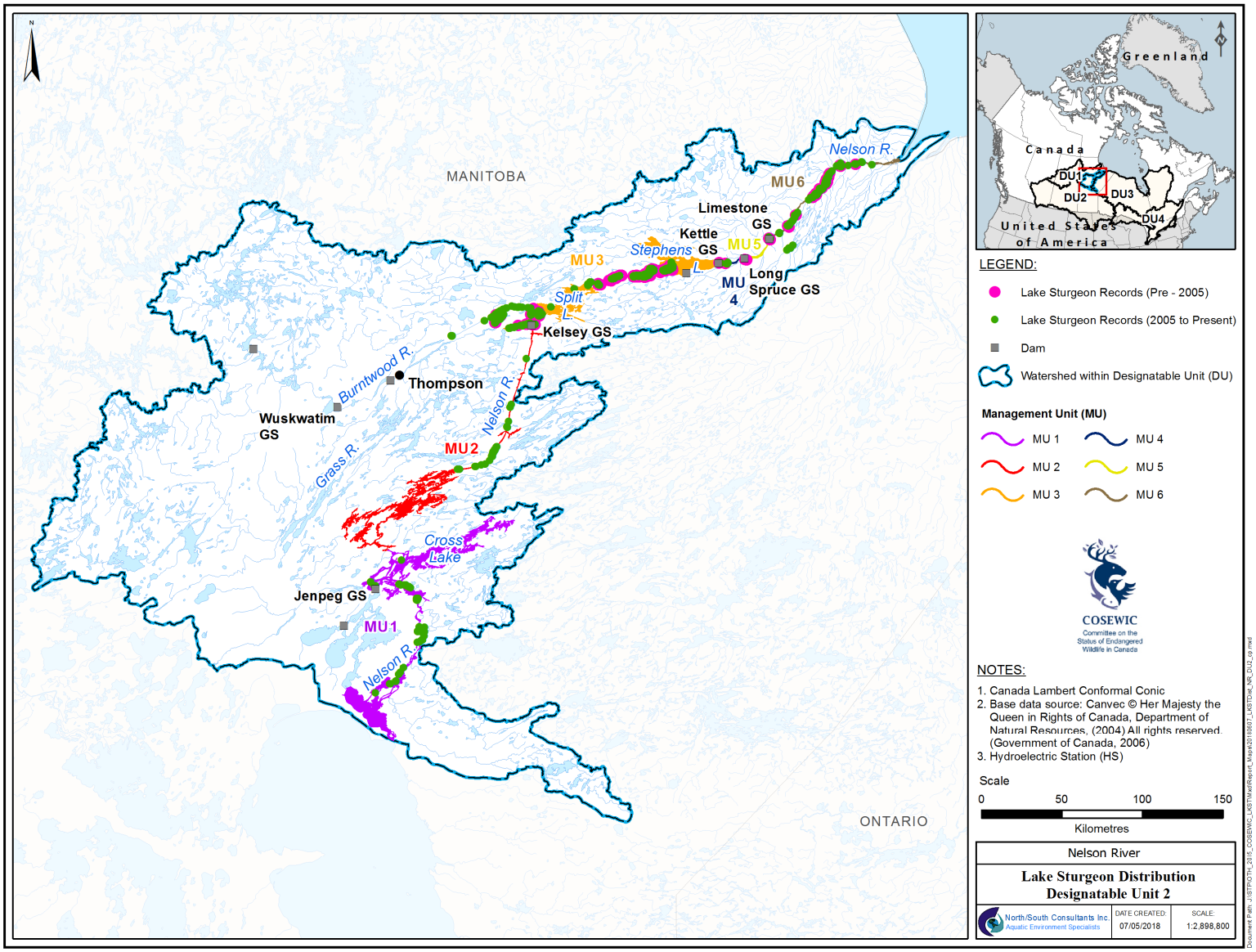

Figure 8. Historical and contemporary Lake Sturgeon distribution in the Nelson River (DU2), showing the location of current management units.

