Photo: US F & W Service

# Lake Sturgeon

*(Acipenser fulvescens)* Great Lakes-Upper St. Lawrence River, Northwestern Ontario and Southern Hudson Bay-James Bay populations in Ontario

## Ontario Recovery Strategy Series

Recovery strategy prepared under the *Endangered Species Act, 2007*

Natural. Valued. Protected.

Ministry of Natural Resources

Ontario

# About the Ontario Recovery Strategy Series

This series presents the collection of recovery strategies that are prepared or adopted as advice to the Province of Ontario on the recommended approach to recover species at risk. The Province ensures the preparation of recovery strategies to meet its commitments to recover species at risk under the Endangered Species Act (ESA) and the Accord for the Protection of Species at Risk in Canada.

### What is recovery?

Recovery of species at risk is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

### What is a recovery strategy?

Under the ESA, a recovery strategy provides the best available scientific knowledge on what is required to achieve recovery of a species. A recovery strategy outlines the habitat needs and the threats to the survival and recovery of the species. It also makes recommendations on the objectives for protection and recovery, the approaches to achieve those objectives, and the area that should be considered in the development of a habitat regulation. Sections 11 to 15 of the ESA outline the required content and timelines for developing recovery strategies published in this series.

Recovery strategies are required to be prepared for endangered and threatened species within one or two years respectively of the species being added to the Species at Risk in Ontario list. There is a transition period of five years (until June 30, 2013) to develop recovery strategies for those species listed as endangered or threatened in the schedules of the ESA. Recovery strategies are required to be prepared for extirpated species only if reintroduction is considered feasible.

### What's next?

Nine months after the completion of a recovery strategy a government response statement will be published which summarizes the actions that the Government of Ontario intends to take in response to the strategy. The implementation of recovery strategies depends on the continued cooperation and actions of government agencies, individuals, communities, land users, and conservationists.

### For more information

To learn more about species at risk recovery in Ontario, please visit the Ministry of Natural Resources Species at Risk webpage at: **www.ontario.ca/speciesatrisk**

## RECOMMENDED CITATION

Golder Associates Ltd. 2011. Recovery Strategy for Lake Sturgeon (*Acipenser fulvescens*) – Northwestern Ontario, Great Lakes-Upper St. Lawrence River and Southern Hudson Bay-James Bay populations in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. vii + 77 pp.

**Cover illustration:** U.S. Fish & Wildlife Service


ISBN 978-1-4435-6784-8



*Cette publication hautement spécialisée* Recovery strategies prepared under the *Endangered Species Act, 2007*, *n'est disponible qu'en anglais en vertu du Règlement 411/97 qui en exempte l'application de la Loi sur les services en français. Pour obtenir de l'aide en français, veuillez communiquer avec Cathy Darevic au ministère des Richesses naturelles au 705-755-5580.*

## AUTHORS

| | |
|---|---|
| John Seyler | Golder Associates Ltd., Sudbury, ON |
| Larry Hildebrand | Golder Associates Ltd., Castlegar, BC |
| Rob Mellow | Golder Associates Ltd., Sudbury, ON |



## ACKNOWLEDGMENTS

We would like to express our thanks to all of the participants of the Lake Sturgeon recovery strategy workshops many of whom also provided information and reviewed this manuscript. This group included:

| | |
|---|---|
| Alexandre Litvinov | Mushkegowuk Environmental Research Centre, Timmins, ON |
| Andries Blouw | Fisheries and Oceans Canada, Winnipeg, MB |
| Anita Imrie | Ontario Ministry of Natural Resources, Peterborough, ON |
| Barry Corbett | Ontario Ministry of Natural Resources, Kenora, ON |
| Bill Maloney | Nishnawbe Aski Nation, Thunder Bay, ON |
| Charles Hendry | Ontario Ministry of Natural Resources, South Porcupine, ON |
| Chris Wilson | Ontario Ministry of Natural Resources, South Porcupine, ON |
| Dave Barbour | Ontario Ministry of Natural Resources, Kapuskasing, ON |
| Dave Stanley | Ontario Power Generation, Niagara-on-the-Lake, ON |
| Douglas Hobden | Ontario Ministry of Natural Resources, Englehart, ON |
| Ed Baker | Michigan Department of Natural Resources, Marquette, MI |
| Joe Hunter | Rainy River First Nation, Emo, Ontario |
| Kevin Reid | Ontario Commercial Fisheries' Association, Blenheim, ON |
| Lloyd Mohr | Ontario Ministry of Natural Resources, Owen Sound, ON |
| Marty Holtgren | Little River Band of Ottawa Indians, Manistee, MI |
| Nancy Auer | Michigan Technological University, Houghton, MI |
| Rob Elliot | United States Fish and Wildlife Service, New Franken, WI |
| Rob Wallace | Saskatchewan Environment, Saskatoon, SK |
| Ron Threader | Ontario Power Generation, Renfrew, ON |
| Ryan Haines | Natural Resource Consultant, Jaffray Melick, ON |
| Shelly Dunn | Fisheries and Oceans Canada, Burlington, ON |
| Shelly Matkowski | Manitoba Hydro, Winnipeg, MB |
| Stacey McKee | Anishinabek/Ontario Fisheries Resource Centre, North Bay, ON |
| Steven Kerr | Ontario Ministry of Natural Resources, Peterborough, ON |
| Tim Haxton | Ontario Ministry of Natural Resources, Peterborough, ON |
| Tom Pratt | Fisheries and Oceans Canada, Sault Ste. Marie, ON |
| Vivian Brownell | Ontario Ministry of Natural Resources, Peterborough, ON |

## DECLARATION

The recovery strategy for the Lake Sturgeon was developed in accordance with the requirements of the *Endangered Species Act, 2007* (ESA). This recovery strategy has been prepared as advice to the Government of Ontario, other responsible jurisdictions and the many different constituencies that may be involved in recovering the species.

The recovery strategy does not necessarily represent the views of all of the individuals who provided advice or contributed to its preparation, or the official positions of the organizations with which the individuals are associated.

The goals, objectives and recovery approaches identified in the strategy are based on the best available knowledge and are subject to revision as new information becomes available. Implementation of this strategy is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy.

## RESPONSIBLE JURISDICTIONS

Ontario Ministry of Natural Resources

Fisheries and Oceans Canada

Parks Canada Agency

## EXECUTIVE SUMMARY

Lake Sturgeon (*Acipenser fulvescens*), also known as Name (Ojibwe), Namay Namaeu (Cree) and Nme (Ottawa and Ojibwe), are Ontario's largest and longest-lived fish species. The origin of this species can be traced back over 200 million years, and they have maintained many of the physical characteristics of their ancestral form. Over a period of less than 200 years, over-exploitation and habitat alteration resulted in dramatic declines in sturgeon stocks throughout much of their historical range. The species has historically been and continues to be significant to Aboriginal people as a source of food and as an integral part of their spiritual and cultural identity. Lake Sturgeon currently inhabit at least 229 waters (128 lakes and reservoirs and 101 rivers) in Ontario. The Committee on the Status of Species at Risk in Ontario (COSSARO) has assigned population status in three regions of Ontario. The Northwestern Ontario population and the Great Lakes-Upper St. Lawrence River population of Lake Sturgeon are classified as threatened. The Hudson Bay-James Bay population is classified as special concern.

The recovery goal for Lake Sturgeon in Ontario is to maintain existing Lake Sturgeon populations throughout their current range and where feasible, to restore, rehabilitate or reestablish, self-sustaining Lake Sturgeon populations which are viable in the long term within their current habitat and/or within habitats they have historically occupied, in a manner consistent with maintaining ecosystem integrity and function. The main objectives to achieving protection and recovery are to:

1. protect or increase extant Lake Sturgeon populations at an abundance commensurate with the capacity of their habitat to support them and the existing fish community;
2. maintain, enhance and, where feasible, restore habitat in order to support Lake Sturgeon;
3. restore Lake Sturgeon populations in locations where they have become extirpated, where feasible and where functional habitat exists;
4. develop local scale Lake Sturgeon management strategies;
5. increase public awareness of the cultural and ecological significance and uniqueness of Lake Sturgeon and the importance of maintaining, enhancing and restoring Lake Sturgeon populations; and
6. address knowledge gaps to enable and enhance protection, conservation and recovery efforts.

It is recommended that the area prescribed as habitat in the habitat regulation protect important habitat features for the Northwestern Ontario and the Great Lakes-Upper St. Lawrence River populations of Lake Sturgeon. Important habitat features include spawning areas, nursery areas, overwintering areas, staging areas and the migration corridors connecting them. In formulating this recommendation, consideration was given to Lake Sturgeon ecology including their long generation times, spawning periodicity, ability and tendency to migrate long distances and the requirement of

distinct habitat types for various life history stages (e.g., eggs, larvae, juveniles, subadults, adults).

Habitat suitability can be constrained by water levels, river flows, sedimentation and water quality which may also affect food availability for Lake Sturgeon. As such, Lake Sturgeon are vulnerable to altered river conditions and habitat fragmentation. Habitat management, from both protection and restoration perspectives, should attempt to maintain high quality habitat throughout river and lake environments and ensure linkages among important habitats upon which Lake Sturgeon depend to carry out their life processes. A clear understanding of the locations of important habitats and linkages between them are key considerations in managing habitat. Important habitats should be identified within the river and lake systems currently occupied by Lake Sturgeon and afforded protection.

The area for consideration in developing a habitat regulation should extend from important habitat features to the high water mark on rivers. It is not practical to identify discrete areas within lake systems that represent important habitat features (e.g., overwintering areas). In lakes the area for consideration in developing a habitat regulation should extend from the high water mark to a depth of 20 metres. Local knowledge should be used to determine if refinements in particular lakes are necessary.

## TABLE OF CONTENTS

## APPENDICES

# 1.0 BACKGROUND INFORMATION

## 1.1 Species Assessment and Classification

| |
|---|
| COMMON NAME: Lake Sturgeon<br><br>SCIENTIFIC NAME: *Acipenser fulvescens*<br><br>SARO List Classification:<br>Northwestern Ontario population: Threatened<br>Great Lakes-Upper St. Lawrence River population: Threatened<br>Southern Hudson Bay-James Bay population: Special Concern<br><br>SARO List History:<br>Lake Sturgeon (Southern Hudson Bay-James Bay population) – Special Concern (2009)<br>Lake Sturgeon (Northwestern Ontario population) – Threatened (2009)<br>Lake Sturgeon (Great Lakes- Upper St. Lawrence River population) – Threatened (2009)<br>Lake Sturgeon – Special Concern (2008)<br><br>COSEWIC Assessment History:<br>Lake Sturgeon (Western population) – Endangered (2005)<br>Lake Sturgeon [Red-Assiniboine Rivers – Lake Winnipeg populations (DU4)] – Endangered (2006)<br>Lake Sturgeon [Winnipeg River – English River populations (DU5)] – Endangered (2006)<br>Lake Sturgeon [Lake of the Woods – Rainy River populations (DU6)] - Special Concern (2006)<br>Lake Sturgeon [Southern Hudson Bay – James Bay populations (DU7)] - Special Concern (2006)<br>Lake Sturgeon [Great Lakes – Upper St. Lawrence populations (DU8)] - Threatened (2006)<br><br>SARA Schedule: No schedule. No status.<br><br>CONSERVATION STATUS RANKINGS:<br>GRANK: G3G4 NRANK: N3N4 SRANK: S3 |

The glossary provides definitions for abbreviations used in the table above.

Nationally, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has proposed eight designatable units (DU) for Lake Sturgeon (*Acipenser fulvescens*) based on genetic and biogeographical distinction (COSEWIC 2006). Five of these designated units fall wholly or partially within Ontario (Figure 1). The Red-Assiniboine Rivers-Lake Winnipeg (DU4) and Winnipeg River-English River (DU5) populations are both considered endangered. The Lake of the Woods-Rainy River (DU6) and Southern Hudson Bay-James Bay populations (DU7) are designated as special concern and the Great Lakes-Upper St. Lawrence River population (DU8) is designated as threatened.

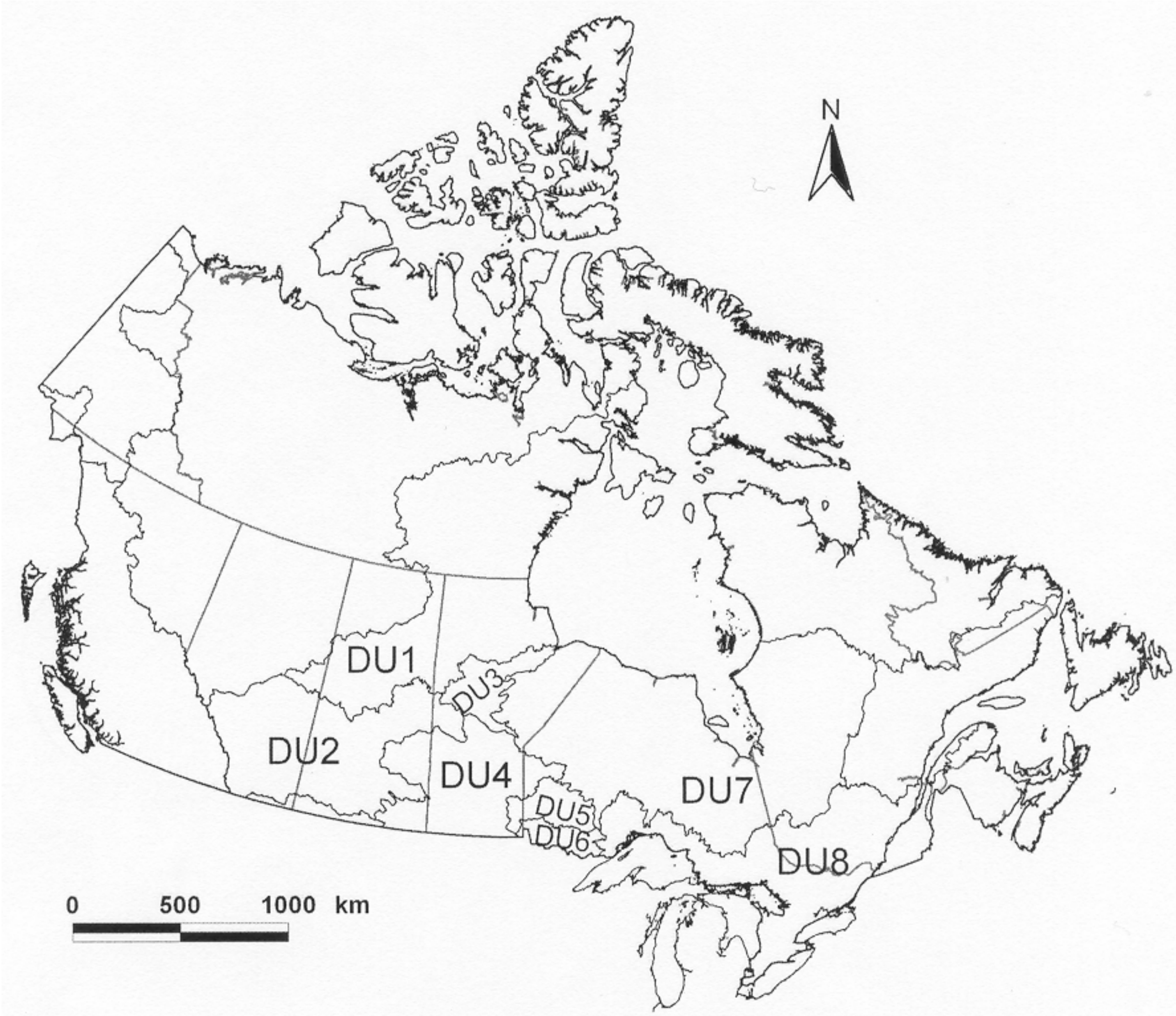


Figure 1. 2003 COSEWIC Lake Sturgeon designated units (COSEWIC 2006).

At the provincial level, the Committee on the Status of Species at Risk in Ontario (COSSARO) has assigned population status in three regions of Ontario. The Northwestern Ontario population (encompassing DU4-6) and the Great Lakes-Upper St. Lawrence River population (encompassing DU8) of Lake Sturgeon are classified as threatened (formerly special concern). The Southern Hudson Bay-James Bay population (encompassing DU7) is classified as special concern status (Figure 2).


Figure 2. 2009 COSSARO Lake Sturgeon designations (OMNR 2009).

## 1.2 Species Description and Biology

Species Description

Lake Sturgeon are Ontario's largest and longest-lived fish and exhibit physical characteristics that have remained unchanged for over 200 million years. Sturgeon are cartilaginous, bottom-dwelling fishes. Conspicuous external bony scutes are very pronounced on larval and juvenile sturgeon, but are less pronounced in larger individuals, as they become embedded in the body wall. Lake Sturgeon have a ventral mouth, a pointed snout and four barbels that are used to sense the environment and to locate food (Harkness and Dymond 1961). They also are characterized by a heterocercal tail. Generally, Lake Sturgeon are dark to light brown or grey in colour on the back and sides, with a lighter coloured belly, but other color variations include red, ruddy or black (COSEWIC 2006). Older Lake Sturgeon generally are a uniform brown colour, while younger sturgeon may have irregular black patches on a brown background.

Genetic Description

Genetic information on Lake Sturgeon has largely been concentrated in the Great Lakes basin (DeHaan et al. 2006; Welsh et al. 2008). Welsh and McClain (2004) examined Lake Sturgeon genetic material from 19 tributaries of Lake Superior, Lake Huron, Lake Erie and Lake Ontario. This analysis showed a great deal of genetic structuring of Lake Sturgeon throughout the Great Lakes, with individuals captured at spawning locations being genetically distinct from one another. The study emphasizes the importance of understanding and conserving genetic integrity of different spawning populations, even within the same major drainage, as a consideration in recovery actions.