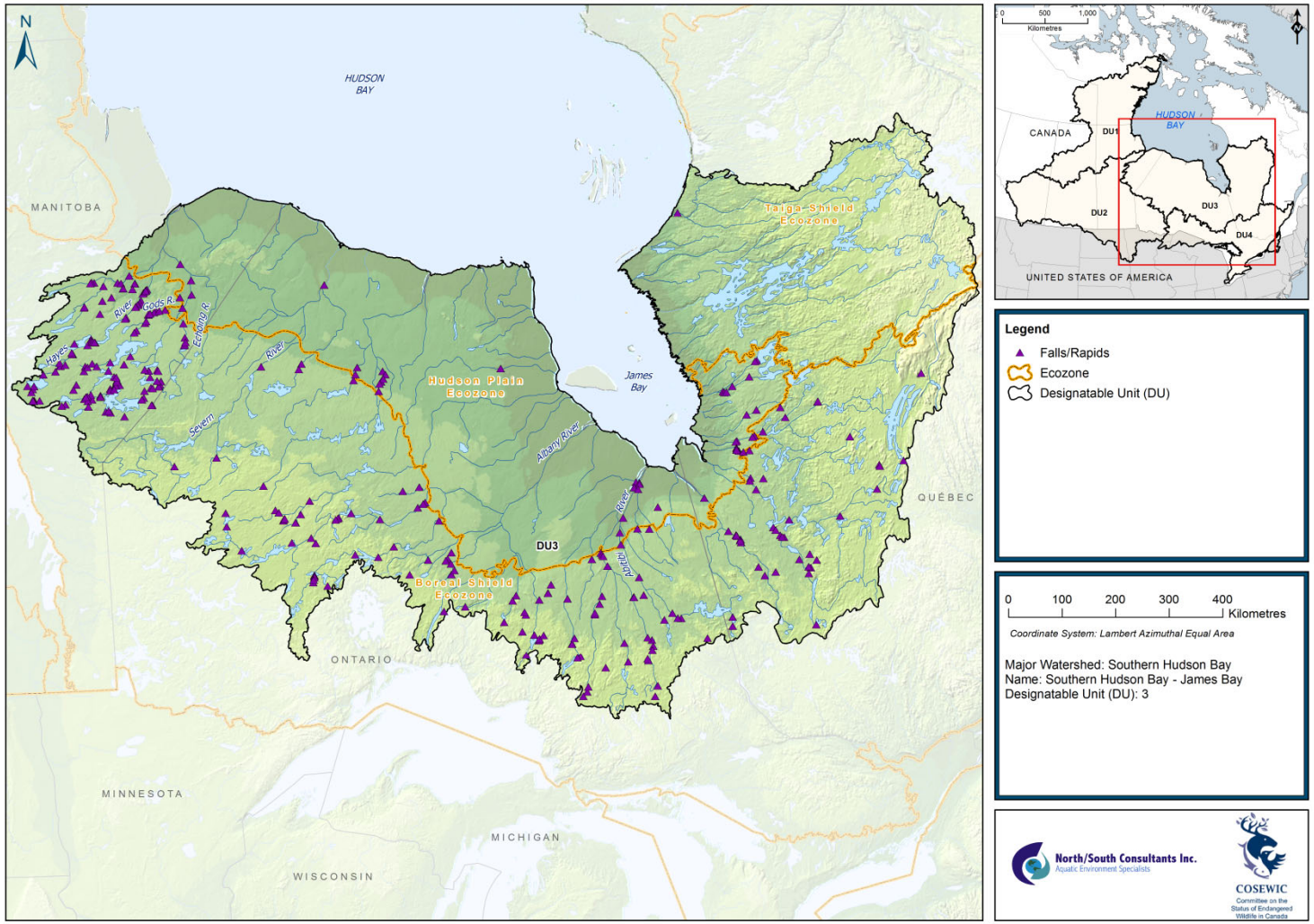

Figure 9. DU3 (Southern Hudson Bay-James Bay) showing the terrestrial ecozones and locations of officially named rapids and falls.

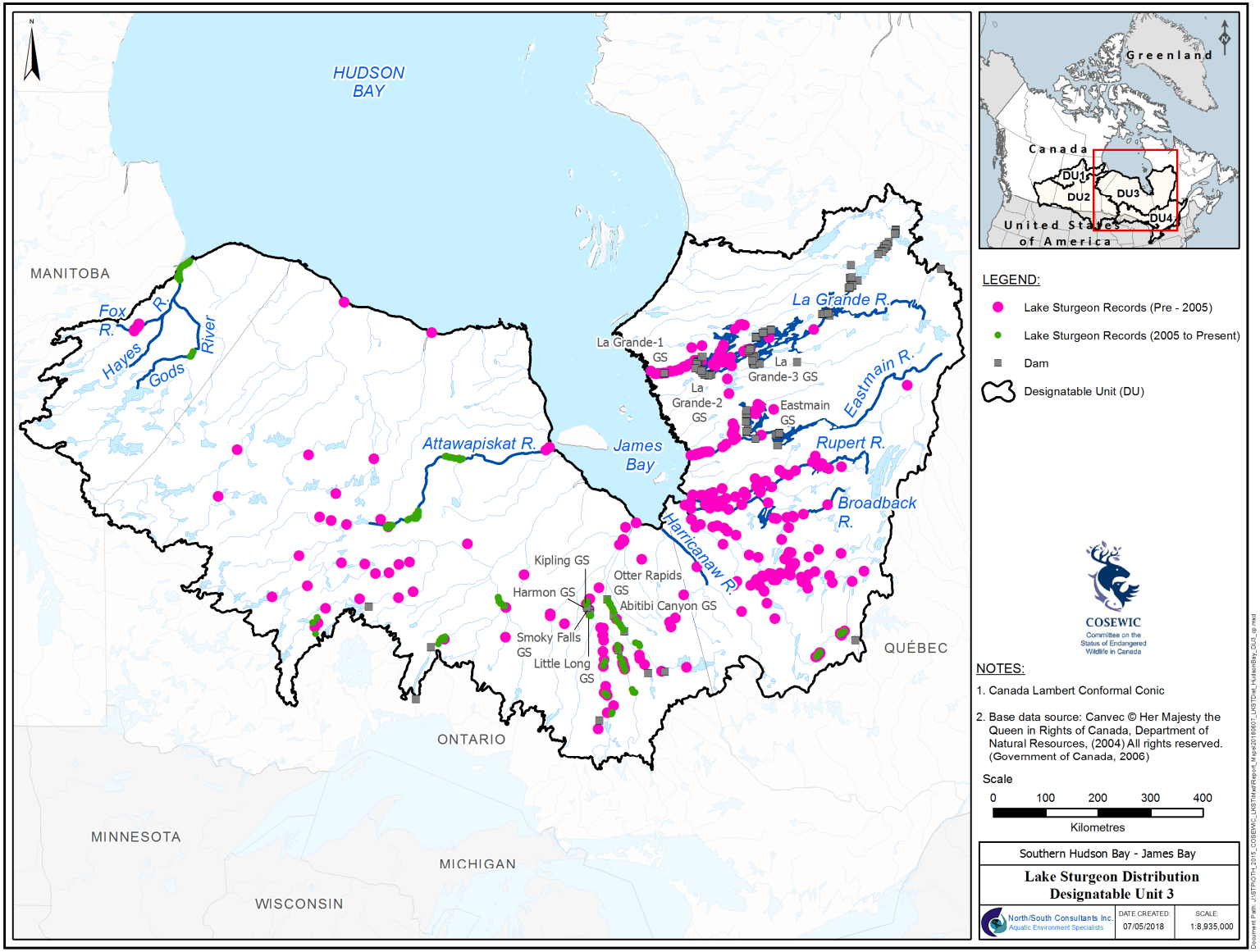

Figure 10. Historical and contemporary Lake Sturgeon distribution in DU3 (Southern Hudson Bay-James Bay).