Recent comparisons of Lake Sturgeon genetic structure and diversity from primary and secondary drainages across Canada identified two divergent groups which are derived from Mississippian and Missourian glacial refugia (Kjartanson 2008). Genetic distance analysis sampling has shown three groupings corresponding to populations from the St. Lawrence drainage, northwestern Ontario, and Hudson Bay drainages/western Canada (McDermid et al. 2011 in press). Analysis of the three major drainages within Ontario confirmed the presence of both genetic groups of sturgeon, as well as areas where secondary contact between them occurred during postglacial colonization (Kjartanson 2008; McDermid et al. 2011 in press). Studies of Lake Sturgeon populations in northern and northwestern Ontario confirmed the presence of both phylogeographic groups, as well as a distinct group in northwestern Ontario that may have resulted from their contact and interbreeding during postglacial events or from separate colonization of this area from the Mississippian refugium (McDermid et al. 2011 in press). Populations in northern Ontario and western Canada are primarily derived from the Missourian postglacial source, whereas Lake Sturgeon from the Great Lakes are primarily Mississippian in ancestry (Kjartanson 2008; McDermid et al. 2011 in press). In both studies, diversity within populations reflected historical influences and connections more than anthropogenic stressors. Genetic similarities among geographically separated populations within major drainages underscore their historical connection and the importance of habitat connectivity (Kjartanson 2008; Wozney et al. 2010; McDermid et al. 2011 in press).

Despite reductions in Lake Sturgeon abundance across much of their range, recent studies have not observed decreases in genetic variability or evidence of inbreeding within populations (DeHaan et al. 2006; Drauch and Rhodes 2007; Welsh et al. 2008). Lake Sturgeon may be protected from expected losses of genetic diversity because of their longevity and overlapping generations. The long generation time of Lake Sturgeon has been shown to buffer genetic loss within and among river segments in the Ottawa River (Wozney et al. 2010).

<u>Traditional Uses</u>

Within Ontario and the Great Lakes watershed there are many aboriginal names for Lake Sturgeon. These include Name (Ojibwe), Namay Namaeu (Cree), and Nme (Ojibwe and Ottawa). This fish was and continues to be significant to many First Nations not only as a source of food, but as an integral part of their spiritual and cultural identity. Subsistence fishing for Lake Sturgeon is a long standing tradition for many First Nation communities (Hopper and Power 1991).

Historically, families would gather at traditional Lake Sturgeon spawning sites in the spring for ceremonies and to capture fish for food (Michalenko et al. 1991). Tribal gatherings, involving many bands from a wide geographical area, were regularly held at well known spawning sites during the spawning run. At Manitou Rapids on the Rainy River, Anishinaabe came from as far away as Lac Seul to the north, Lake Winnipeg to the west and Lake Superior to the east. In some years, up to 1,500 Anishinaabe attended these gatherings (Rainy River First Nations 2002 as found in OMNR 2009). Such large gatherings, fed by sturgeon, facilitated the renewal of friendships and social ties, the discussion of military and political affairs, and the holding of religious ceremonies (Holtzkamm and Waisberg 2004). Lake Sturgeon were harvested using hook and lines, weirs and spears. Spearing was often done from wooden platforms constructed to extend over rapids (Holtzkamm et al. 1988). For many First Nations, Lake Sturgeon hold a certain spiritual and cultural significance and to those who follow the clan system, members of the sturgeon clan are considered to be mediators and teachers (Abraham 2008).

Lake Sturgeon continue to be highly valued by many First Nations communities today. For example, elders of the Namaygoosisagagun Ojibways Development Corporation, near Armstrong, make the journey to Smoothrock Lake each spring to capture and harvest Lake Sturgeon to share with the community (A/OFRC 2007). Rainy River First Nation harvest Lake Sturgeon to smoke for food and to provide a source of wild gametes. They consider themselves stewards of the river and believe their responsibility is to share their accumulated knowledge with present and future generations. Today, they operate the only Lake Sturgeon hatchery in Ontario.

<u>Species Biology</u>

For the purpose of this description of species biology and the description of habitat requirements that follows, Lake Sturgeon life history stages are defined as follows:

- eggs: from deposition, through incubation, to hatch;
- larvae: including drift phase of life cycle;
- young-of-the-year: larvae once drift phase is complete up to the end of the first year of life;
- yearlings: age one up to end of the second year of life;
- juveniles: age 2 to 10 years;
- sub-adults: 10 years up to onset of maturity; and
- adults: from onset of maturity onwards.

Growth of Lake Sturgeon is relatively rapid during the first 10 years of life (Harkness 1923) and then slows from that point onward (Scott and Crossman 1973; Magnin 1977; Threader and Brousseau 1986). Male and female Lake Sturgeon grow at similar rates until approximately 20 years of age after which female growth generally exceeds that of male fish (Bruch 1999). There is, however, considerable geographical variation in growth rates across the species range, much of which is explained by latitudinal variation (OMNR 2009).

Sexual maturity in Lake Sturgeon is generally attained between the ages of 12 and 20 years for male fish and 14 to 33 years for female fish (Appendix 1). Delayed maturation contributes to rapid growth rates early in the life history of Lake Sturgeon as energy is devoted to somatic growth versus gonad development (Beamesderfer and Farr 1997). Egg production is correlated with weight and can range from 8,744 to 12,264 eggs per kg of fish (Bruch et al. 2006). Although egg production generally increases with size of fish, it can be variable in fish of the same weight.

Male Lake Sturgeon generally spawn every 2 to 3 years, whereas females may only spawn every 4 to 9 years (Roussow 1957; Scott and Crossman 1973; Kempinger 1988; Mosindy and Rusak 1991). Spawning occurs in the spring which, in Canada, occurs from early May to late June at water temperatures between 10ºC to 20ºC (Appendix 2). Most observations of spawning activity have been made during daylight hours. However, Bruch and Binkowski (2002) reported that Lake Sturgeon had no preference for day or night spawning. Male Lake Sturgeon typically arrive or stage below spawning areas prior to the arrival of females (Bruch and Binkowski 2002). Female Lake Sturgeon are typically surrounded by multiple male fish during spawning and broadcast adhesive eggs over rock and rubble substrate (Kempinger 1988). Spawning can consist of multiple acts of egg deposition, involving different male Lake Sturgeon. Lake Sturgeon abandon spawning locations immediately after spawning (Bruch and Binkowski 2002; Golder 2010a).

Multiple spawning events (e.g., two separate periods of spawning activity involving different females) have been noted in some systems (Kempinger 1988; LaPan et al. 2000; Auer and Baker 2002; Nichols et al. 2003; Friday 2006; A. Ecclestone, pers. comm. 2010). This has been linked to migration distances (e.g., the proximity of overwintering habitat in relation to spawning locations), warming trends (e.g., lake vs. river environments) and spring water temperature fluctuations. Bruch and Binkowski (2002) noted that sudden declines in water temperatures after the onset of spawning activity resulted in a second, delayed spawning run occurring, up to four weeks after the first. Rusak and Mosindy (1997) concluded that the Lake of the Woods-Rainy River system supports both lake and river dwelling populations of Lake Sturgeon and the timing of spawning migrations and spawning activity is different, with river dwelling Lake Sturgeon spawning before the arrival of lake dwelling sturgeon.

Eggs incubate for approximately 5 to 14 days depending on water temperature (Scott and Crossman 1973; Kempinger 1988; Smith 2003; Johnson et al. 2006). No parental care is provided to the eggs. Egg mortality is high with a natural hatch rate estimated to be less than one percent (Nichols et al. 2003; Dumont et al. 2011). Kempinger (1988) attributed sedimentation and rapid increases in flow to high egg mortality. Poor egg survival is often attributed to unfavourable water temperatures since optimal survival and development of Lake Sturgeon eggs occurs between 14ºC and 17ºC. Total egg mortality has been documented for Lake Sturgeon when water temperatures exceed 20ºC (Wang et al. 1985).

Eggs are the most likely life history stage to be preyed upon by other fishes although very little information exists regarding fish predation on Lake Sturgeon (Caroffino et al. 2010). Predators of Lake Sturgeon eggs include sucker species (Catostomidae), Logperch (*Percina caprodes*), Common Carp (*Cyprius carpio*), Yellow Perch (*Perca flavescens*), Round Goby (*Neogobius melanostomus*) and other Lake Sturgeon (Kempinger 1988; Caroffino et al. 2010; Nichols et al. 2003). Crayfish (*Orconectes* spp.) can also be important predators of eggs that have settled in interstitial spaces (Caroffino et al. 2010; Scribner and Baker 2008).

Larval emergence is temperature dependent (LaHaye et al. 1992; Smith 2003; Smith and King 2005a). Newly hatched Lake Sturgeon larvae are pelagic and negatively phototactic. Yolk sac larvae exhibit diurnal behaviour: they tend to hide in the interstices of gravel during the day and emerge at night when light levels are diminished (Harkness and Dymond 1961; Kempinger 1988). Shortly after emergence they begin a “swim-up” phase, leaving the bottom to enter the water column, which is important for larval drift. Larval drift may be temperature dependent. Smith (2003) reported that larval drift was not initiated until water temperatures reached 15ºC. Kempinger (1988) reported that nocturnal (2100 to 0200 hours) drifting downstream typically peaks between 8 and 14 days post-hatch. Auer and Baker (2002) documented larvae drift to 26 km below a spawning site, 15 to 27 days post-spawning on the Sturgeon River and up to 45 km, 25 to 40 days post-spawning. Larval drift is passive and dependent on water velocity and discharge (D’Amours et al. 2001). Depending upon the length of interval between separate spawning episodes, there can be more than one larval drift period (Auer and Baker 2002). It is unclear whether larvae display specific habitat preferences. Some literature suggests that larval drift is not uniform in a river and that larvae are distributed unevenly within the water column and across a river reach (Johnston et al. 1995; Auer and Baker 2002; Smith and King 2005b). However, there is speculation that larval Lake Sturgeon may actually select a particular habitat rather than simply being dispersed into areas where water velocity is reduced (D’Amours et al. 2001; Smith and King 2005b). Lake Sturgeon may mature in their natal river or move downstream into lakes (Holtgren and Auer 2004). Positive correlations between rates at which water temperatures warm during the spawning and incubation periods, river flows in June, when larvae drift downstream from spawning areas and juvenile year class strength have been demonstrated in spawning tributaries in the St. Lawrence River (Nilo et al. 1997). This study suggests that Lake Sturgeon year class strength is determined during the first few months of life and that climate and hydrological conditions are important factors.

Evidence of piscivorous fish species preying upon early life history stages of Lake Sturgeon has not been widely reported in the literature. Larval Lake Sturgeon have no defence mechanisms from predation and are vulnerable while drifting downstream to nursery habitat. Caroffino et al. (2010) found that, although some larval predation occurred in the Peshtgo River, Wisconsin, it was not widespread.

High and variable mortality of eggs and larvae is expected from fish species which have life history characteristics similar to Lake Sturgeon (e.g., highly fecund and able to spread reproductive effort over multiple years) (Winemiller and Rose 1992). This strategy allows Lake Sturgeon populations to persist despite high mortality of early life stages.

Lake Sturgeon are generalist, benthic feeders; their diet including a diversity of benthic fauna, such as amphipods, chironomids, oligocheates, ephemeroptera, trichoptera, dipteral, molluscs, crayfish and fish eggs (Sandilands 1987; Chiasson et al. 1997; ESG International Inc. 2003; Nilo et al. 2006). Diet studies conducted in rivers suggest there is a preference for drifting prey (Kempinger 1996; Nilo et al. 2006). Dipteran larval abundance was related to juvenile Lake Sturgeon presence in the lower Peshtigo River, Wisconsin (Benson et al. 2005). Sandilands (1987) noted that large invertebrates (e.g., crayfish) become a more frequent diet item in larger sturgeon. Chiasson et al. (1997) noted that juvenile and adult Lake Sturgeon were more active at night in the Mattagami and Groundhog rivers and related this to foraging behaviour In this instance low invertebrate abundance may have necessitated increased foraging. Large adult Lake Sturgeon are also known to feed on pelgic schooling fish species such as rainbow smelt (L. Mohr, pers. comm. 2010).

Movements of adult Lake Sturgeon associated with spawning and foraging behaviour have been well documented. Prior to spawning, reproductive adults generally migrate upstream to reach spawning grounds and return to feeding areas during the summer (Rusak and Mosindy 1997; McKinley et al. 1998). Lake Sturgeon will migrate from lakes or downstream reaches of rivers into shallower, faster waters upstream (Smith 2003; Holtgren and Auer 2004; Smith and King 2005b). Spawning migrations can be quite extensive. Some adult populations can travel 200 km to 400 km upstream (Scott and Crossman 1973; Kempinger 1988; Rusak and Mosindy 1997; Auer 1999). Bruch (1999) recorded an autumn migration to staging areas in Wolf and Upper Fox rivers. Foraging and reproductive adults exhibit different behaviours with respect to timing, location and extent of movement (M. Friday, pers. comm. 2010; A. Ecclestone, pers. comm. 2010). In the Pic River, spawning adults will migrate more than 80 km upstream and then travel downstream following spawning, to forage in lower reaches of the river (A. Ecclestone, pers. comm. 2010). Welsh and McLeod (2010) found that Lake Sturgeon moved upstream on the Namakan River in the late summer, to overwinter in lake environments.

## 1.3 Distribution, Abundance and Population Trends

Lake Sturgeon originally had a wide geographic range in North America encompassing the Mississippi, Great Lakes and Hudson Bay drainages (Figure 3). Lake Sturgeon are the only species of sturgeon found in the Great Lakes basin (Hubbs and Lagler 1964; Scott and Crossman 1973).

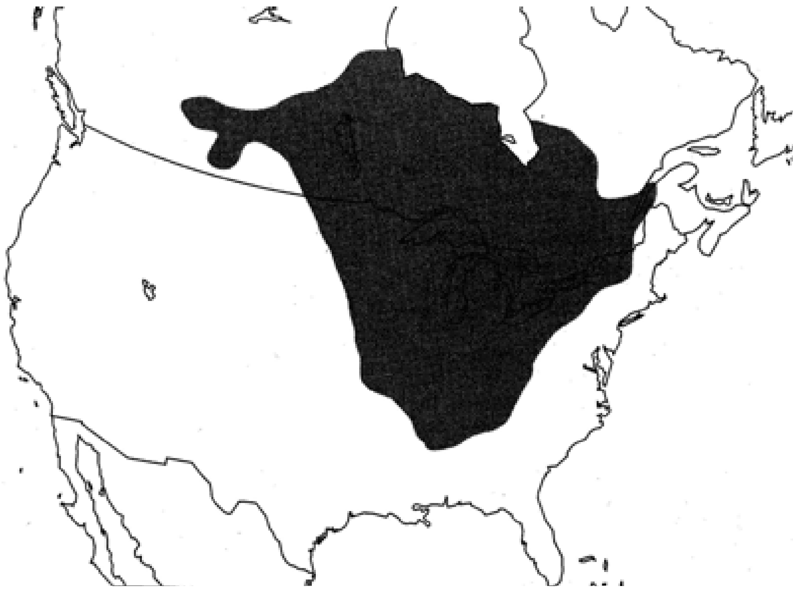

Figure 3. Historical distribution of Lake Sturgeon in North America (Williamson 2003).

There are at least 229 waters (128 lakes and reservoirs and 101 rivers) in Ontario which support Lake Sturgeon (Kerr 2002). Lake Sturgeon are present in all of the Great Lakes and major connecting waterways. Although their distribution is somewhat sporadic throughout the province, their inland distribution is concentrated in the northern portion of Ontario (e.g., north of the French and Mattawa rivers). Figure 4 illustrates the current and historical distribution of Lake Sturgeon across Ontario, based upon technical literature and professional opinion of contributors to this recovery strategy.

Lake Sturgeon were once very abundant in the Great Lakes and in large inland lakes and rivers in Ontario. Many populations underwent a rapid decline, within a short period of time following European settlement, due to habitat loss, overfishing, and declining water quality (Harkness and Dymond 1961; OMNR 2009). The status of Lake Sturgeon within each of the three COSSARO designated regions in Ontario is described below. It is important to note that there are many information gaps regarding the distribution and status of Lake Sturgeon, particularly in northwestern and northeastern Ontario, areas of the province which are currently remote. Much of this information may exist in the form of aboriginal traditional knowledge (ATK).