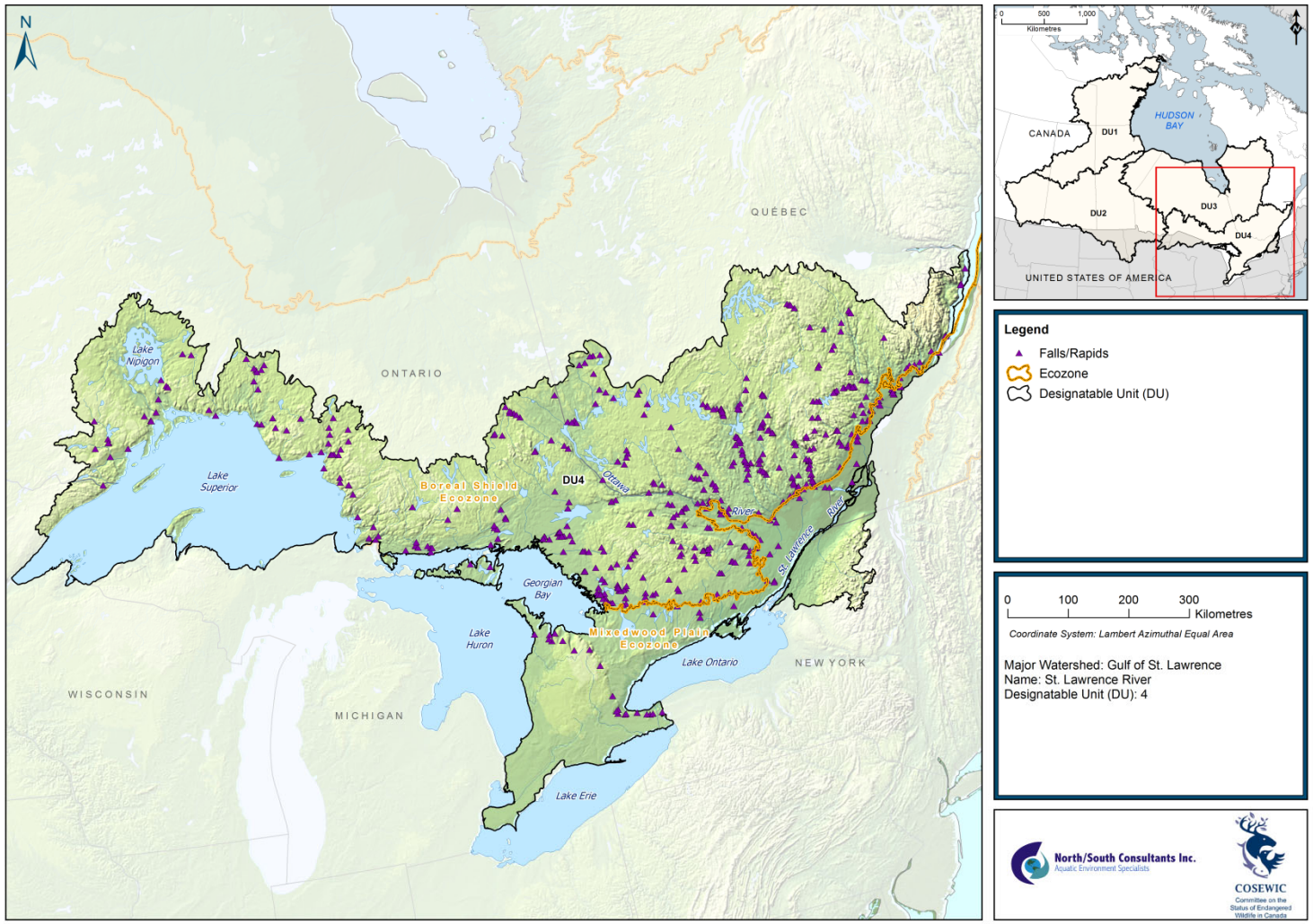

Figure 11. DU4 (Great Lakes-Upper St. Lawrence) showing the terrestrial ecozones and locations of officially named rapids and falls.

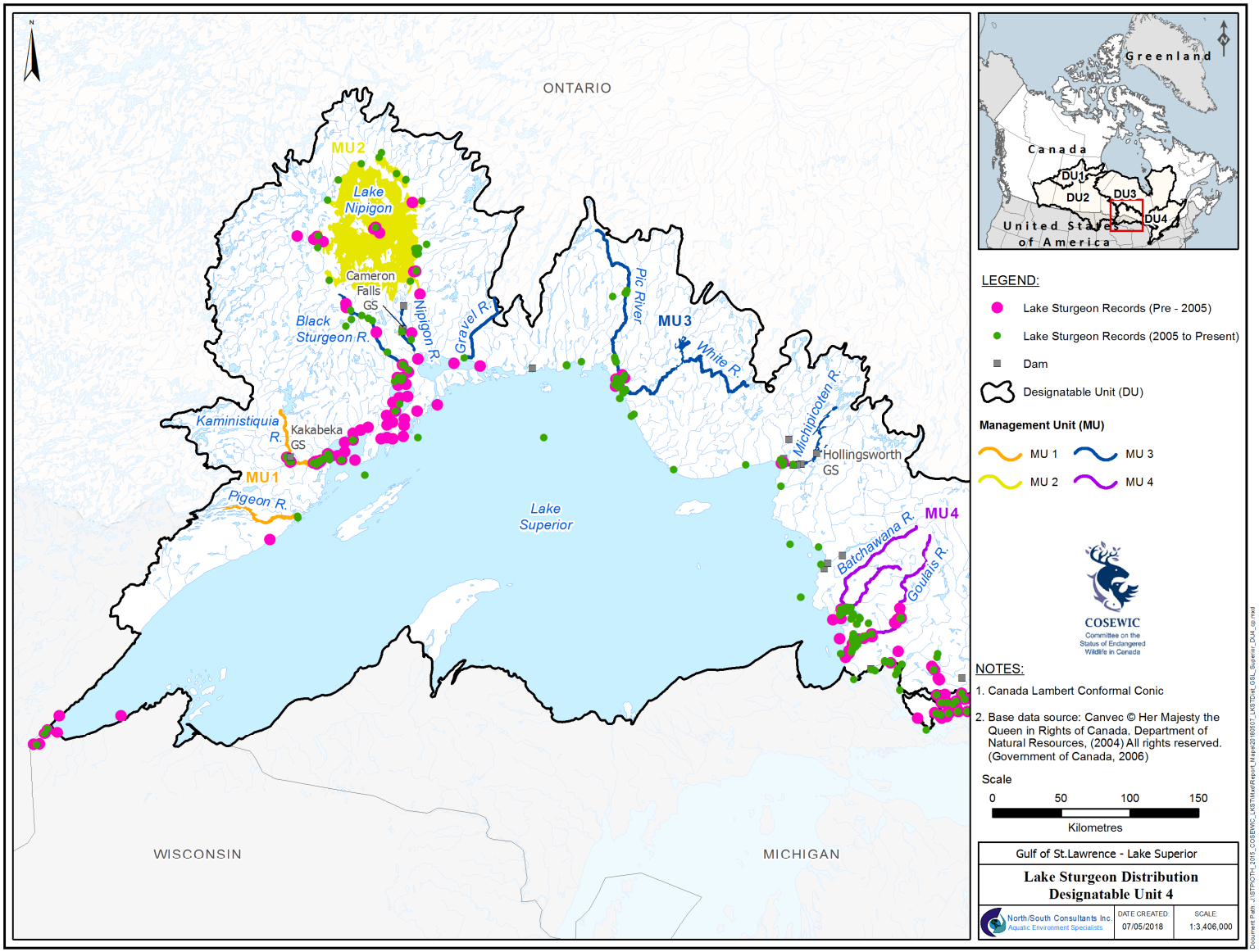

Figure 12. Historical and contemporary Lake Sturgeon distribution in the Lake Superior basin (DU4), showing the location of current management units.