<u>The Northwestern Ontario Population (DU4-6)</u>

The Rainy River system (DU6) ultimately drains into the Winnipeg River. Assessment of Lake Sturgeon status has been conducted on a number of waters in the Lake of the Woods-Rainy River system and the evidence suggests that this sub-population is improving. Recent assessment studies completed by the Minnesota Department of Natural Resources indicate that numbers of Lake Sturgeon greater than 100 cm in length have more than tripled from approximately 16,000 in 1990 (Mosindy and Rusak 1991) to almost 55,000 in 2004 (Stewig 2005). This improvement has been attributed to water quality improvements and controls on sport and commercial harvest. Although sport fishing has been prohibited in Ontario waters it is still permitted in Minnesota

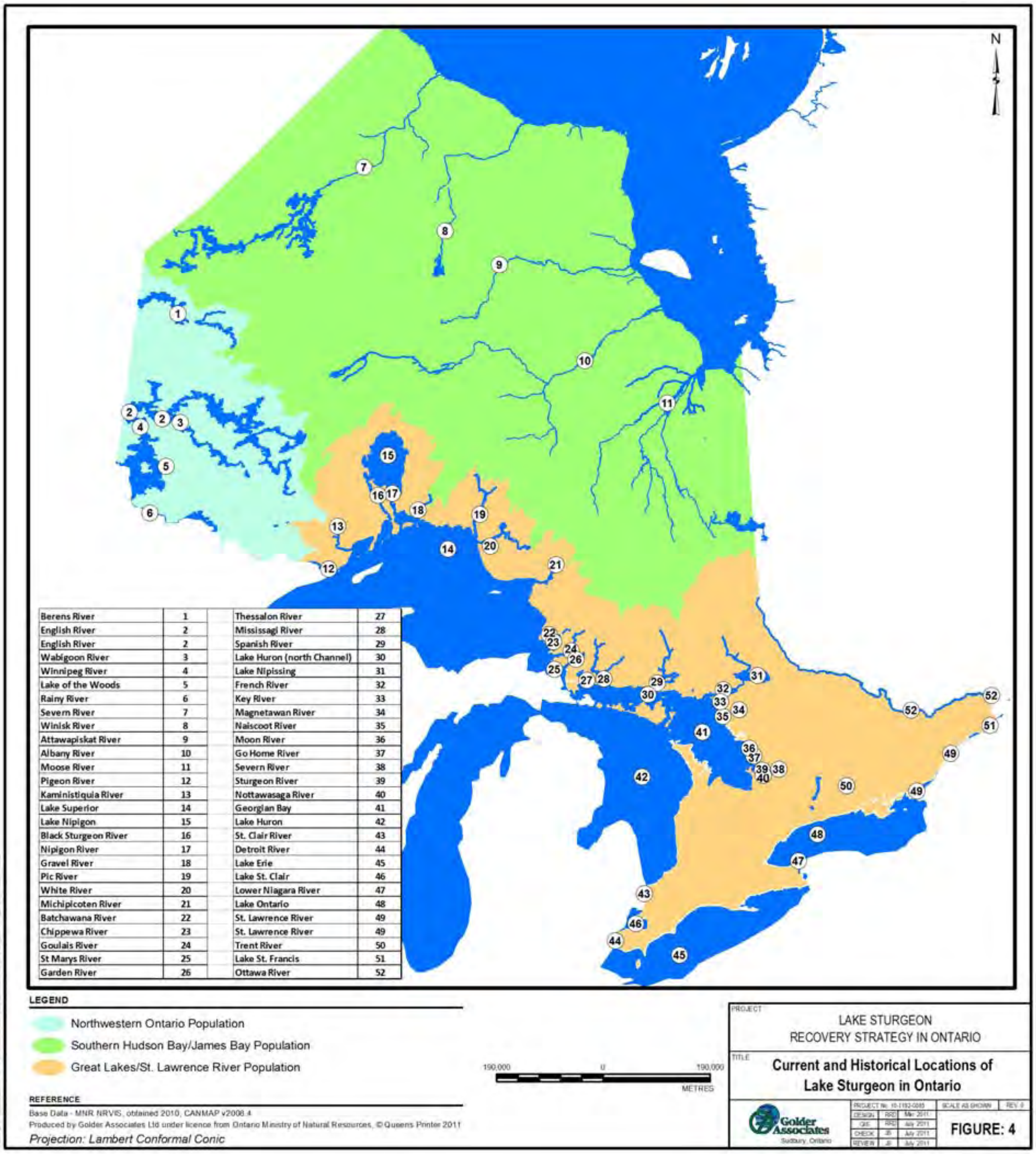


Figure 4. Current and historical distribution of Lake Sturgeon in Ontario.

waters. The Rainy River First Nation possesses a commercial quota for Lake Sturgeon, but has adopted a voluntary moratorium on commercial harvest. A commercial quota also exists for the Seine River, but it is inactive. Subsistence harvesting still occurs by the Rainy River First Nation.

A number of recent Lake Sturgeon population assessment studies have been completed in Lac La Croix-Namakan River system, located upstream of Rainy Lake.

Investigators have documented robust populations in Sturgeon and Eva lakes and in the Namakan River (McLeod 2008a, McLeod 2008b; OMNR 2009b). Lake Sturgeon presence has also been documented in Rainy Lake (Adams et al. 2006), the Seine River (Mcleod 1999), Namakan Reservoir (Shaw 2010), Little Turtle Lake-River system, Lac La Croix and in numerous small lakes located within Quetico Provincial Park (B. Corbett pers. comm. 2011).

Only the upper portion of the Winnipeg-English River system lies within Ontario (DU5). Very little historical information exists regarding Lake Sturgeon in the Ontario waters of this system. Recent studies conducted by the OMNR and local First Nation communities have resulted in the capture of low numbers of Lake Sturgeon in the Ontario waters of this system (Ochiichagwe'babigo'ining Ojibway First Nation 2009). Information provided by local First Nation communities indicates that Lake Sturgeon are present in the lower English River and in the Ontario portion of the Winnipeg River (B. Corbett pers. comm. 2011). Flows in the Ontario portions of these rivers and downstream within Manitoba are influenced by dams located in both provinces. The Lake of the Woods Control Board, representing federal and provincial governments is responsible for regulating flows.

Commercial harvest in the Winnepeg River ended in the 1970s. Assessments completed in the Ontario waters of the Winnepeg-English river system have documented the presence of both juvenile and adult Lake Sturgeon (Duda 2009 unpublished data). The population trajectory for Lake Sturgeon in these waters remains unknown (Table 1) (Cleator et al. 2010a). In Manitoba waters of the Winnipeg River, catch and release fishing is still permitted, whereas sport fishing for Lake Sturgeon is prohibited in Ontario's portion of the Winnipeg River. Subsistence harvesting still occurs in the Ontario portion of the Winnipeg River, whereas it is not allowed in the Manitoba waters. Sturgeon are seldom captured in the recreational fishery or observed at traditional spawning sites. These populations have been ranked as endangered by COSEWIC (2006).

The upper portion of the Berens River (DU4), which flows west into Lake Winnipeg, is located in Ontario and portions of these waters support Lake Sturgeon. There are no dams or control structures within the Ontario portion of the Berens River (Cleator et al. 2010b). Lake Sturgeon are harvested by First Nations for subsistence purposes. Commercial harvests on the Berens River were halted in the 1970s. Sport fishing for Lake Sturgeon is prohibited in Ontario's portion of the Berens River. Based upon biological data collected during Lake Sturgeon netting, 2003 to 2009, it is believed that this population may be increasing in size (Cleator et al. 2010b).

Table 1. Population status and trajectory of Lake Sturgeon populations in Ontario tributaries and lakes, Northwestern Ontario population (McLeod 2008b; Cleator et al. 2010a; 2010b).

| Waterbody | Population Status | Population Trajectory[1] | Jurisdiction(s) |
|---|---|---|---|
| Lake of the Woods/Rainy River/Rainy Lake | Extant | Increasing | Ontario, Minnesota |
| Lac La Croix-Namakan River System | Extant | Stable[2] | Ontario, Minnesota |
| Lower English River | Unknown | Unknown | Ontario, Manitoba |
| Winnipeg River | Extant | Unknown | Ontario, Manitoba |
| Berens River (including Berens Lake, Pikangikum Lake | Extant | Increasing | Ontario, Manitoba |

[1] Population trajectory was assessed using COSEWIC criteria as described in Pratt (2008), with the exception of Lac La Croix- Namakan River system.
[2] Population trajectory derived using information provided in McLeod (2008b).

<u>The Great Lakes-Upper St. Lawrence River Population (DU8)</u>
Genetic analyses have shown a great deal of genetic structuring of Lake Sturgeon throughout the Great Lakes, with individuals captured at spawning locations being genetically distinct from one another (DeHaan et al. 2006; Welsh et al. 2008; Welsh and McClain 2004). As many as 9 or 10 tributaries of Lake Superior in Canada and the U.S. still support self-sustaining sub-populations although all are believed to be below historical levels. A physically isolated sub-population exists within Lake Nipigon. Remnant Lake Sturgeon sub-populations exist in the Kaministiquia, Pic, Black Sturgeon, Pic, Nipigon, Batchewana and Goulais rivers (Pratt 2008). Evidence of successful natural reproduction has been documented in the Kaministiquia, Pic and Goulais rivers. Lake Sturgeon abundance in Lake Superior was historically lower than in the other Great Lakes (Hubbs and Lagler 1964; Auer 2003). Historically, exploitation was not as intense on Lake Superior as in the other Great Lakes. However, many sub-populations were severely impacted and reduced to levels from which they have never recovered. Many of the tributaries to Lake Superior have been dammed (Mohr et al. 2008). The status of all Lake Superior sub-populations is considered to be low with only two sub-populations, the Kaministiquia River and the Lake Nipigon sub-populations, identified as stable (Table 2). Population trajectories in the remaining rivers are unknown (Pratt 2008). Spawning runs are absent in 12 of 22 historic spawning tributaries (State of the Great Lakes 2009). There is no recreational or commercial harvest of Lake Sturgeon permitted within the Ontario waters of Lake Superior or within tributaries and lakes listed in Table 2. However, Wisconsin allows sport harvesting on Lake Superior through a tag system.

The fish community objectives for Lake Superior include the recommendation to rehabilitate and maintain spawning populations of Lake Sturgeon that are self-sustaining throughout their native range (Horns et al. 2003).

Table 2. Population status and trajectory of Lake Sturgeon populations in Ontario tributaries and lakes of Lake Superior (Pratt 2008).

| Waterbody | Population Status | Population Trajectory[1] | Jurisdiction(s) |
|---|---|---|---|
| Pigeon River | Extant | Unknown | Ontario; Minnesota |
| Kaministiquia River | Extant | Stable | Ontario |
| Wolf River | Extirpated | - | Ontario |
| Black Sturgeon River and Lake | Extant | Unknown | Ontario |
| Nipigon River | Extant | Unknown | Ontario |
| Lake Nipigon | Extant | Stable | Ontario |
| Gravel River | Unknown | Unknown | Ontario |
| Prairie River | Extirpated | - | Ontario |
| Pic River | Extant | Unknown | Ontario |
| White River | Unknown | Unknown | Ontario |
| Michipicoten River | Unknown | Unknown | Ontario |
| Batchawana River | Extant | Unknown | Ontario |
| Chippewa River | Unknown | Unknown | Ontario |
| Harmony River | Extirpated | - | Ontario |
| Stokely Creek | Extirpated | - | Ontario |
| Goulais River | Extant | Unknown | Ontario |

[1] Population trajectory was assessed using COSEWIC criteria as described in Pratt (2008).

Lake Sturgeon abundance remains below historic estimates in Lake Huron. In Ontario, there are 23 tributaries and three lakes with historical records of Lake Sturgeon sub-populations that drain into Lake Huron (Table 3). Until recently, small commercial fisheries have been sustained in the Ontario waters of southern Lake Huron and the North Channel in areas where adult and juvenile habitat is abundant. Spawning has been documented in the Mississagi, Spanish and Garden rivers in the North Channel and Nottawasaga River in Georgian Bay (Fielder et al. 2008). Spawning also takes place at the mouth of the St. Clair River at the south end of the main basin of Lake Huron. Fish community objectives for Lake Huron include the recommendation to increase the abundance of Lake Sturgeon to the extent that the species is removed from its threatened status in United States waters and to maintain or rehabilitate populations in Canadian waters (DesJardine et al. 1995). Recreational and commercial fisheries for Lake Sturgeon are currently closed across Lake Huron.

Table 3. Population status and trajectory of Lake Sturgeon populations in Ontario tributaries and inland lakes of Lake Huron and Georgian Bay watershed (Pratt 2008).

| Waterbody | Population Status | Population Trajectory[1] | Jurisdiction |
|---|---|---|---|
| St. Mary's River | Extant | Unknown | Ontario |
| Root River | Extirpated | - | Ontario |
| Garden River | Extant | Unknown | Ontario |
| Echo River | Extirpated | - | Ontario |
| Thessalon River | Extant | Unknown | Ontario |
| Mississagi River | Extant | Stable | Ontario |
| Blind River | Extirpated | - | Ontario |
| Serpent River | Unknown | - | Ontario |
| Spanish River | Extant | Stable | Ontario |
| Lake Nipissing | Extant | Increasing | Ontario |
| French River | Extant | Unknown | Ontario |
| Magnetewan River | Unknown | Unknown | Ontario |
| Naiscoot River | Extant | Unknown | Ontario |
| Seguin River | Extirpated | - | Ontario |
| Moon River | Extant | Unknown | Ontario |
| Go Home River | Extant | Unknown | Ontario |
| Severn River | Extant | Unknown | Ontario |
| Lake Simcoe | Extirpated | - | Ontario |
| Sturgeon River | Extant | Unknown | Ontario |
| Nottawasaga River | Extant | Stable | Ontario |
| Manitou River | Extirpated | - | Ontario |

| Waterbody | Population Status | Population Trajectory[1] | Jurisdiction |
|---|---|---|---|
| Sauble River | Extant | Unknown | Ontario |
| Saugeen River | Extirpated | - | Ontario |

[1] Population trajectory was assessed using COSEWIC criteria as described in Pratt (2008).

Table 4. Population status and trajectory of Lake Sturgeon populations in Lake Erie and connecting waterways (Pratt 2008).

| Waterbody | Population Status | Population Trajectory[1] | Jurisdiction(s) |
|---|---|---|---|
| Lake St. Clair | Healthy | Stable | Ontario; Michigan |
| St. Clair River | Healthy | Stable | Ontario; Michigan |
| Detroit River | Extant | Increasing | Ontario; Michigan |
| Lake Erie | Extant | Unknown | Ontario; Michigan; Ohio; Pennsylvania; New York |

[1] Population trajectory was assessed using COSEWIC criteria as described in Pratt (2008).

Lake Sturgeon spawn in two major tributaries of Lake Nipissing, the Sturgeon River and the South River. Spawning assessments over the past two decades indicate successful natural recruitment suggesting the possibility of a modest recovery (Maraldo 1997). The population trajectory of the Lake Nipissing Lake Sturgeon sub-population was assessed as increasing by Pratt (2008).

The Lake Sturgeon sub-population of Lake St. Clair and connecting waters (Detroit and St. Clair rivers) appears to have remained stable for the past 40 years (OMNR 2009). Recreational harvest of Lake Sturgeon is permitted in the U.S., but not in the Canadian waters of Lake St. Clair and the St. Clair River. Sturgeon in Lake St. Clair and the St. Clair River are believed to be healthy with stable population trajectories (Pratt 2008).

Lake Sturgeon abundance in Lake Erie has been severely reduced since the early 1900s and continues to be well below historic levels. Five historic Lake Sturgeon spawning sub-populations in the U.S. waters of Lake Erie are all considered extirpated. There are no known Lake Sturgeon spawning tributaries on the Ontario portion of Lake Erie (OMNR 2009). There is a lack of current knowledge regarding the population status of Lake Sturgeon in western Lake Erie (Table 4). However, individuals are consistently captured in assessment gear in the western basin, but rarely in the central and eastern basins of Lake Erie (State of the Great Lakes 2009). No commercial or recreational fishing is permitted for Lake Sturgeon anywhere in Lake Erie. Fish community objectives for Lake Erie call for the protection and restoration of riverine and estuarine habitats to prevent the extirpation of Lake Sturgeon (Ryan et al. 2003).

Although juvenile Lake Sturgeon were once scarce in Lake Erie, they have been captured more frequently in the western end of the lake in recent years (OMNR 2009).

In the Canadian waters of Lake Ontario, spawning activity has been documented in two major tributaries, the Niagara and Trent rivers (Table 5) (State of the Great Lakes 2009). Lake-wide fish community objectives call for the recovery of Lake Sturgeon populations to the point where they can be removed from the threatened list (Stewart et al. 1999). Commercial fishing was closed in the late 1970s by both Ontario and New York. Based on incidental catches and spawning observations there are indications that Lake Sturgeon may be making a modest recovery in some parts of the lake (OMNR 2009).

Table 5. Population status and trajectory of Lake Sturgeon populations in Ontario tributaries of Lake Ontario and connecting waterways (Pratt 2008 and GLFC 2010).

| Waterbody | Population Status | Population Trajectory[1.] | Jurisdiction(s) |
|---|---|---|---|
| Ganaraska River | Extirpated | - | Ontario |
| Don River | Extirpated | - | Ontario |
| Trent River | Extant | Unknown | Ontario |
| Salmon River | Extirpated | - | Ontario |
| Napanee River | Extirpated | - | Ontario |
| Amherst Island, Lake Ontario | Extirpated | - | Ontario |
| Lower Niagara River | Extant | Stable | Ontario; New York |
| St Lawrence River (Iroquois) | Extant | Stable | Ontario; New York |
| St Lawrence River (Lake St. Francis) | Extant | Stable | Ontario; Quebec; New York |

1. Population trajectory was assessed using COSEWIC criteria as described in Pratt (2008).

Small sub-populations of Lake Sturgeon inhabit the Ontario portion of the St. Lawrence River (OMNR 2009). An isolated sub-population exists in Lake St. Francis between the Moses-Saunders and Beauharmois generating stations. Healthy sub-populations of Lake Sturgeon exist in the lower portions of the St. Lawrence River, notably in Lac St. Pierre and in the Des Prairies and St. Maurice rivers (State of the Great Lakes 2009). Commercial fishing is permitted within Quebec waters, but not in the Ontario waters of the St. Lawrence River.

The Ottawa River has been fragmented by dams. Lake Sturgeon are found throughout the Ottawa River and its tributaries although there is significant variation in relative abundance between river reaches (Table 6). Generally, their greatest abundance is in unimpounded reaches (Haxton 2002; Haxton and Findlay 2008). Although many of the populations inhabiting tributaries have been extirpated, Lake Sturgeon in the Ottawa River appear to be stable (OMNR 2009). No sport or commercial fisheries exist in Ontario waters. However, both fisheries exist in Quebec waters of the Ottawa River. Currently, exploitation rates are low and do not appear to be impeding recovery in the system (Haxton and Findlay 2008).

Table 6. Population status and trajectory of Lake Sturgeon populations in Ontario tributaries and lakes of the Ottawa River (Pratt 2008; OMNR 2009).

| Waterbody | Population Status | Population Trajectory[1.] | Jurisdictions |
|---|---|---|---|
| Ottawa River (Gatineau-Ottawa) | Extant | Increasing | Ontario; Quebec |
| Ottawa River (Lac Deschenes) | Extant | Stable | Ontario; Quebec |
| Ottawa River (Lacs des Chats) | Extant | Stable | Ontario; Quebec |
| Ottawa River (Lac des Rocher) | Extant | Unknown | Ontario; Quebec |
| Ottawa River (Lac Coulounge, Lower and Upper Allumette Lake) | Extant | Increasing | Ontario; Quebec |
| Ottawa River (Holden Lake, Lac La Cave) | Extant | Stable | Ontario; Quebec |
| Lake Temiskaming | Extant | Decreasing | Ontario; Quebec |

1. Population trajectory was assessed using COSEWIC criteria as described in Pratt (2008).

The Southern Hudson Bay-James Bay Population (DU7)

The Hudson Bay-James Bay drainage area includes a number of large rivers (e.g., Moose, Albany, Attawapiskat, Winisk and Severn) with drainage areas ranging from 56,000 to 136,000 km$^2$. The Moose River basin is a highly fragmented system, due to natural barriers and dams (Seyler 1997b). Lake Sturgeon habitat in the Moose River basin has been impacted by hydroelectric development and the logging industry (e.g., pulp and paper) (Gibson et al. 1984; Nowak and Hortiguela 1986; Payne 1987). Aside from studies conducted within the Moose River Basin, very little information exists regarding Lake Sturgeon sub-populations within the other large rivers. All the river basins have sustained some level of commercial exploitation in the past and a few small

First Nations commercial operations remain on the upper (inland) portions of the Albany and Winisk rivers. Lake Sturgeon remain abundant in the vicinity of coastal communities and near reserves and are harvested for subsistence purposes in many First Nation communities (Browne 2007). Catch and release fishing is permitted for Lake Sturgeon in this special concern zone. Lake Sturgeon sub-populations within the major rivers making up the Moose River basin (Abitibi, Groundhog, lower Kapuskasing, Mattagami, Missinaibi and Moose rivers) are generally stable, although abundance in discrete sections of some of these rivers is below historical levels and may be continuing to decline (Gibson et al. 1984; Nowak and Hortiguela 1986; Payne 1987).

## 1.4 Habitat Needs

Lake Sturgeon are potamodromous (i.e. migratory and live strictly within freshwater), but have some tolerance for brackish water. They are a large, slow-growing, migratory species that move extensively between habitats to fulfill seasonal and life history stage requirements. The quantity and quality of habitat needed to support the life functions of reproduction, feeding and growth, refugia and movement varies during its extended life history. A description of the habitat requirements of each life history stage is provided below. In addition, an open connection between habitats is paramount for the survival of this species.

Most sub-populations spawn in high-gradient reaches of large rivers, often below waterfalls, with current velocities of 0.5 to 1.3 m/s, water depths of 0.1 to 2 m, and substrates of coarse gravel, cobble, boulders, hardpan or sand (Auer 1996b; Lane et al. 1996; McKinley et al. 1998; Peterson et al*.* 2007). Spawning in the connecting waters of the Great Lakes and St. Lawrence River has been observed at depths of 9 to 12 m with velocities similar to those above (e.g., greater than 0.5 m/s) (Manney and Kennedy 2002; Nichols et al. 2003). Observations in the Riviere des Prairies near Montreal indicated individual females utilized from 13 to 48 $m^2$ of spawning habitat (Fortin et al*.* 2002). Observations in the Groundhog River, in northeastern Ontario indicate that large numbers of spawning Lake Sturgeon have selected the same discrete, 30 to 50 $m^2$ section of habitat, within an extensive set of rapids in successive years, despite suitable habitat being available nearby (Golder 2010a). In this case, fish movement to other, seemingly suitable spawning microhabitats does not appear to be restricted by physical conditions (e.g., flows, natural barriers). Lake Sturgeon abandon spawning locations immediately after spawning (Bruch and Binkowski 2002; Golder 2010a).

Some lake dwelling sub-populations are known to spawn along rocky lake shorelines exposed to wave action (COSEWIC 2006; Peterson et al. 2007). Adults that reside primarily within lake environments will travel extensive distances to access suitable spawning locations. This migration of adult Lake Sturgeon is functionally linked to transition between adult feeding/overwintering and spawning habitat. Non-fragmented habitats are critical for Lake Sturgeon as adults migrate considerable distances. Studies in the St. Lawrence River indicated Lake Sturgeon moved 138 to 225 km (Dumont et al. 1987; Fortin et al. 1993). In Lake Winnebago, Wisconsin, Lake Sturgeon travelled up to 228 km to spawn (Lyons and Kempinger 1992). Based on observations of natural populations with unrestricted access to lake and river habitats, Auer (1996b) recommended that management strategies should allow Lake Sturgeon access along unobstructed corridors to move between feeding, overwintering and spawning habitat.

Many authors have reported that Lake Sturgeon will move upstream to the furthest impassable barrier, natural or artificial, to spawn. A summary of Lake Sturgeon spawning migrations within the Great Lakes basin is provided in Auer (1996b). In the Pic River, a tributary to Lake Superior, adult Lake Sturgeon enter the river in the spring and migrate approximately 95 km to stage in a single pool several kilometres downstream of spawning locations. These adults spawn at Kagiano Falls on the Kagiano River and at Manitou Falls on the Pic River (A. Ecclestone, pers. comm. 2010). Radiotelemetry monitoring indicates that single and multiple spawning events have taken place at these locations. Friday and Chase (2010) have recorded annual movements of adults in the Kaministiquia River, 47 km upstream to spawn near the base of Kakabeka Falls, an impassable barrier, each spring. During some years two separate spawning events during the same season have been documented at this location (Friday 2005). In the Wolf and Upper Fox rivers in Wisconsin, Bruch (1999), recorded an autumn migration from Lake Winnebago to staging areas in the spawning tributaries. Adult Lake Sturgeon were found to concentrate in 2 to 10 m deep pools, up to three kilometres away from spawning locations. McLeod and Debruyen (2009) documented two migration patterns on the Namakan River system; a one-step migration during which mature Lake Sturgeon moved directly to spawning locations and then retreated downstream, and a two-step migration involving upstream movement in the fall, overwintering near spawning areas and a short migration to spawning locations the following spring.

In shallow sections of rivers, flows may dictate whether or not spawning areas are accessible. Many northern Ontario rivers are primarily surface water fed systems and, in comparison to southern Ontario streams, are influenced less by groundwater inputs. Consequently low winter precipitation and spring rainfall can result in extremely low spring flows, as experienced during 2010. On the Kagiano River and the Groundhog River, adult Lake Sturgeon were unable to reach preferred spawning locations and investigators found no evidence that spawning occurred at these locations in 2010 (A. Ecclestone, pers. comm. 2010; Golder 2010a).

Once larval Lake Sturgeon drift downstream from their spawning grounds, it becomes unclear whether they display specific habitat preference; this represents a significant knowledge gap particularly in lake environments. Larval drift has been documented substantial distances downstream of spawning locations as much as 61 km (Auer and Baker 2002). Young-of-the-year Lake Sturgeon have been reportedly captured over a variety of substrates including sand, pea size gravel and organic substrate (Kempinger 1996; Peake 1999; Holtgren and Auer 2004). Association with substrate may be particularly important during daylight hours when juveniles remain relatively stationary (Benson et al. 2005). Young-of-the-year tend to exhibit nocturnal behaviour, actively feeding at night. The most commonly reported characteristics of young-of-the-year and yearling habitat are shallow water (e.g., <2 m) and low velocities.

Part of the attraction of young-of-the-year Lake Sturgeon to particular substrates during daylight hours may be related to its properties as camouflage (Benson et al. 2005). Auer and Baker (2002) reported that the lower sections of the Sturgeon River, characterized as deep and slower-flowing, represented important nursery habitat for young-of-the-year Lake Sturgeon.

Lake Sturgeon may mature in their natal river or move downstream into lakes to forage in deep water (Holtgren and Auer 2004). Some studies suggest limited range movement of young Lake Sturgeon (Sandilands 1987; Thuemler 1988; Lyons and Kempinger 1992). Auer and Baker (2002) noted that Age-0 Lake Sturgeon were commonly associated with the lower sections of the Sturgeon River, Michigan, settling out of the current near the mouth of the river. On the Black River, Michigan, young-of-the-year Lake Sturgeon occupied the lower section of river for three to four months post-hatch before moving into lacustrine habitat (Smith and King 2005b). Benson et al. (2005) reported that young-of-the-year Lake Sturgeon remained in their natal stream over the summer, moved downstream in relation to declines in water temperatures. The extent of seasonal movements may vary with discharge. In the Sturgeon River, juveniles moved, on average, more than 15 km during late summer and early fall, eventually into deeper, lacustrine habitat for the winter (Holtgren and Auer 2004).

Prey availability may be an important determinant of habitat selection. In order to achieve the rapid growth rate associated with early life history stages, habitat that provides an adequate food supply is essential. Chiasson et al. (1997) noted that juvenile and sub-adult Lake Sturgeon were most commonly associated with clay substrate where macroinvertebrates were most abundant, on the Groundhog and Mattagami rivers in northeastern Ontario. These sturgeon appeared to exhibit increased activity during the evening and night, attributed to the diel movement (e.g., drift) of prey items. Invertebrate abundance is low in northern rivers and probably contributes to slow growth of juvenile Lake Sturgeon in these systems (Beamish et al. 1996).

Seasonal habitat utilization was examined by Seyler (1997b) in the Groundhog River. The majority of yearlings, juveniles and sub-adults occupied discrete pools during periods of high flow. However, during summer and autumn, at lower flows, they exhibited no depth preference and were evenly distributed across habitat features (e.g., pools, runs). In the Winnipeg River, juvenile Lake Sturgeon preferred deep areas of the river (e.g., >13.7 m) and a variety of substrate types during spring, summer and autumn months (Barth et al. 2009). Shallow water was rarely utilized by juveniles during day or night. Radiotelemetry and mark-recapture studies conducted near Carmichael Falls on the Groundhog River suggest that sub-adults moved very little over the course of the year (NEA 1992).

Telemetry studies conducted in Black Lake, Michigan, provided evidence that various life history stages of Lake Sturgeon occupied different portions of the lake (Smith and King 2005b). The authors suggested that habitat may be selected in order to avoid direct competition for food resources. This study also showed that yearling and juvenile Lake Sturgeon occupied different depths and preferred different substrates. Juveniles were generally associated with deep, offshore areas and organic substrate, while yearling Lake Sturgeon were associated with nearshore areas, with significant sand and organic substrate.  Juvenile Lake Sturgeon in the lower St. Clair River moved very little and showed a high degree of site fidelity, generally occupying depths of 12 to 18 m (Lord 2007).  It was hypothesized that juveniles may have selected these areas in relation to abundance of preferred food items and a lack of Zebra Mussel (*Dreissena polymorpha*) coverage.  Werner and Hayes (2005) examined the diets of juvenile and adult Lake Sturgeon in the St. Lawrence River which appeared to be a factor in habitat selection by individuals of different sizes.  The smallest individuals demonstrated a preference for chironomids and amphipods associated with soft substrates, while larger Lake Sturgeon preferred molluscs associated with boulder and cobble substrates.

Following spawning, some adult Lake Sturgeon move to feeding areas.  In the Pic River, telemetry studies indicated that adults retreat downstream, soon after spawning and remain in the lower Pic River throughout the summer before re-entering Lake Superior to overwinter.  These fish appear to utilize deep pools located in the lower river frequently (A. Ecclestone, pers. comm. 2010).  Telemetry studies conducted in the Black Sturgeon River, a tributary of Lake Superior which flows into Black Bay indicated that adults enter the river for feeding and spawning, but move back out into Black Bay in October and November to overwinter (M. Friday, pers. comm. 2010).  Adult Lake Sturgeon in the Kaministiquia River, also a tributary of Lake Superior, are year-round river residents, showing high fidelity to discrete summer and overwintering locations in the lower river (Friday and Chase 2010).  In a radiotelemetry study conducted near Carmichael Falls on the Groundhog River, Phoenix (1991) noted that adults moved substantially during the summer months, but were relatively immobile over the winter. Seasonal movements in lakes are not well known.  Mark recapture studies in the St. Lawrence River fluvial lakes (Lac Saint-Louis, Lac Saint Pierre and Lac des Deux Montagnes) indicated that movements were limited, except during spawning migrations (Fortin et al. 1993).  In waters with limited invertebrate production (e.g., northern latitudes) and high Lake Sturgeon abundance, individuals may need to forage over extensive areas in order to fulfill feeding requirements.

After spawning upstream in the Rainy River and its tributaries, radio-tagged Lake Sturgeon moved out into the southern portion of Lake of the Woods, making extensive feeding movements oriented to mainland and island shorelines throughout Big Traverse Bay during late spring to late summer (Rusak and Mosindy 1997).  By early fall, fish had returned to overwintering areas, showing high fidelity to either the lower stretches of the river or portions of the lake offshore from the river mouth.  Movements during winter were the most restricted of any season.  In the Namakan River, in northwestern Ontario, telemetry studies involving sub-adult and adults indicated that Lake Sturgeon moved upstream in the late summer and autumn to overwinter in lake environments (Welsh and McLeod 2010).  No movement was detected between November and April over two study years.

## 1.5 Limiting Factors

The life history traits exhibited by Lake Sturgeon, including large body size, delayed maturation, low natural mortality, longevity and high fecundity have allowed this species to survive short term extremes in environmental conditions and have contributed to the long term success of the species. The species has exhibited a remarkable ability to adapt to change over periods of many centuries. The decline of this species over much of its range, over a relatively short period of time (e.g., since the late 1800s) suggests that Lake Sturgeon are not able to adapt rapidly to changes in their environment caused by multiple stressors (e.g., high rates of exploitation coupled with habitat loss). Adaptation by populations or groups of organisms is generally measured over several generation times. Spawning periodicity, late age of maturation and the longevity of Lake Sturgeon may contribute to the inability of Lake Sturgeon to adapt rapidly to changes in their environment or to recover quickly from perturbation.

Various life history stages of Lake Sturgeon (e.g., eggs, larvae, juveniles, sub-adults and adults) require specialized habitats, often located far apart. Existing sub-populations frequently require both lake and river environments to carry out life processes. Research has shown that Lake Sturgeon tend to move large distances to access preferred habitat. As such Lake Sturgeon may be vulnerable to many forms of instream development and the disruption of physical connections between preferred habitats.

## 1.6 Threats to Survival and Recovery

A number of factors have contributed to the historical decline of Lake Sturgeon. Current threats include habitat alteration and fragmentation, pollution, illegal harvest, exploitation, species invasions and climate change (Harkness and Dymond 1961; Rochard et al. 1990; Birstein et al. 1997). These threats must be addressed in order to achieve recovery of Lake Sturgeon in Ontario.

The loss of habitat that occurred beginning early in the twentieth century may have been far less important than overfishing in contributing to their precipitous decline. In fact, many of the populations were reduced to remnant populations prior to major environmental perturbations affecting Lake Sturgeon habitat, including dam construction in Ontario. The combined impacts of habitat loss, overexploitation, increased industrialization, pollution, and species invasions make it difficult to establish current cause and effect relationships in Lake Sturgeon populations.

Exploitation

Exploitation (e.g., the legal harvest of fish) is not considered as a current threat to Lake Sturgeon recovery as recreational harvests and commercial harvests, for the most part, have been prohibited across Ontario. However, overexploitation was a key factor in the historical decline of Lake Sturgeon in Ontario (Harkness and Dymond 1961; Brousseau 1987). Prior to the mid 1800s, Lake Sturgeon had limited value and were considered a nuisance by commercial fishers for tearing nets while targeting other fish species. Commercial harvest on the Great Lakes peaked at 4,901 metric tonnes in 1885 (Baldwin et al. 2002). Commercial fisheries for Lake Sturgeon were also established on several larger inland waters including Lake Nipissing, Lake Nipigon, Lake of the Woods, Lake Simcoe and the Ottawa River. By the 1930s, harvest in the Great Lakes had declined to approximately two percent of the historic peak in Canadian waters, concurrent with a dramatic decline in abundance. Overfishing was so severe across much of the Lake Sturgeon range in Ontario that most populations which were overexploited in the late 1800s and early 1900s have not recovered. It has been shown that high adult mortality, particularly early adults, has a large impact on population fitness and on population recovery (Velez-Espino and Koops 2008).