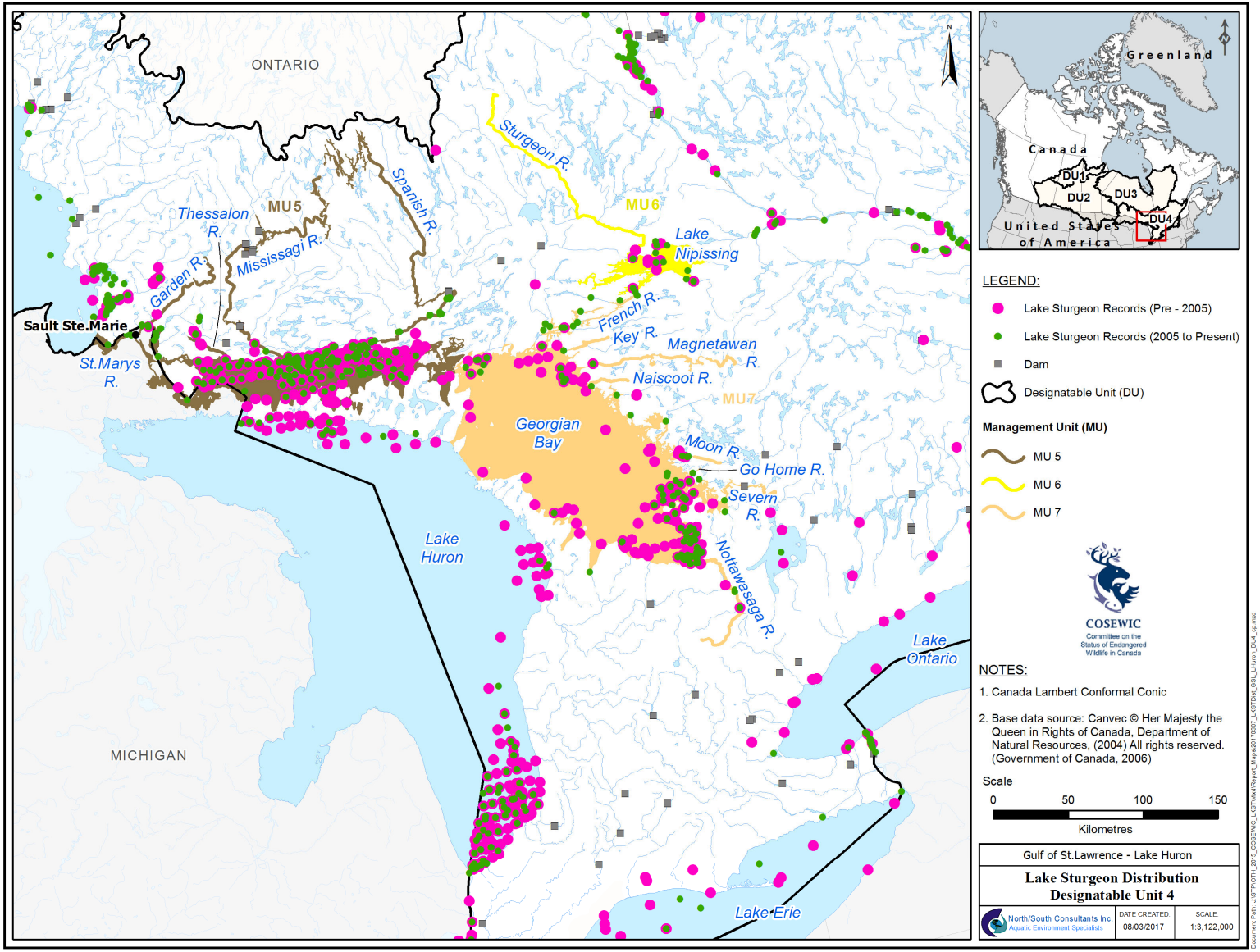

Figure 13. Historical and contemporary Lake Sturgeon distribution in the Lake Huron basin (DU4), showing the location of current management units.