The harvest of Lake Sturgeon in Ontario by recreational, commercial and subsistence fisheries continued at much lower rates after the declines. The commercial harvest was terminated in three of the four Great Lakes in the 1970s, continuing only in Lake Huron and in Lake St. Clair. Those commercial fisheries were closed in 2009. Commercial fishing continues in Quebec waters of the Ottawa River.

Recreational fishing for Lake Sturgeon existed throughout Ontario until 2008 when the OMNR restricted the sport fishery to catch-and-release only. In 2010, Ontario completely closed the sport fishery within waters inhabited by the Northwestern Ontario and Great Lakes/Upper St. Lawrence River Lake Sturgeon populations. Catch and release angling is still permitted in waters inhabited by the Southern Hudson Bay/James Bay Lake Sturgeon population. As closures of both commercial and sport fisheries in Ontario are relatively recent, it is too early to detect recovery responses of Lake Sturgeon populations.

First Nation subsistence fisheries have existed for thousands of years. There are no recent estimates for the harvest associated with the current subsistence fishery or First Nation commercial harvests in Ontario, although it is believed to be relatively low in terms of absolute numbers of fish. Several First Nation bands currently have small commercial Lake Sturgeon quotas. In northwestern Ontario, there are 33 licences, with a total sturgeon quota of 21,920 kg, issued to First Nations. Fifteen of these licences are inactive and harvest from the remaining licences is minimal. In most cases, only a few Lake Sturgeon are harvested annually and sold locally within the community. In northeastern Ontario, a commercial fishing licence, with a 200 kg sturgeon quota, is issued to First Nations for the Moose River. This licence is believed to have been inactive since 1996 (OMNR 2009).

<u>Habitat Alteration and Fragmentation</u>

Habitat alteration due to existing dams, future dam construction and operating regimes associated with these facilities represent significant risks to Lake Sturgeon recovery in Ontario. There are approximately 200 waterpower facilities currently operating in Ontario. In addition, there remains significant potential to increase capacity through redevelopment and development of new sites. At present, there are an estimated 70 to 80 active waterpower development proposals across the province (Golder 2010b).

Lake Sturgeon is a long-lived, migratory species that requires distinct habitat types throughout its life cycle. Habitat suitability may be constrained by the management of water levels, river flows, the creation of dams and by food availability. Where a particular life history stage occupies or congregates in discrete locations, they become more vulnerable to localized disturbance. Studies on the Ottawa River indicate that Lake Sturgeon distribution, especially of juveniles, is positively correlated with unimpounded river habitat (Haxton and Findlay 2008).

The Moose River basin is one of the most fragmented river systems in North America. The overall and cumulative impacts on the region's Lake Sturgeon sub-populations is unknown (Seyler 1997a). However, Lake Sturgeon have been impacted in discrete sections of rivers that have been impounded (Gibson et al. 1984; Nowak and Hortiguela 1986; Payne 1987). In these cases, the effects of habitat alteration due to historical log drives (e.g., bark deposition and scouring) and dam construction (e.g., loss of riverine habitat and fragmentation) as well as overfishing contributed to localized declines in abundance and eventual recruitment failure.

Many hydroelectric dams were historically constructed at natural barriers on rivers (e.g., waterfalls), where the greatest potential to build hydraulic head and to generate power existed. The fast flowing habitat below these features likely represented spawning habitat for fish species such as Lake Sturgeon. Where dam construction has created artificial barriers to upstream migration and disrupted formerly continuous habitat, Lake Sturgeon sub-populations have become fragmented (Wozney et al. 2010). Despite the construction of barriers, Lake Sturgeon will spawn at the base of dams (Auer 1996b; Haxton 2006). Flow management to provide access to and from spawning habitat, the provision of suitable spawning substrate and suitable flows to facilitate hatching and larval drift can be used to enhance Lake Sturgeon reproduction (McKinley et al. 1998; Haxton and Findlay 2008).

While several of the larger tributaries in Lake Huron still provide access to larval and juvenile habitat, most have artificial control structures located before the first major historical spawning location, impeding access to spawning habitats. Water level management during historical spawning runs has been identified as an issue on several tributaries (e.g., Moon River, Spanish River, Thessalon River) (Mohr et al. 2008).

The historical loss of habitat through impoundment and fragmentation and the failure to mitigate these losses is likely the greatest ongoing impediment slowing the recovery of sub-populations of Lake Sturgeon inhabiting highly developed systems such as the Ottawa River (Haxton and Findlay 2008). Lake Sturgeon in fragmented reaches of the Ottawa River exist in reduced numbers and have size distributions consisting predominately of larger individuals, indicating recruitment failure (Haxton 2002; Haxton and Findlay 2008; Haxton and Findlay 2009).

There is evidence that Lake Sturgeon sub-populations can persist within relatively short segments of rivers. In the Winnipeg River, high abundance and representation of all life history stages is maintained within a 10 km section of the river between two hydroelectric dams. The upstream dam, Pointe du Bois Generating Station, was constructed at a natural barrier in 1909 and Lake Sturgeon still pass through the lower Dam, Slave Falls Generating Station also constructed at a natural barrier. In this instance a variety of suitable habitats are available to resident Lake Sturgeon including riverine spawning conditions at the base of the upstream dam (S. Matkowski, pers. comm. 2010). This isolated sub-population appears to have remained healthy for several generations since dam construction.

Downstream passage through hydroelectric facilities and dams can cause injury or direct mortality to all life history stages of Lake Sturgeon from exposure to extreme changes in water pressure, cavitation, shear, turbulence or mechanical injuries, entrainment and impingement (Cada 1998). Cavitation can be related to engineering performance, which can be mitigated during shutdowns and may not, therefore, be a constant threat. Turbine and entrainment mortality, although poorly documented, are recognized threats to Lake Sturgeon subpopulations within fragmented rivers. On the Mattagami River in northern Ontario, variable numbers of adult Lake Sturgeon are entrained each spring, within a diversion channel of the river. The number of individuals entrained is dependent on the timing and duration of spills, relative to post-spawning movement (Seyler et al. 1996). Intakes of most hydroelectric facilities are covered by grates or angled bar racks spaced such that they would prevent passage of adult Lake Sturgeon through turbines, but not the passage of larval or juvenile fish. Fish survival through turbines is generally dependent on the size of fish being entrained, with higher survival in smaller fishes (EPRI 1997). The development of ‘fish friendlier’ turbines will require technological advances.

The development of technology to provide safe passage of Lake Sturgeon over lowhead barriers, through culverts and through or around hydroelectric facilities, both upstream and downstream, relative to their swimming capabilities, is ongoing. Relative to salmonids, the swimming performance (e.g., sustained, prolonged and burst swimming capabilities) of Lake Sturgeon is poor (Peake et al. 1997). Ideally, fishways should provide upstream passage for all migratory species inhabiting the river on which they are located. Water velocities within fishways should be less than the maximum attainable speed of all sizes and species that they are designed to pass. New fish passage designs must reflect the unique swimming capabilities of the Lake Sturgeon.

Dredge and fill activities can result in increased turbidity, reduced light penetration, altered water circulation patterns, and decreased levels of dissolved oxygen (Jeane and Pine 1975; Johnston 1981). Dredging and channelization for navigation has resulted in the destruction of Lake Sturgeon habitat throughout the St. Lawrence River and several of the connecting waterways in the Great Lakes (Edwards et al. 1989).

Where dredging occurs near the mouths of rivers, important nursery habitat may be affected. River deltas may be particularly important habitat for juvenile sturgeon (Mosindy and Rusak 1991; N. Auer pers. comm. 2010). The lower portion of the Kaministiquia River has been altered substantially to accommodate commercial marine traffic. Adult Lake Sturgeon utilize a dredged turning basin as summer habitat but move upstream to overwinter (Friday and Chase 2010). Dredging was implicated as the cause for loss of a Lake Sturgeon spawning shoal in the upper Niagara River near Buffalo Harbour (Carlson 1995). In the lower St. Lawrence River, the disposal of dredged material was observed to modify the existing substrate causing a reduction in food organisms for Lake Sturgeon (Munro 2000; Hatin et al. 2007). The effects of dredging on Lake Sturgeon have not been well documented. Declining water levels due to climate change may necessitate an increase in dredging activity and potential interactions with Lake Sturgeon need to be examined.

Pollution and Water Quality

Deterioration in water quality has been identified as contributing to historical declines in Great Lakes Lake Sturgeon populations. Historically, logging and lumber operations used waterways to move wood to mills and factories. Massive spring log drives and log jams were common in larger rivers and their tributaries. Accumulations of wood fibre and the discharge of chemical wastes from pulp and paper mills contributed to the collapse of sturgeon fisheries on Lake Superior (Lawrie and Raher 1973), Lake of the Woods (Mosindy 1987), Lake Nipissing (Harkness and Dymond 1961; Maraldo 1997) and the Spanish River (Dymond and Delaporte 1952). The accumulation of bark and wood fibre during the period of log drives on the Ottawa River altered the river bed and water chemistry of the river (Haxton 2008). Wood fibre accumulations on river beds may have influenced invertebrate production, contributing to localized declines in the Moose River Basin (Payne 1987). The relative density of macroinvertebrates, the predominant food source for Lake Sturgeon, was found to be significantly reduced in rivers where substrate was covered with wood chips (Beamish et al. 1998).

It is believed that winter anoxia caused by the discharge of untreated pulp and paper effluent into Lacs de Deux Montagnes has had long-term effects on recruitment and the recovery of Lake Sturgeon in that section of the St. Lawrence River (Dumont and Mailot in prep.). More recently, sewage effluent was determined responsible for widespread mortality of Lake Sturgeon eggs and larvae in the L'Assomption River, Québec (Dumas et al. 2003). Releases of chlorinated sewage upstream of a Lake Sturgeon spawning area on the Detroit River is believed to have affected survival of offspring (Manny et al. 2005).

As bottom feeders, Lake Sturgeon may be exposed to high levels of contaminants and pollutants. Studies have shown that the uptake of contaminants from the benthos can have deleterious effects including growth retardation, muscle degeneration, and reproductive impairment in other species of sturgeon (Feist et al. 2005; Webb et al. 2006). With their long lifespan, larger older Lake Sturgeon tend to have high mercury concentrations. In northern Ontario maximum harvestable size restrictions, placed on commercial fishers were based upon concentrations of mercury found in old Lake Sturgeon (Seyler 1997a). Although mercury concentrations were elevated in Ottawa River Lake Sturgeon, they were not believed to be sufficient to impede population recovery (Haxton and Findlay 2008). The effect of contaminant loading on survival and reproduction of Lake Sturgeon requires further research.

Illegal Harvest
The illegal harvest of Lake Sturgeon in Ontario has been intensified by the increasing global demand for sturgeon flesh and caviar (Williamson 2003). As sturgeon stocks elsewhere in the world collapse (e.g., the Caspian Sea), there has been increasing demand for North American caviar. The price of caviar makes sturgeon poaching a very lucrative pursuit and poaching for sturgeon is a relatively common activity (Cohen 1997). In recent years there has been an increase in cases involving poaching and illegal trade in Lake Sturgeon in North America (Traffic 2003).

Species Invasions
Since they feed almost exclusively on small benthic organisms on the lake/river substrate, Lake Sturgeon may be sensitive to competition with non-native organisms which have similar benthic feeding habits (e.g., Round Gobies) or become prey for other bottom feeding species (e.g., at the egg stage). Heavy infestations of Zebra Mussels can reduce the foraging activity of sturgeon. Lake Sturgeon also require clean substrate for spawning. Lord (2007) found that juvenile Lake Sturgeon tended to avoid habitat colonized by Zebra Mussels. These results suggested that zebra mussels may have limited juvenile Lake Sturgeon habitat suitability by affecting availability of their preferred prey, dipteran larvae. Conversely, Werner and Hayes (2005) reported dreissenids were targeted by adult Lake Sturgeon and made up a significant component of their diet on the St. Lawrence River.

Patrick et al. (2009) demonstrated, under laboratory conditions, that sea lamprey attacks can cause mortality in sub-adult and adult Lake Sturgeon. Both direct mortality, caused by acute anemia after an attack and indirect mortality, resulting from secondary fungal infection, was found to be size dependent (e.g., more frequent in smaller individuals). This study demonstrates that sea lamprey control likely benefits sub-adult and adult Lake Sturgeon by reducing predation. Larval and young-of-the-year Lake Sturgeon may be sensitive to the lampricide trifluromethyl-4-nitrophenol (TFM) (Boogaard et al. 2003). Auer (1998) recommended that chemical treatments for sea lamprey be adjusted and carefully monitored in rivers used by Lake Sturgeon or an alternate control method needed to be considered. Johnson et al. (1999) concluded that that concentrations of TFM used for sea lamprey treatment can be about 1.3 times those concentrations needed to kill sea lampreys and still not produce significant mortality among juvenile Lake Sturgeon. However, Lake Sturgeon were more sensitive to TFM than other fish species (e.g., Rainbow Trout, Northern Pike, and Muskellunge). The Great Lakes Fishery Commission (GLFC) has developed protocols for treating streams in which young-of-the-year Lake Sturgeon are known to be present (Seelye et al. 1989). Typically, lampricide applications are conducted at four to six year intervals. Any treatment-related impacts to sturgeon, if they occur, should be ameliorated by the infrequency of treatment (Johnson et al. 1999). However, in 2005 the GLFC recommended suspension of the use of lampricide concentration protocols on waterbodies where lamprey abundance is above targeted levels. A research project is currently underway in several Great Lakes tributaries, examining the effects of lampricide exposure on juvenile lake surgeon held in traps within the rivers, during lampricide treatment (T. Pratt, pers. comm. 2010). Lake Sturgeon are not the preferred hosts of sea lamprey. However, reduced utilization of lampricides may have serious implications for other fish such as salmonid species in the Great Lakes.

Direct predation on Lake Sturgeon eggs by fish and invertebrates has been documented by several authors (Kempinger 1988; Nichols et al 2003; Caroffino et al. 2010). The spread of invasive fish (e.g., Round Goby, *Neogobius melanostomus*) and invertebrate (e.g., Rusty Crayfish, *Orconectes rusticus*) species to waters inhabited by Lake Sturgeon represents a threat to egg survival.

<u>Climate Change</u>
As our climate changes, predictive models suggest that temperatures will become warmer, water levels may decrease and current hydrological patterns may be altered. Disruption of the timing of peak flows due to variability in temperature and changes to ice cover, the timing and magnitude of precipitation events, may disrupt the timing of spawning and hatching events, result in habitat loss and create barriers between critical habitats (e.g., overwintering and spawning locations). In natural systems, Lake Sturgeon may be capable of adapting to changing environmental conditions, as they have done for millions of years. In developed systems, decreasing water levels may result in greater demands on water budgets from existing users and fish species. Dredging activities may be required, where navigation becomes an issue, resulting in the loss of nursery habitat (e.g., at the mouths of rivers), increased turbidity during dredging activities and loss of benthic food sources.

## 1.7 Knowledge Gaps

The following knowledge gaps exist with respect to Lake Sturgeon biology and impacts of threats on Lake Sturgeon populations:

<u>Information Management</u>

- the current status of remnant Lake Sturgeon sub-populations across Ontario and their distribution in remote areas of northeastern and northwestern Ontario;
- the locations of important habitat features including staging, spawning, nursery, and overwintering areas. It is recognized that much of this information may exist within First Nation communities in the form of ATK;
- identification of factors impeding recovery in drainages and in localized portions of drainages where Lake Sturgeon abundance is believed to be declining;
- risk assessments to determine where Lake Sturgeon are or may be potentially at risk due to existing and future threats (e.g., instream development); and
- an inventory of existing water control structures to identify which facilities can be decommissioned/removed in order to benefit Lake Sturgeon recovery.

<u>Research and Assessment</u>

- larval, young-of-the-year and yearling habitat preferences and the factors that contribute to habitat suitability;

- disease prevalence with respect to introductions and/or supplemental stocking of Lake Sturgeon;
- standardized assessment and data gathering protocols incorporating Lake Sturgeon sub-population and habitat utilization criteria;
- understanding of the effects of lampricide on larval Lake Sturgeon and how lamprey control measures can be balanced with Lake Sturgeon recovery;
- uncertainty with respect to population structure and population dynamics associated with healthy sub-populations (e.g., age structure, recruitment), including minimum viable population size;
- understanding of what levels of harvest are sustainable;
- potential impacts of climate change on habitat, behavior, survival and recovery;
- impact of introduced species on Lake Sturgeon and how they interact;
- effectiveness of current measures to effectively mitigate threats (e.g., flow management);
- linkage(s) between habitat suitability and availability and population dynamics (e.g., year class strength, survival);
- effects of contaminants on growth, reproduction, survival and body burden;
- understanding of carrying capacity of lake and river habitats, in particular with respect to fragmented systems;
- understanding of the ecological role of Lake Sturgeon within aquatic communities and impacts of increasing Lake Sturgeon abundance on existing fish communities;
- efficacy of habitat enhancement methods; and
- effectiveness of Lake Sturgeon stocking efforts currently being implemented in other jurisdictions.

Technological Advances

- technology to pass all life history stages of Lake Sturgeon across and around man-made barriers, both upstream and downstream; and
- improved technology related to turbine design, in order to reduce entrainment and impingement mortality of all life stages of Lake Sturgeon.