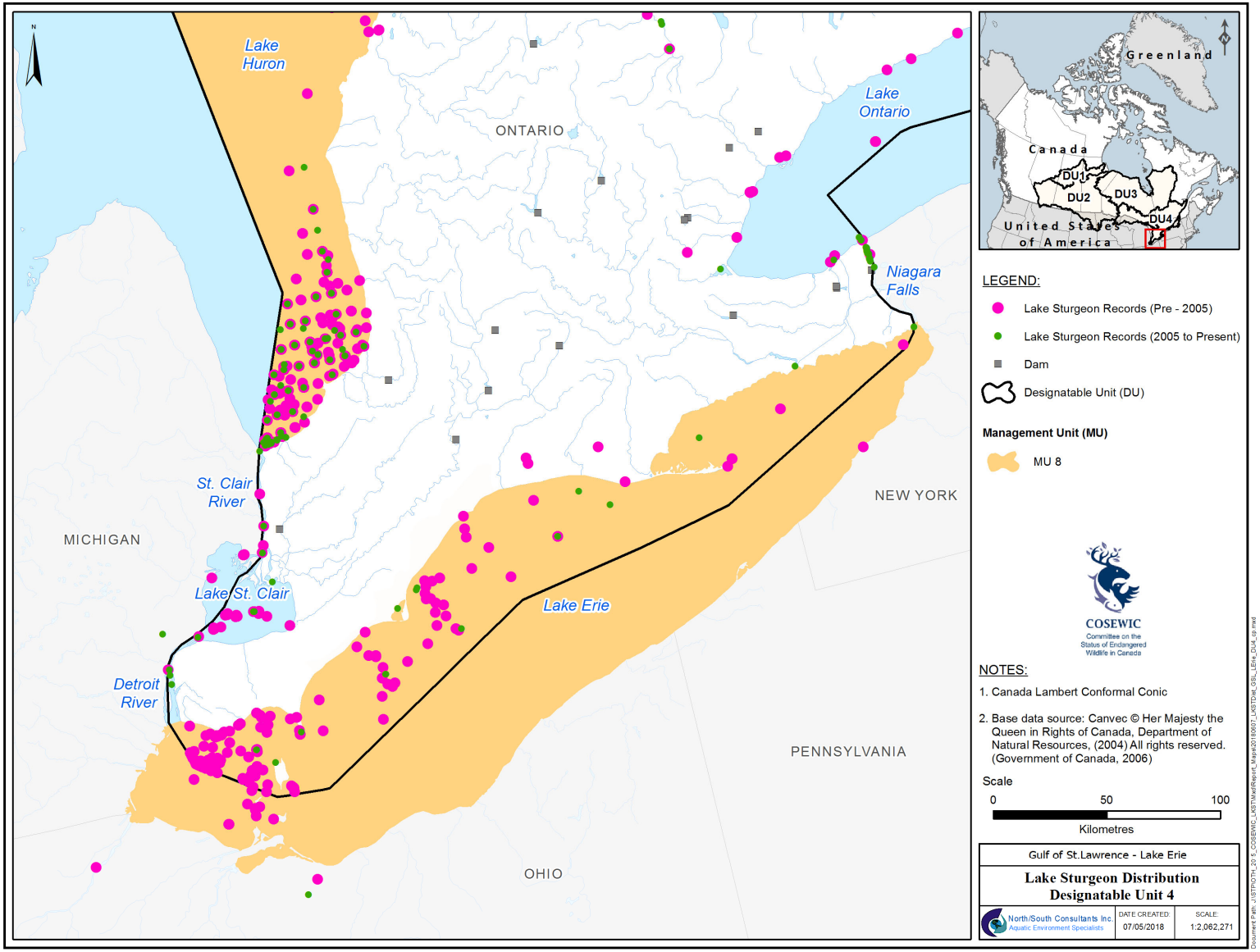

Figure 14. Historical and contemporary Lake Sturgeon distribution in the Lake Erie basin (DU4), showing the location of current management units.