As new knowledge is generated it should be incorporated within local scale management strategies, water management guidelines and monitoring programs**.**

## 1.8 Recovery Actions Completed or Currently Underway

A number of Lake Sturgeon management/recovery plans have been developed in various jurisdictions and these should be considered in the implantation of recovery approaches in Ontario. The Lake Sturgeon Management Plan for Lake of the Woods and Rainy River, developed by the Minnesota Department of Natural Resources, OMNR and the Rainy River First Nation includes long-term population goals and criteria that will be used to evaluate population status in the Lake of the Woods-Rainy River system (Minnesota Department of Natural Resources 2009). A Lake Sturgeon rehabilitation plan has been developed for Lake Superior on behalf of the Great Lakes Fishery

Commission, outlining population and habitat management goals (Auer 2003). The long term objective is to restore viable populations in each of the tributaries previously known to support Lake Sturgeon. The Michigan Department of Natural Resources has developed a Lake Sturgeon rehabilitation plan that includes the Detroit and St. Clair rivers and Lake St. Clair, Lake Erie and Lake Huron (Hay-Chielewski and Whelan 1997).

Kerr et al. (2011) reviewed a number of Lake Sturgeon habitat creation/enhancement projects that have been completed and recommend that artificially created spawning grounds should provide a range of suitable conditions for spawning under varying seasonal conditions of water discharge. Several authors have reported increased utilization and egg survival on artificially created spawning habitat (Lapan et al. 1997; Dumont et al. 2004; Dick et al. 2006; Johnson et al. 2006; Dumont et al. 2011; Dumont and Mailhot in prep.). The availability of suitable spawning habitat may not necessarily be a limiting factor for recovering Lake Sturgeon sub-populations and consideration should be given to creating or enhancing other important habitats (e.g., staging and nursery areas) in systems where these features are in limited supply.

The OMNR has legislative responsibility for waterpower development and the operation of waterpower facilities. In 2002, the OMNR issued the Water Management Planning Guidelines for Waterpower (OMNR 2002a). This guidance document is utilized by industry, the OMNR and others to prepare Water Management Plans (WMPs) for waterpower facilities throughout the Province. The Ontario Waterpower Association (OWA) has developed a best management practices (BMP) guide for waterpower projects in relation to Lake Sturgeon (OWA 2009). It is essential that documents such as these be utilized by project proponents and resource managers to mitigate potential environmental effects on Lake Sturgeon. The monitoring of outcomes related to the implementation of BMPs outlined in OWA (2009) is critical to understanding Lake Sturgeon responses to mitigation measures.

Flow regimes (e.g., operating regimes) can be managed to benefit Lake Sturgeon. Auer (1996a) monitored Lake Sturgeon spawning activity in relation to peaking and run-of-the-river (ROR) flows below a hydroelectric facility on the Sturgeon River, Michigan, from 1987 to 1992. Greater numbers of Lake Sturgeon were present at spawning areas when more natural flows were implemented, particularly when water temperatures were optimal for spawning (e.g., 10°C - 15°C). The author attributed easier access to spawning rapids, particularly for large individuals (e.g., females) as the reason for increased spawning activity. Efforts are being made to ensure adequate flows below hydroelectric facilities to enhance Lake Sturgeon spawning in several tributaries (Auer 1996a; Friday 2006b).

The application of Lake Sturgeon culture and stocking may be an essential tool required to recover some Lake Sturgeon sub-populations in Ontario. Smith (2009) and Smith and Hobden (2011) consolidates information on Lake Sturgeon culture and existing stocking conservation programs. Stocking could be used both as a short-term and long-term management strategy, through reintroduction or rehabilitation stocking methods. Reintroduction stocking involves the release of individuals into waters they formerly occupied (OMNR 2002b). The goal of reintroduction projects is to re-establish naturally reproducing populations. Supplemental stocking is the addition of individuals to an existing population (OMNR 2002b). Supplemental stocking is used to address population deficiencies such as low abundance or weak recruitment. Although Lake Sturgeon culture has been occurring for over 20 years, evaluating stocking success requires at least one generation (e.g., 15 - 20 years). Consequently most ongoing stocking programs and stocking techniques have not been fully evaluated.

Generally, U.S. management agencies have applied stocking as a management strategy more than Canadian agencies. A number of states are currently committed to Lake Sturgeon stocking programs. Wisconsin and Michigan currently implement the largest stocking programs (Smith and Hobden 2011). Lake Sturgeon stocking initiatives have also been implemented by stewardship groups and industry in the provinces of Manitoba, Saskatchewan and Quebec (Smith 2009). The Manitou Rapids Fish Hatchery, in northwestern Ontario has cultured and released Lake Sturgeon since 1993 for the Rainy River and Dalles First Nation communities. Streamside culture facilities have been used as a means to raise and release young-of-the-year Lake Sturgeon in several U.S. rivers (Auer and Baker 2009; Mann et al. 2011). The stocking of Lake Sturgeon is currently not endorsed within the Ontario fish stocking guidelines for inland waters (OMNR 2002b).

Effective passage of Lake Sturgeon around hydroelectric facilities and other high relief structures will require additional research and technological advances. There are some instances of subadult Lake Sturgeon using vertical slot fishways (Hay-Chmielewski and Whelan 1997, Anderson et al. 2007). Recent experimentation with a side-baffle ladder design shows promise in facilitating up and downstream movement of Lake Sturgeon (Kynard et al. 2010).

# 2.0 RECOVERY

## 2.1 Recovery Goal

The recovery goal for Lake Sturgeon in Ontario is to maintain existing Lake Sturgeon populations throughout their current range and where feasible restore, rehabilitate or reestablish self-sustaining Lake Sturgeon populations which are viable in the long term within their current habitat and/or within habitats they have historically occupied, in a manner consistent with maintaining ecosystem integrity and function. Long-term viability is characterized by successful spawning and hatching, natural recruitment, stable genetic diversity and size and age structures that include representation of all life history stages.

Recovery actions should be implemented on a finer geographic scale than the designated units developed by COSEWIC and the population units identified by COSSARO. Fisheries and Oceans Canada has established Lake Sturgeon management units (SMUs) based upon existing genetic structuring and geographic isolation (e.g., known barriers to migration). Sturgeon Management Units have been developed for Lake Sturgeon within the Red Assiniboine rivers (Cleator et al. 2010a) and within the Winnipeg and English rivers (Cleator et al. 2010b), both of which are inhabited by Lake Sturgeon that are part of the Northwestern Ontario population and for Lake Sturgeon in the Great Lakes/St. Lawrence River population (Pratt 2008). At the present time, SMUs have not been defined for Lake Sturgeon in the Rainy River system or for the Southern Hudson Bay-James Bay population.

## 2.2 Protection and Recovery Objectives

Beginning in the mid to late 1800s, over-exploitation and habitat alteration resulted in dramatic declines in Lake Sturgeon stocks throughout much of their historical range including Ontario. The species has historically been and continues to be significant to many First Nations as a source of food and as an integral part of their spiritual and cultural identity. Recovery objectives have been developed in order to prevent the further decline of Lake Sturgeon populations and, where functional habitat exists, restore populations, recognizing their cultural value to First Nations and their socioeconomic value to all of the people of Ontario for education and research and for sustainable use (e.g., harvest). Where scientific evidence can demonstrate that recovery objectives will not be compromised, Lake Sturgeon should be managed for multiple uses including harvest.

Table 7 contains a list of protection and recovery objectives for Lake Sturgeon in Ontario.

Table 7. Protection and recovery objectives

| No. | Protection or Recovery Objective |
|---|---|
| 1 | Protect or increase extant Lake Sturgeon populations at an abundance commensurate with the capacity of their habitat to support them and the existing fish community. |
| 2 | Maintain, enhance and, where feasible, restore habitat in order to support Lake Sturgeon. |
| 3 | Restore Lake Sturgeon populations in locations where they have become extirpated, where feasible and where functional habitat exists. |
| 4 | Develop local scale Lake Sturgeon management strategies. |
| 5 | Increase public awareness of the cultural and ecological significance and uniqueness of Lake Sturgeon and the importance of maintaining, enhancing and restoring Lake Sturgeon populations. |
| 6 | Address knowledge gaps to enable and enhance protection, conservation and recovery efforts. |

## 2.3 Approaches to Recovery

Table 8 summarizes recovery approaches associated with recovery objectives. A relative priority has been assigned to each approach based upon the need to complete and urgency of completing actions. Critical approaches must occur, are the highest priority for survival/recovery and implementation should be initiated immediately. Necessary approaches also must occur but are less urgent to implement and should be implemented within five years. Beneficial approaches will help achieve recovery goals, but are not considered as important as the preceding two categories.

Responses to management actions (e.g., recovery efforts) may take multiple generation times to detect where Lake Sturgeon declines have been severe. Where suitable numbers of mature adults persist and access to preferred habitats is maintained, recovery time may be more rapid. This appears to be the case for the recovery of Lake Sturgeon sub-populations in the Lake St. Clair-Ste Clair River and in the Lake of the Woods-Rainy River corridors. Relative timeframes associated with recovery objectives and approaches are categorized as long-term or within 200 years (e.g., 1 - 3 generations), medium term or 10 to 15 years (e.g., a spawning cycle for adult female Lake Sturgeon plus time required for their offspring to reach a size at which survival and abundance can be measured) and short-term or achievable within 10 years. This is necessary to provide both long-term vision and intermediate achievable milestones along the path to Lake Sturgeon recovery. Ongoing approaches are a subset of long-term approaches that are distinguished by the fact that they are the same action carried out repeatedly on a systematic basis.

Table 8. Approaches to recovery of the Lake Sturgeon in Ontario

These approaches apply to both threatened and special concern populations unless stated otherwise.

| Relative Priority | Relative Timeframe | Recovery Theme | Approach to Recovery | Threats or Knowledge Gaps Addressed |
|---|---|---|---|---|
| **1.** Protect or increase extant Lake Sturgeon populations at an abundance commensurate with the capacity of their habitat to support them and the existing fish community and fisheries. | | | | |
| Critical | Long-term | Management | **1.1** Evaluate potential impacts, utilize best management practices and incorporate state-of-the-art science and technology in project and water management planning to minimize Lake Sturgeon mortality. | Threats:<br>• Habitat alteration and fragmentation<br>Knowledge Gaps:<br>• Locations of important habitat features (spawning, staging, nursery, overwintering)<br>• Determining effectiveness of mitigation<br>• Efficacy of habitat enhancement |
| Critical | Medium-term | Management | **1.2** Develop tools to evaluate and address the cumulative impacts of instream development and other anthropogenic stressors on Lake Sturgeon populations and sub-populations. | Threats:<br>• Exploitation<br>• Habitat alteration and fragmentation<br>• Pollution and water quality<br>• Illegal harvest<br>Knowledge Gaps:<br>• Identification of local factors impeding recovery<br>• Current status of sub-populations |

| Relative Priority | Relative Timeframe | Recovery Theme | Approach to Recovery | Threats or Knowledge Gaps Addressed |
|---|---|---|---|---|
| Critical | Medium-term | Assessment and Management | **1.3** Assess impediments to Lake Sturgeon recovery on a local scale and implement appropriate actions.<br>• Where feasible, remove existing threats (e.g., low head barriers). | Threats:<br>• Habitat alteration and fragmentation<br>• Pollution and water quality<br>• Illegal harvest<br>• Species invasions<br>Knowledge Gaps:<br>• Inventory control structures<br>• Risk assessment of sub-populations |
| Necessary | Long-term | Management | **1.4** Where appropriate, increase Lake Sturgeon abundance through habitat improvement, mitigation or removal of factors resulting in unnatural mortality. | Threats:<br>• Habitat alteration and fragmentation<br>• Pollution and water quality<br>• Illegal harvest |
| Necessary | Medium-term | Management | **1.5** Where there is capacity for population increases, no habitat limitations and Lake Sturgeon abundance is too low to expect a population increase through natural reproduction of remnant sub-populations, increase abundance through stocking using fish culture guidelines specifically created for Lake Sturgeon.<br>• Develop stocking plans to provide site-specific guidance for stocking initiatives. | Threats:<br>• Exploitation<br>Knowledge Gaps:<br>• Ecological role and impacts of increasing Lake Sturgeon abundance<br>• Impacts of reintroduction on other fish species<br>• Effectiveness of stocking efforts |
| Beneficial | Long-term | Protection and Management | **1.6** When it is deemed necessary to provide a pool of genetic material or individuals to support recovery actions (e.g., reintroductions) identify and protect sub-populations or portions of sub-populations of Lake Sturgeon. | Threats:<br>• Exploitation<br>• Habitat alteration and fragmentation<br>• Pollution and water quality<br>• Illegal harvest |

| Relative Priority | Relative Timeframe | Recovery Theme | Approach to Recovery | Threats or Knowledge Gaps Addressed |
|---|---|---|---|---|
| Beneficial | Short-term | Research and Management | **1.7** Identify population characteristics and performance measures associated with healthy populations and levels of exploitation that are sustainable without jeopardizing Lake Surgeon recovery. | Threats:<br>• Exploitation<br>Knowledge Gaps:<br>• Population structure uncertainty<br>• Sustainable harvests |
| Beneficial | Medium-term | Management | **1.8** Where feasible, restore recreational and commercial Lake Sturgeon fisheries and manage harvests on a sustainable basis without jeopardizing recovery. | Threats:<br>• Exploitation<br>Knowledge Gaps:<br>• Sustainable harvests |

| | | | | |
|---|---|---|---|---|
| **2.** Maintain, enhance and, where feasible, restore habitat in order to support Lake Sturgeon. | | | | |
| Critical | Short-term | Protection and Management | **2.1** Inventory and map important Lake Sturgeon habitat features. | Knowledge Gaps:<br>• Important habitat features<br>• Risk assessment of sub-populations |
| Critical | Ongoing | Protection and Management | **2.2** Ensure no net loss of habitat from development activities and achieve net gains of habitat to the degree possible. | Threats:<br>• Habitat alteration and fragmentation<br>• Pollution and water quality<br>Knowledge Gaps:<br>• Inventory of habitat features |
| Critical | Ongoing | Protection and Management | **2.3** Evaluate potential impacts, utilize best management practices and incorporate state-of-the-art science and technology during development to protect/maintain functional Lake Sturgeon habitat. | Threats:<br>• Habitat alteration and fragmentation<br>• Pollution and water quality |
| Critical | Ongoing | Protection and Management | **2.4** Address cumulative effects during development that may affect Lake Sturgeon. | Threats:<br>• Habitat alteration and fragmentation<br>• Pollution and water quality |
| Critical | Long-term | Management | **2.5** Protect and restore productive capacity of habitat to support Lake Sturgeon through habitat enhancement, mitigation or removal of factors that compromise habitat suitability and availability of all life history stages.<br>• Use local knowledge and data to determine suitability of habitat to support Lake Sturgeon.<br>• Develop habitat enhancement programs to maintain or improve habitat for all life history stages.<br>• Report efficacy of habitat enhancement programs. | Threats:<br>• Habitat alteration and fragmentation<br>• Pollution and water quality<br>Knowledge Gaps:<br>• Carrying capacity<br>• Effectiveness of mitigation<br>• Efficacy of habitat enhancement<br>• Inventory control structures<br>• Linkages between habitat and population dynamics<br>• |

| | | | | |
|---|---|---|---|---|
| Necessary | Short-term | Management | **2.6** Identify existing facilities where operating regimes could be modified to benefit Lake Sturgeon. | Threats:<br>• Habitat alteration and fragmentation<br>Knowledge Gaps:<br>• Inventory of water control structures<br>• Risk assessment of sub-populations |
| Beneficial | Short-term | Management | **2.7** Identify facilities/structures that could be decommissioned/removed to benefit Lake Sturgeon. | Threats:<br>• Habitat alteration and fragmentation<br>Knowledge Gaps:<br>• Inventory of water control structures |
| **3.** Restore Lake Sturgeon populations in locations where they have become extirpated, where feasible and where functional habitat exists. | | | | |
| Necessary | Short-term | Management | **3.1** Develop a provincial government policy to govern circumstances under which stocking may be used for reintroduction of Lake Sturgeon to waters they previously occupied. | Knowledge Gaps:<br>• Ecological role and impacts of increasing Lake Sturgeon abundance |
| Necessary | Short-term | Research and Management | **3.2** Assess potential ecological and social impacts of reintroducing Lake Sturgeon into former habitat (e.g., Lake Simcoe). | Knowledge Gaps:<br>• Ecological role and impacts of increasing Lake Sturgeon abundance<br>• Impacts of reintroduction on other fish species |
| Necessary | Long-term | Management | **3.3** Reintroduce Lake Sturgeon to waters they formerly occupied, which are capable of providing habitat requirements for all life history stages. | Threats:<br>• Exploitation<br>• Illegal harvest<br>Knowledge Gaps:<br>• Effectiveness of stocking<br>• Impacts of reintroduction on other fish species |

| | | | | |
|---|---|---|---|---|
| **4.** Develop local scale Lake Sturgeon management strategies. | | | | |
| Critical | Short-term | Inventory and Management | **4.1** Support aboriginal communities in collecting and managing traditional ecological and community knowledge of Lake Sturgeon. | Knowledge Gaps:<br>• Assessment of current status and distribution<br>• Locations of important habitat features<br>• Risk assessment of sub-populations |
| Critical | Short-term | Inventory and Management | **4.2** Consolidate and synthesize existing scientific and unpublished information regarding Lake Sturgeon distribution. | Knowledge Gaps:<br>• Assessment of current status and distribution<br>• Locations of important habitat features<br>• Risk assessment of sub-populations |
| Critical | Short-term | Management | **4.3** Adopt Lake Sturgeon management units (SMUs) as a basis for developing management strategies. | Threats:<br>• Exploitation<br>• Habitat alteration and fragmentation<br>• Pollution and water quality<br>• Illegal harvest |
| Critical | Short-term | Management | **4.4** Develop SMU designations for Lake Sturgeon within the Lake of the Woods-Rainy River catchment and for the Southern Hudson Bay-James Bay population. | Threats:<br>• Exploitation<br>• Habitat alteration and fragmentation<br>• Pollution and water quality<br>• Illegal harvest |

| | | | | |
|---|---|---|---|---|
| Critical | Short-term | Management | **4.5** Through collaboration with First Nations, stakeholders and government agencies, develop management strategies for each SMU where Lake Sturgeon are listed as threatened, incorporating appropriate recovery actions and measurable recovery targets. | Threats:<br>• Exploitation<br>• Habitat alteration and fragmentation<br>• Pollution and water quality<br>• Illegal harvest |
| Critical | Ongoing | Management | **4.6** Create/maintain partnerships between First Nations, federal, provincial governments and state agencies and collaborate on management/recovery planning initiatives where Lake Sturgeon populations occupy inter-jurisdictional waters. | Threats:<br>• Exploitation<br>Knowledge Gaps:<br>• Risk assessment of sub-populations |
| Necessary | Short-term | Management | **4.7** Through collaboration with First Nations, stakeholders and government agencies, develop management strategies for each SMU where Lake Sturgeon are listed as special concern, incorporating appropriate recovery actions and measurable recovery targets. | Threats:<br>• Exploitation<br>• Habitat alteration and fragmentation<br>• Pollution and water quality<br>Illegal harvest |
| **5.** Increase public awareness of the cultural, ecological significance and uniqueness of Lake Sturgeon and the importance of maintaining, enhancing and restoring Lake Sturgeon populations. | | | | |
| Necessary | Short-term | Education and Communications | **5.1** Engage the public, stakeholders and industry and promote awareness of the significance of Lake Sturgeon and imminent threats to their recovery. | Threats:<br>• Exploitation<br>• Habitat alteration and fragmentation<br>• Pollution and water quality<br>• Illegal harvest |

| | | | | |
|---|---|---|---|---|
| Necessary | Short-term | Management | **5.2** Promote use of best management practices (OWA 2009) by the water power industry | Threats:<br>• Habitat alteration and fragmentation<br>Knowledge Gaps:<br>• Effectiveness of mitigation<br>• Efficacy of habitat enhancement<br>• Lake Sturgeon passage<br>• Improved technology |
| Beneficial | Ongoing | Education and Communications | **5.3** Develop or adapt existing education, science-transfer and public awareness programs focusing on local communities, schools, fishers and local conservation organizations. | Threats:<br>• Exploitation<br>• Pollution and water quality<br>• Illegal harvest |
| Beneficial | Ongoing | Outreach, monitoring and Stewardship | **5.4** Develop stewardship programs to actively involve Aboriginal communities and the public in recovery initiatives and monitoring activities. | Threats:<br>• Exploitation<br>• Illegal harvests |
| **6.** Address knowledge gaps to enable and enhance protection, conservation and recovery efforts. | | | | |
| Critical | Short-term | Management | **6.1** Determine distribution and abundance of extant Lake Sturgeon sub-populations in Ontario. | Knowledge Gaps:<br>• Distribution and current status of populations<br>• Risk assessment |
| Critical | Medium-term | Management | **6.2** Complete assessments of the status of Lake Sturgeon sub-populations and identify important habitat features. | Knowledge Gaps:<br>• Distribution and current status of populations<br>• Locations of important habitat features<br>• Risk assessment |
| Necessary | Ongoing | Research | **6.3** Promote and support Lake Sturgeon research to address key information gaps, impact mitigation and removal of threats to recovery. | Knowledge Gaps:<br>• All: See Section 1.7 |

| | | | | |
|---|---|---|---|---|
| Necessary | Ongoing | Research and Management | **6.4** Develop partnerships, between aboriginal communities, government and academic researchers, industry, commercial fishers and anglers to address key information gaps, explore adaptive management approaches to mitigating impacts and managing populations and habitat. | Knowledge Gaps:<br>• Distribution and current status of populations<br>• Early life history habitat preferences<br>• Effectiveness of mitigation<br>• Efficacy of habitat enhancement methods |
| Necessary | Short-term | Management | **6.5** Develop standardized sampling and assessment protocols for Lake Sturgeon sub-population assessment and habitat utilization assessment and utilize these in follow-up monitoring programs where recovery actions are implemented. | Knowledge Gaps:<br>• Standardized assessment<br>• Determining effectiveness of mitigation<br>• Efficacy of habitat enhancement methods |

Narrative to Support Approaches to Recovery

Guidance from Aboriginal peoples and communities, based on their unique knowledge, perspectives and practices, will be important to Lake Sturgeon protection and recovery activities. In implementing the recommendations of this recovery strategy, Ontario should be mindful of Aboriginal and treaty rights protected under Section 35 of the *Constitution Act 1982* and meet any obligations to consult with Aboriginal peoples where its actions may adversely affect an established or asserted Aboriginal or treaty right.

*Objective 1: Protect or increase extant Lake Sturgeon populations at an abundance commensurate with the capacity of their habitat to support them and the existing fish community.*

Where Lake Sturgeon are threatened, protection and avoiding further harm to extant sub-populations should take precedence over all other recovery actions. For the Southern Hudson Bay-James Bay population, listed as special concern, the management priority should be to ensure that future impacts on Lake Sturgeon and their habitats do not result in sub-population declines. The recovery of subpopulations of Lake Sturgeon may not always be possible due to significant, irreversible biological, chemical and physical changes in their habitat. Where sub-populations of Lake Sturgeon are presently at risk of extirpation, the protection of remnant stock may be the only option available to managers.

Where Lake Sturgeon are known to be present and where a potential action may represent a risk, and adequate information does not exist, a precautionary approach should be adopted in relation to preventing harm to Lake Sturgeon and their habitat. In these cases, it is prudent to afford protection to Lake Sturgeon to mitigate potential impacts or defer decisions related to development until such time as adequate information can be gathered to reduce the uncertainty of risk. Where the risk to Lake Sturgeon is deemed to be low, an adaptive management approach to managing Lake Sturgeon and their habitat should be considered.

In developed areas, an understanding of the cumulative effects and the risk that additional development may represent to maintaining and restoring Lake Sturgeon populations should be integrated in decision making. Studies of Lake Sturgeon sub-populations within highly fragmented systems demonstrate that altering habitat and restricting movement between important habitat features have negative affects. Lake Sturgeon management strategies must address the risks (e.g., cumulative effects) that proceeding with multiple developments on systems represent to Lake Sturgeon recovery and the maintenance of secure (e.g., currently healthy) populations.

The removal or mitigation of existing threats to Lake Sturgeon should be evaluated. Velez-Espino and Koops (2009) demonstrated that adult mortality, in particular late juveniles, has a larger impact on Lake Sturgeon population fitness, than reproductive success (e.g., periodic reproductive failure). Minimizing sources of adult mortality (e.g., harvest, entrainment) should be considered where management goals include increasing Lake Sturgeon abundance. However, continuous, intense recruitment failure caused by the inaccessibility to spawning habitat or degradation of important habitat can play important roles in inhibiting or prolonging Lake Sturgeon recovery. The removal of low head barriers to improve or restore Lake Sturgeon movement along river corridors should be examined. The effects of barrier removal must take into account social and ecological impacts (e.g., provision of upstream access to aquatic invasive species).

Lake Sturgeon stocking has occurred for more than 20 years in some North American jurisdictions. The only existing Lake Sturgeon culture facility in Ontario is operated by the Rainy River First Nation. Using brood stock from the Rainy River, Lake Sturgeon fry have been released back into the river and into the upper Winnipeg River (J. Hunter, pers. comm. 2010). Stocking should be considered as a tool to accelerate Lake Sturgeon recovery where suitable habitat conditions exist and abundance is too low to expect natural reproduction to result in recovery or for reintroduction of Lake Sturgeon (e.g., into areas of their historic range where they have been extirpated). The prevention, removal or mitigation of threats and barriers to Lake Sturgeon recovery should take precedence over stocking as a recovery tool.

Closely related sources of donor stock should be used in recovery efforts with adequate representation of genetic diversity. Smith (2009) provides an evaluation of current stocking programs in various jurisdictions and cites factors which may affect the success of stocking programs. Welsh et al. (2007) provides recommendations for selecting stocking sites and donor populations based on genetics for Lake Sturgeon in the Great Lakes. There is currently no existing policy within the provincial government to guide recovery proponents or govern the circumstances under which stocking might be used as a tool in Lake Sturgeon recovery. In addition to identifying appropriate donor stock, the development of stocking plans will require an assessment of existing facilities to rear Lake Sturgeon, a decision on stocking locations and appropriate size or life history stage to stock, a cost analysis and a stocking assessment plan to measure the success of stocking efforts in relation to stocking goals. Stocking rates and goals should be based upon a fundamental understanding of the capacity of the system to support Lake Sturgeon (e.g., carrying capacity). In addition to provincial policy, stocking plans should integrate federal and inter-jurisdictional Lake Sturgeon policies and goals.

*Objective 2: Maintain, enhance and, where feasible, restore habitat in order to support Lake Sturgeon.*

Habitat management should attempt to restore and protect habitat throughout lake and river environments, mimic natural flow regimes and maintain linkages among important habitats upon which Lake Sturgeon depend to carry out their life processes. Protection should be afforded by maintaining the quality and quantity of existing habitat and mitigating or preventing changes to the biological environment (e.g., species introductions). A clear understanding of the locations of important habitats and maintaining existing linkages between habitats in any given watershed are key considerations in managing habitat. Where it cannot be demonstrated that potential effects of new development on Lake Sturgeon can be mitigated, development should not be permitted to proceed.

Mapping of important habitat features does not exist for most systems currently supporting Lake Sturgeon in Ontario and represents a major knowledge gap. This information will be required as baseline information for the development of local scale management strategies. Existing aboriginal traditional knowledge and local knowledge and/or scientific data should be used to identify important habitats and the connections between them. In locations where no information exists, several years of data collection extending over several seasons (e.g., spring, summer and winter) may be required to determine movement, habitat utilization and site fidelity, especially where conditions (e.g., flows) are highly variable.

It is not realistic to believe that it is possible to recover Lake Sturgeon to their historic levels of abundance throughout their historical range, given the dramatic changes that have occurred in Ontario's aquatic ecosystems since their decline. However, efforts to restore or enhance habitat in disturbed systems in order to support Lake Sturgeon is inherent to the recovery goal. Lake Sturgeon habitat creation or enhancement should be considered where conditions are conducive to recovery. Most Lake Sturgeon habitat enhancement efforts have been focused on creating or improving spawning habitat or modifying flows to enhance habitat suitability. Within any given system or corridor, Lake Sturgeon require a number of connected habitat features, and spawning habitat may not always be a limiting factor to Lake Sturgeon recovery. There is a need for managers to develop habitat enhancement programs to improve habitat for other life history stages (e.g., larvae and juveniles) and to document the efficacy of their efforts.

Randall (2008) attempted to quantify habitat required by individual Lake Sturgeon, however, the linkages between habitat quantity and the number of Lake Sturgeon that it can support have not been clearly established and in any event, are likely unique to each river and lake. There are gaps in our understanding of Lake Sturgeon habitat, particularly for larval, young-of-the-year and yearling life history stages. The determination of whether or not there is existing capacity within a system to support increased Lake Sturgeon abundance will be dependent upon identifying habitats that are potentially suitable for various life history stages of Lake Sturgeon and ensuring connectivity between them. A Lake Sturgeon habitat suitability index (HSI) model was developed for application within large, low gradient rivers in northern Ontario (Threader et al. 1998). Habitat suitability models can be a useful basis for habitat evaluation. However, local knowledge and data is critical to assessing habitat suitability prior to selecting and implementing recovery approaches.

The threat(s) that existing water control structures impose on the recovery of Lake Sturgeon sub-populations should be evaluated from the perspective of identifying opportunities to enhance habitat suitability and biological processes. The potential ecological implications of modifying habitat to benefit Lake Sturgeon must consider habitat requirements of other fish species. Habitat modification may also have significant implications to existing development and human activities which should be fully explored as local scale management strategies are developed.

The best management practices guide developed by the OWA for Lake Sturgeon provides project proponents and managers with tools and approaches to mitigating potential effects of hydroelectric development (OWA 2009). Managers and industry should work together to identify where and how adaptive management approaches can be implemented to benefit Lake Sturgeon. Hydroelectric operations providing adequate flows and timing of flows to accommodate the upstream and downstream migration of spawning adults, egg incubation and larval drift will enhance Lake Sturgeon recovery. The water power industry should be engaged to carry out collaborative experiments designed to benefit Lake Sturgeon, through modifying existing operating regimes (e.g., modifying current water management operating procedures, enhancing existing habitat). These efforts and their outcomes should be documented and shared to advance understanding of how Lake Sturgeon and other resident fish species respond to the artificial manipulation of habitat conditions.

*Objective 3: Restore Lake Sturgeon populations in locations where they have become extirpated, where feasible and where functional habitat exists.*
The feasibility of reintroducing Lake Sturgeon should be assessed in areas where they have been extirpated and where habitat requirements of all life history stages can be met. The causes for Lake Sturgeon extirpation should be clearly understood and addressed or removed before reintroduction. Tables 1 to 6 list systems where Lake Sturgeon has been extirpated. Habitat assessments should be completed on these systems prior to considering reintroduction. The decision to reintroduce Lake Sturgeon should fully consider social and ecological implications. The effects of introducing a large benthivore like Lake Sturgeon on resident fish species are not fully understood. Reintroduction is a long-term recovery approach and may require an extensive stocking program to achieve. Detecting natural reproduction or recruitment may require an extensive monitoring program which should be extended to assessing responses of other fish species to the establishment of viable Lake Sturgeon sub-populations.

*Objective 4: Develop Local Scale Lake Sturgeon Management Strategies.*
The biology, genetics and behavior of Lake Sturgeon sub-populations, their current sub-population status and the magnitude and the extent of existing threats should all be used to guide the selection of recovery approaches at the SMU scale. Recovery actions should incorporate strategies to address the nature of local threats (e.g., geographical extent, timing, duration and magnitude), the current status of Lake Sturgeon sub-populations and their recovery potential. First Nations, stakeholders and industry should be involved in every aspect of developing and implementing management strategies. Specific recovery targets (e.g., numbers of adult breeders) should be developed on a sub-population (e.g., SMU) basis. Current SMU boundaries have been derived, in part, upon Lake Sturgeon genetics. As additional genetic structuring information becomes available, management strategies may require modification to ensure that genetic considerations with respect to sub-population recovery are taken into account.

A large amount of information related to Lake Sturgeon distribution, habitat and the status of sub-populations exists in aboriginal communities in the form of ATK and it may be considered sensitive. This information is extremely important to fully understand the current distribution of Lake Sturgeon and locations of habitat features, especially in remote areas of northern Ontario where new hydroelectric and mining development is occurring or imminent. Aboriginal communities should be supported in collecting and managing this information. The synthesis of ATK should take place prior to the development of management strategies.

Biological information on Lake Sturgeon sub-populations, genetics and habitat assessment information is required to facilitate informed decision-making with respect to selecting, implementing recovery actions and developing recovery targets for Lake Sturgeon sub-populations. The first step in developing management strategies should be the consolidation and synthesis of existing knowledge of Lake Sturgeon (e.g., unpublished data, local knowledge and ATK).

Recovery targets will vary depending on the recovery potential of each sub-population and habitat availability within each SMU. Appendix 3 summarizes recovery targets that have been established in existing Lake Sturgeon recovery/management plans. Recommended criteria that should be used to develop measurable recovery targets include:

- annual spawning activity (numbers of spawning adults, presence of viable eggs);
- hatching success (production of larvae);
- natural recruitment (juveniles);
- age structure (number of year classes);
- population structure (representation of all life history stages);
- stable genetic diversity; and
- functional habitat (suitable, connected habitat consisting of features required to meet all life history requirements).

Lake Sturgeon recovery planning is currently being undertaken by Fisheries and Oceans Canada within COSEWIC designated units (DU) 4, 5 and 8, portions of which are located in Ontario. Appendix 4 summarizes Lake Sturgeon management units that have been established by Fisheries and Oceans Canada with assistance from the OMNR. Provincial management strategies should be consistent with Federal species recovery strategies and incorporate recovery approaches and targets based upon current and historical distributions and status of Lake Sturgeon and locations of important habitat features. A risk assessment should be completed as part of each management strategy, identifying information gaps, establishing the nature of existing threats and future development relative to the status of sub-populations and habitat features and identifying opportunities for population recovery and habitat enhancement. The outcomes of Lake Sturgeon risk assessments should be used as planning tools to identify areas where new development should proceed with caution or be deferred (e.g., high risk/minimal information), where new and existing development should take into account Lake Sturgeon habitat requirements (e.g., low risk, where an adaptive management approach may be warranted) and to evaluate cumulative impacts on Lake Sturgeon sub-populations

It is recommended that Ontario use SMUs as the starting point for the development of management strategies for threatened Lake Sturgeon populations. Appendix 4 summaries of SMU designations for the Lake of the Woods-Rainy River catchment in northwestern Ontario (DU6) do not currently exist. In order to initiate recovery planning for this population, it is critical that federal and provincial managers, First Nation communities and stakeholders agree upon SMU boundaries. The development of management strategies should be initiated immediately to ensure harmonization with Federal recovery planning processes.