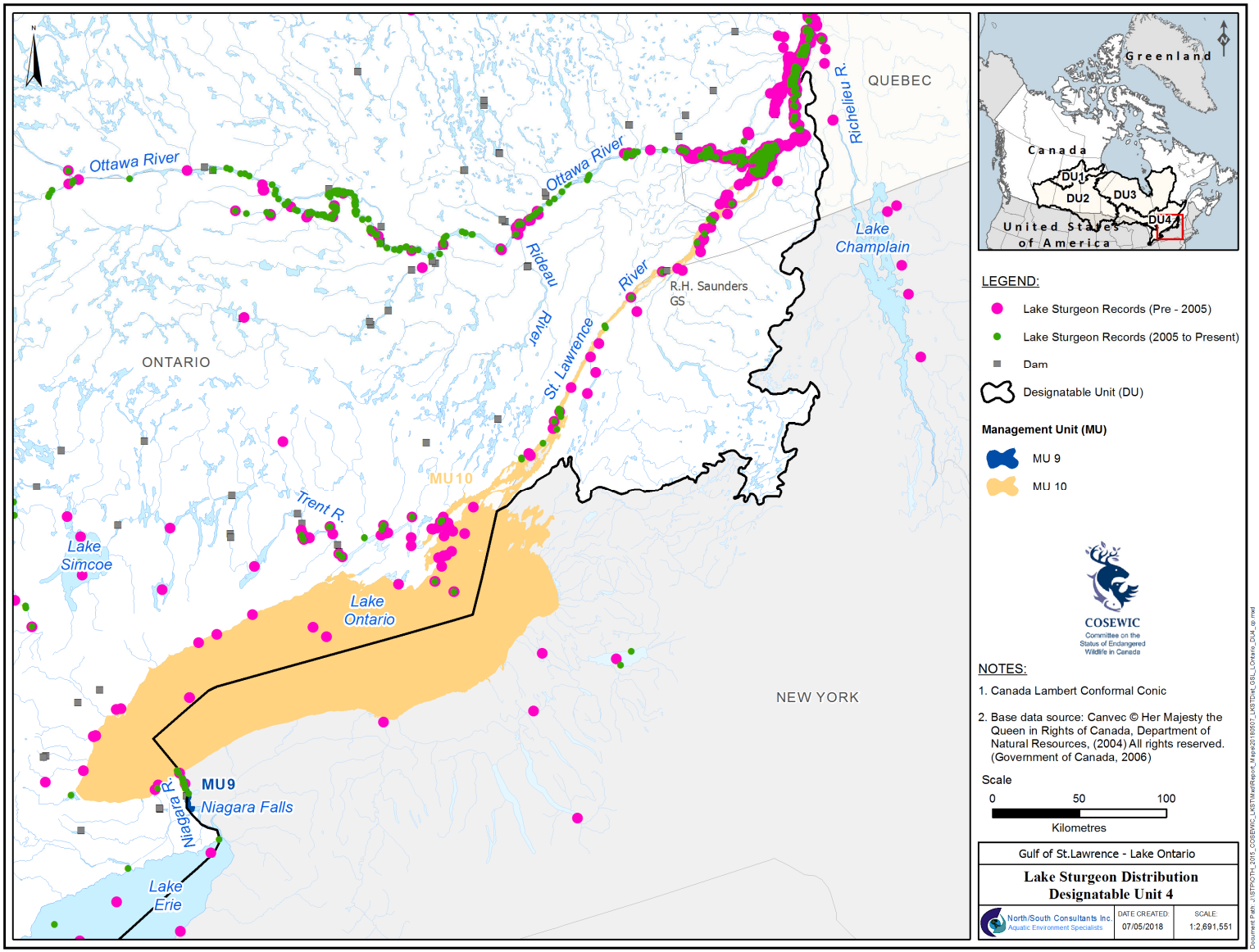

Figure 15. Historical and contemporary Lake Sturgeon distribution in the Lake Ontario basin (DU4), showing the location of current management units.

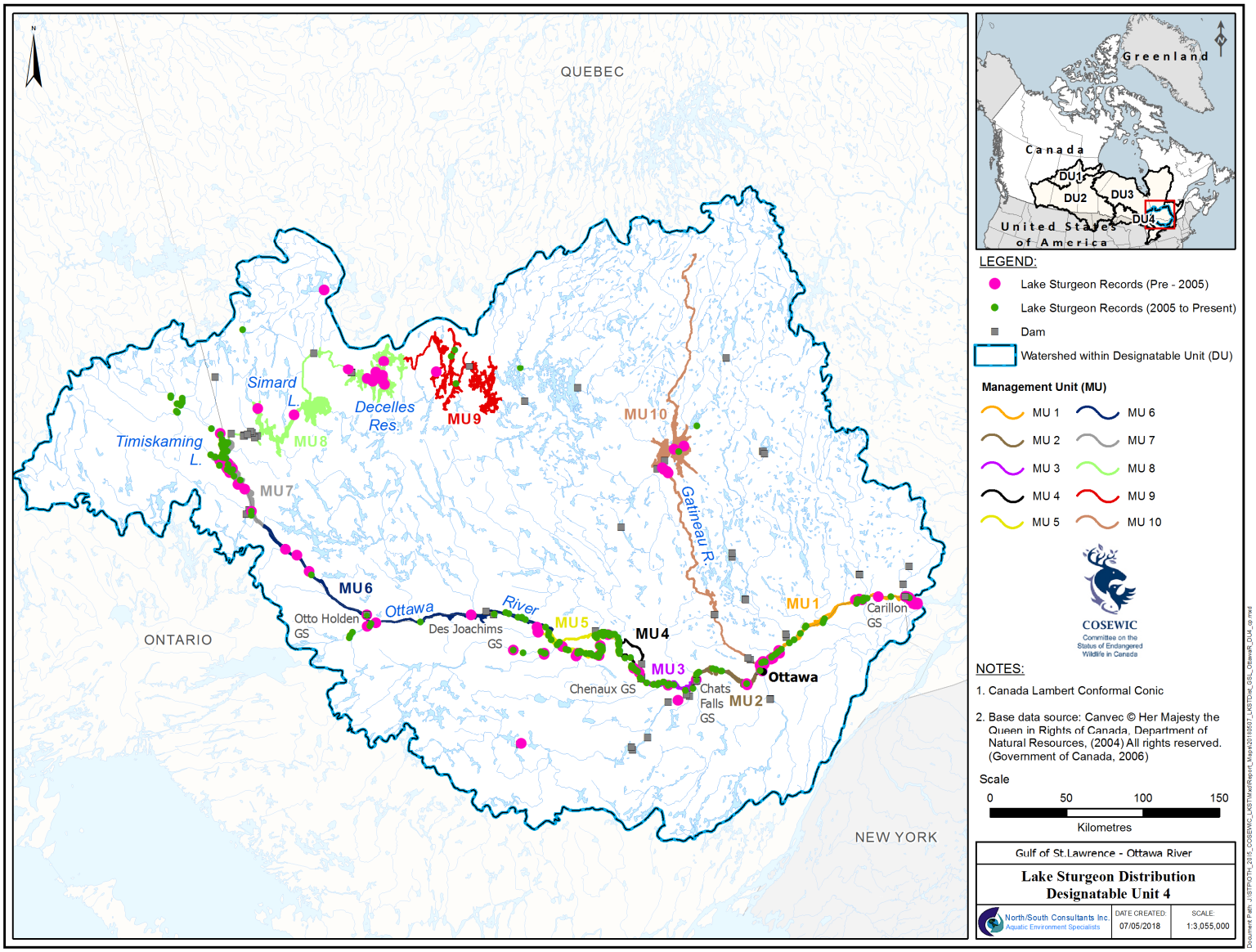

Figure 16. Historical and contemporary Lake Sturgeon distribution in the Ottawa River (DU4), showing the location of current management units.

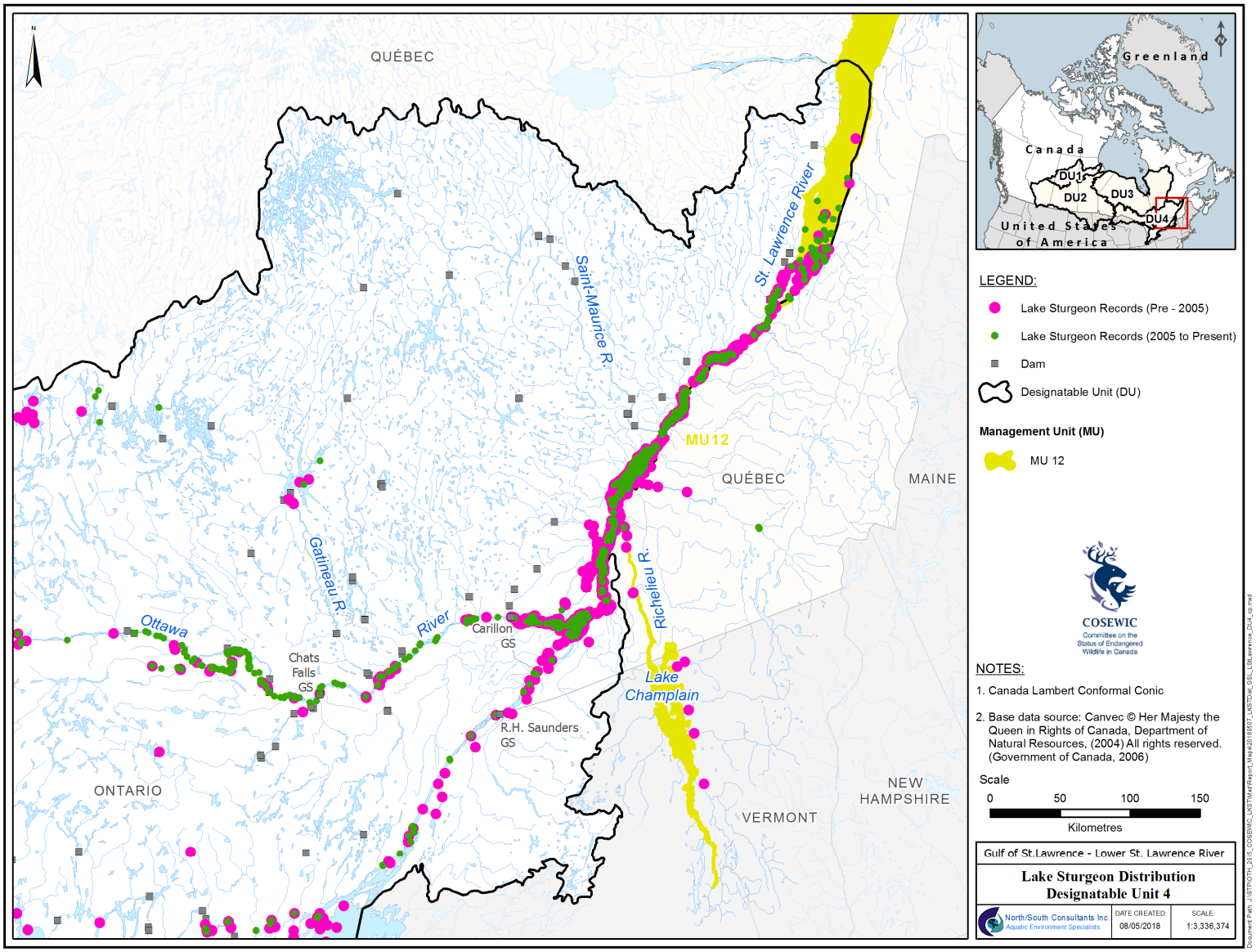

Figure 17. Historical and contemporary Lake Sturgeon distribution in the Upper St. Lawrence River (DU4), showing the location of current management units.