Management strategies should also be developed for Lake Sturgeon within the Southern Hudson/James Bay population (DU7) currently listed as special concern. These strategies should also be based upon SMU designations which currently do not exist. Criteria that should be considered in determining SMU boundaries for management planning for this population and the selection of appropriate recovery actions include:

- ecological and physical connectivity within river systems and between rivers and the lakes they empty into;
- locations of natural and manmade barriers as they relate to, and potentially dictate, Lake Sturgeon movement;
- migration or range of Lake Sturgeon;
- historic and current abundance;
- potential for recovery; and
- genetic structure (e.g., historical ancestry).

Although this population has been designated special concern, there are sections of rivers where Lake Sturgeon declines have been documented (Gibson et al. 1984; Nowak and Hortiguela 1984; Payne 1987) and where protection and avoiding further harm to extant sub-populations should take precedence over all other recovery actions. In northern Ontario where a large number of development projects which have potential to interact with Lake Sturgeon sub-populations are currently underway or planned, the development of management strategies will be a key component of managing potential impacts in river systems.

Several of the management units established by Fisheries and Oceans Canada overlap provincial and international boundaries. Recovery planning and efforts should be coordinated or undertaken cooperatively in these cases, wherever possible. Existing management plans should be considered in the development of Provincial management strategies. In the Far North, Lake Sturgeon management strategies must be consistent with community land use plans that have been prepared or are being developed in many First Nation communities.

There are many examples of collaborative initiatives between jurisdictions related to Lake Sturgeon management and recovery including the federal (DFO) recovery process currently underway, the Ontario- Minnesota Border Waters Fisheries Atlas (OMNR 2004), the Lake Sturgeon Management Plan for Lake of the Woods and Rainy River (MDNR 2009), the Lake Sturgeon Rehabilitation Plan for Lake Superior (Auer 2003) and

Recommendations for the Rehabilitation of Lake Sturgeon in Lake Ontario, the Lower Niagara River and the Upper St. Lawrence River (GLFC in prep). An important consideration in recovery is related to inter-jurisdictional waters inhabited by Lake Sturgeon. For example, there are differences in sport and commercial fishery regulations regarding Lake Sturgeon on shared waters including Lake St. Clair and the St. Clair River (Michigan), Ottawa River (Québec), Rainy River and Lake of the Woods (Minnesota), and Lake Superior (Wisconsin).

*Objective 5: Increase public awareness of the cultural and ecological significance and uniqueness of Lake Sturgeon and the importance of maintaining, enhancing and restoring Lake Sturgeon populations.*
Increasing public and industry awareness of the ecological and cultural significance of Lake Sturgeon and involving the public, industry and aboriginal communities as hands-on partners in recovery efforts is an important cornerstone of the recovery strategy. Stewardship activities and educational initiatives are important throughout the current range of Lake Sturgeon, but should be focused within geographic locations and communities where Lake Sturgeon are imperiled and in areas where they have been extirpated and where recovery is possible. Existing provincial programs, such as the stakeholder based Community Fish and Wildlife Improvement Program (CFWIP) and Fishways, an educational program, should be adapted for use in pursuing this recovery approach. Other models for Lake Sturgeon stewardship exist in North America. Perhaps the best known is Sturgeon for Tomorrow, a non-profit organization formed in the 1970s in Oshkosh, Wisconsin. This organization now has chapters located throughout Wisconsin and Michigan and plays active roles in education, supporting research and guarding against the illegal harvest of Lake Sturgeon.

*Objective 6: Address knowledge gaps to enable and enhance protection, conservation and recovery efforts.*
A number of the critical knowledge gaps listed in Section 1.7 should be addressed through the implementation of management approaches described above. Many of the outstanding gaps will require extensive research and/or monitoring and in several cases, advances in industrial technology. Collaborative research initiatives and adaptive management experiments should be designed and implemented by Aboriginal communities, stakeholders, industry and government agencies to advance understanding of Lake Sturgeon habitat utilization and the mitigation and removal of existing threats.

Standardized assessment and data gathering protocols incorporating Lake Sturgeon population and habitat utilization criteria should be developed and adopted by agencies, industry and researchers and applied in baseline inventory, monitoring and research programs. Spawning assessments, including mark and recapture of females, hatching success and juvenile abundance assessments should be used as the primary tools to monitor population responses to management actions implemented to increase Lake Sturgeon abundance, mitigate threats or enhance habitat. Performance measures should include documentation of multiple spawning events by female Lake Sturgeon and survival of offspring beyond the early juvenile stage (e.g., 2 - 10 years of age).

The monitoring of outcomes related to Lake Sturgeon recovery approaches is critical to adaptive management. Lake Sturgeon do not spawn every year and strong spawning runs (e.g., large numbers of adults) do not always translate into strong year classes due to high levels of mortality of early life history stages. This underlies the importance of designing and maintaining long-term data sets and utilizing multiple, specific, measurable recovery criteria in order to detect responses to management actions.

Currently, the duration of monitoring programs associated with development (e.g., post construction monitoring) is highly variable. The recommended time frame for monitoring recovery and the responses of Lake Sturgeon to mitigation actions should encompass one full reproductive cycle for female Lake Sturgeon plus sufficient time for their offspring to reach a sufficient size at which survival and abundance can be measured (e.g., 10 - 15 years). Collaboration between First Nation communities, local stakeholders, government agencies, industry and academia will be important to the success of monitoring programs.

## 2.4 Area for Consideration in Developing a Habitat Regulation

*Under the Endangered Species Act, 2007, a recovery strategy must include a recommendation to the Minister of Natural Resources on the area that should be considered in developing a habitat regulation. A habitat regulation is a legal instrument that prescribes an area that will be protected as the habitat of the species. The recommendation provided below by the recovery strategy authors will be one of many sources considered by the Minister of Natural Resources when developing the habitat regulation for this species.*

This recommendation applies to the Northwestern Ontario and Great Lakes/Upper St. Lawrence River populations of Lake Sturgeon identified as threatened by COSSARO.

In formulating this recommendation, consideration is given to Lake Sturgeon ecology including their long generation times, spawning periodicity, large body size, ability and tendency to migrate long distances and the requirement of distinct habitat types, lacustrine and lotic, for various life history stages (e.g., eggs, larvae, juveniles, subadults, adults). Habitat suitability may be constrained by water levels, river flows, sedimentation and water quality which may also affect food availability for Lake Sturgeon. Lake Sturgeon are vulnerable to altered river conditions (e.g., where flow management diverges from natural hydrographs) and habitat fragmentation. Although there is some evidence that Lake Sturgeon can adapt to changing conditions, behavioral adaptations may not be immediately identifiable and the effects on localized sub-populations may not be discernable for several generations (e.g., 100 years). It is also important to recognize that short-term coping behaviors may not necessarily become entrenched as heritable adaptive responses and that adaptation is a slow process requiring multiple generations. The effects of fragmentation and habitat management will likely be dependent upon the quantity, quality and diversity of habitats available/accessible to Lake Sturgeon.

Important habitat features include staging areas, spawning areas, nursery habitats, overwintering areas and the corridors that connect them. It is recommended that important habitat features, where utilization by Lake Sturgeon has been confirmed within the past 50 years through existing knowledge or scientific data, should be included in the habitat regulation. Important habitat features created as the result of existing structures (e.g., base of dams) or modifications to rivers and lakes (e.g., dredged areas) utilized by Lake Sturgeon should also be included in the regulation. Protection of important habitat features should be provided, in all waters, both lentic and lotic, currently occupied by Lake Sturgeon and in all historically occupied waters where Lake Sturgeon reintroduction is deemed feasible. The areas or boundaries of important habitat features are highly variable between systems and will be highly dynamic within systems due to changing flows and water levels.

The area for consideration in developing a habitat regulation should extend to the high water mark on rivers. It is not practical to identify discrete areas within lake systems that represent important habitat features (e.g., overwintering areas). Kerr et al. (2011) provides a summary of habitat characteristics for various life history stages of Lake Sturgeon. Lake Sturgeon presence has been documented at a variety of depths, but rarely deeper than 20 m. In lakes the area for consideration in developing a habitat regulation should extend from the high water mark to a depth of 20 m. Local knowledge should be used to determine if refinements in particular lakes are necessary.

Staging Areas

Lake Sturgeon spawning activity takes place in the spring near the end of or following spring freshet. Adult Lake Sturgeon may congregate in deep areas (e.g., pools where water velocities are lowest) adjacent to spawning locations awaiting optimal environmental conditions (e.g., appropriate water temperatures) prior to spawning or near the mouths of rivers (Rusak and Mosindy 1997). Lake Sturgeon can occupy staging areas for variable periods, from late winter prior to the spring freshet (Bruch 1999) to several days immediately prior to and during spawning (Smith 2003; Holtgren and Auer 2004; Smith and King 2005b).

Spawning Areas

Spawning activity is generally associated with high gradient sections of rivers below waterfalls or within rapids and at the base of dams. Egg deposition generally takes place in shallow water (e.g., less than 2.0 m) over coarse (e.g., cobble, rubble) substrate in flows ranging from 0.5 to 1.3 m/s (Auer 1996b; Lane et al. 1996; McKinley et al. 1998; Peterson et al. 2007). Where several areas of rapids exist in sequence or in extensive areas of rapids, Lake Sturgeon may only utilize discrete sections of spawning habitat, defined by suitable physical conditions (e.g., flows, depth). In large, deep rivers lacking rapids (e.g., St. Clair River), spawning can take place in deeper water (Manney and Kennedy 2002).

Nursery Areas

Habitat preference by early life history stages is not well understood. Nursery habitats are generally located downstream of spawning areas. Lake Sturgeon may mature in their natal river or move downstream into lakes to forage in deep water (Holtgren and Auer 2004). Individuals making up each of the early life history stages tend to congregate in discrete sections of rivers and lakes providing abundant food. Auer and Baker (2002) and Benson et al. (2005) reported that the lower sections of the Sturgeon and Peshtigo rivers, respectively, characterized as deep and slower-flowing, represented important nursery habitat for young-of-the-year Lake Sturgeon.

Overwintering Areas

Lake Sturgeon may congregate in the lower reaches of rivers during the winter or move into lakes during the winter months (Rusak and Mosindy 1997; Holtgren and Auer 2004). It is believed that Lake Sturgeon remain relatively immobile in rivers during the winter, occupying deep riverine areas (Friday and Chase 2010; Phoenix 1991) or lake environments (M. Friday, pers. comm. 2010; Welsh and McLeod 2010). This may be a means of minimizing energy expenditure during periods of low food availability.

Connecting Corridors

Connectivity between habitat features allows Lake Sturgeon to fulfill seasonal and life history stage requirements. Migration distances are highly variable and dependent upon the relative locations of the habitat features described above. In a review of adult migration in tributaries of the Great Lakes, Auer (1996a) identified distances ranging from 32 to 225 km. Downstream movement of early life history stages, including larvae, between spawning and nursery areas should also be maintained.

## GLOSSARY

Anthropogenic: Caused by humans.

ATK: Aboriginal Traditional Knowledge.

Benthic: Pertaining to the ecological region at the lowest level of a body of water including the sediment surface and some sub-surface layers. Organisms living in this zone are called benthos.

Burst swimming performance: Represents high velocities that can be maintained for less than 20 seconds, using energy entirely generated by anaerobic processes.

Carrying Capacity: Number of Lake Sturgeon the resources of a given area can support, usually through the most unfavorable period of the year.

Caviar: A highly valued delicacy composed of salted, unfertilized eggs from female fish.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): The committee responsible for assessing and classifying species at risk in Canada.

Committee on the Status of Species at Risk in Ontario (COSSARO): The committee established under Section 3 of the *Endangered Species Act, 2007* that is responsible for assessing and classifying species at risk in Ontario.

Conservation status rank: A rank assigned to a species or ecological community that primarily conveys the degree of rarity of the species or community at the global (G), national (N) or subnational (S) level. These ranks, termed G-rank, N-rank and S-rank, are not legal designations. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by the letter G, N or S reflecting the appropriate geographic scale of the assessment. The numbers mean the following:

1 = critically imperiled
2 = imperiled
3 = vulnerable
4 = apparently secure
5 = secure

Designatable unit**:** biologically-based unit that may be designated based on conservation status, guided by the general policy objective of preventing irreplaceable units of biodiversity from becoming extinct or extirpated from a jurisdiction in Canada.

Dreissenid: Small bivalves (clam-like) of the family Dreissenidae. Two species have invaded the Great Lakes (zebra and quagga mussels; *Dreissena polymorpha* and *Dreissena bugensis* respectively).

Endangered: A species facing imminent extinction or extirpation.

*Endangered Species Act, 2007* (ESA): The provincial legislation that provides protection to species at risk in Ontario.

Extant: A species or population that still exists within a particular area or known range.

Extirpation: The elimination of a species or subspecies from a particular area but not from its entire range.

Fluvial: A term to refer to the physical processes associated with rivers and streams and the deposits and landforms created by them.

Great Lakes Fishery Commission (GLFC): The Great Lakes Fishery Commission was established in 1955 by the Canadian/United States Convention on Great Lakes Fisheries. The commission coordinates fisheries research, controls the invasive sea lamprey and facilitates cooperative fishery management among the state, provincial, tribal, and federal management agencies.

High water mark: The usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land. In flowing waters (rivers, streams) this refers to the "active channel/bank-full level" which is often the 1:2 year flood flow return level. In inland lakes, wetlands or marine environments it refers to those parts of the waterbody bed and banks that are frequently flooded by water so as to leave a mark on the land and where the natural vegetation changes from predominately aquatic vegetation to terrestrial vegetation (excepting water tolerant species). For reservoirs this refers to normal high operating levels (Full Supply Level). For the Great Lakes this refers to the 80th percentile elevation above chart datum as described in DFO's Fish Habitat and Determining the High Water Mark on Lakes (DFO 2007 ).

Larval drift: A period of time within which newly hatched Lake Sturgeon rise from the substrate and drift downstream from the spawning and incubation areas via currents while still absorbing their yolk sac.

Heterocercal tail**:** In fish, a tail in which the tip of the vertebral column turns upward, extending into the dorsal lobe of the tail fin; the dorsal lobe is often larger than the ventral lobe. The heterocercal tail is present in many fossil fish, in the sharks (*Chondrichthyes),* and in the more primitive bony fish (e.g., the families *Acipenseridae* and *Polyodontidae*).

Invasive species: Plants, animals, aquatic life and micro-organisms that compete with and dominate native species when introduced outside of their natural environment.

Macroinvertebrates: Animals without backbones typically larger than 0.5 mm that live on rocks, logs, sediment, debris and aquatic plants during some period in their life, and includes crayfish, clams and snails, aquatic worms and the immature forms of aquatic insects.

Mitigation: Elimination or reduction of frequency, magnitude, or severity of environmental, economic, legal, or social risks, or minimization of the potential impact of a threat.

Negatively phototactic**:** The movement of an organism away from a source of light.

Opportunistic feeder**:** General feeding practice based on the abundance and availability of various food sources.

Peaking operation: Hydroelctric operation in which water is stored in a reservoir for a period of time and then spilled through turbines to generate electricity when demand is highest.

Population: For the purpose of this recovery strategy, the term population is synonymous with the three populations designated by the Committee on the Status of Species at Risk in Ontario (COSSARO). These are the Northwestern Ontario population, the Southern Hudson Bay/James Bay population and the Great Lakes/Upper St. Lawrence River population.

Potamodromous: A migratory fish species that lives in freshwater only.

Prolonged swimming performance: Covers a spectrum of speeds between sustained and burst swimming.

Radiotelemetry: A technology involving a small portable transmitter that emits radio waves which are picked up by a receiver through an antenna.

Refugium: A location of an isolated or relict population of a once widespread species.

Run-of-the-river (ROR): A term referring to hydroelectric generation whereby the natural flow and elevation drop of a river are used to generate electricity without the need for a large reservoir to store water (e.g., water is passed as it enters the system).

*Species at Risk Act* (SARA): The federal legislation that provides protection to species at risk in Canada. This act establishes Schedule 1 as the legal list of wildlife species at risk to which the SARA provisions apply. Schedules 2 and 3 contain lists of species that at the time the act came into force needed to be reassessed. After species on Schedule 2 and 3 are reassessed and found to be at risk, they undergo the SARA listing process to be included in Schedule 1.

Species at Risk in Ontario (SARO) List: The regulation made under section 7 of the *Endangered Species Act, 2007* that provides the official status classification of species at risk in Ontario. This list was first published in 2004 as a policy and became a regulation in 2008.

Special concern: Refers to a species not endangered or threatened, but that may become threatened or endangered due to a combination of biological characteristics and identified threats.

Sub-population: Lake Sturgeon sub-populations are groups of individuals that are geographically distinct with very little or no genetic exchange. Sub-populations may be composed of all individuals utilizing a drainage area or isolated groups of individuals within a drainage system.

Sustained swimming performance: Occurs at relatively low velocities and represents speeds that can be maintained for a period greater than 200 minutes, making use of energy derived exclusively from aerobic processes.

Threatened: A species not endangered, but is likely to become endangered if steps are not taken to address factors threatening it.

Trifluromethyl-4-nitrophenol (TFM): A chemical treatment used to control the spread of sea lamprey, an invasive species to the upper Great Lakes.

## REFERENCES

Abraham, J. 2008. In celebration of sturgeon. Minnesota Conservation Volunteer. May-June 2008 issue.

Adams, W.E., Jr, L.W. Kallemeyn, and D. W. Willis. 2006. Lake sturgeon population characteristics in Rainy Lake, Minnesota and Ontario. Journal of Applied Ichthyology. 22: 97-102.

Anderson, E. K., Z. Q. R. Chen, H. Bandeh, M. Hannum, K. Carr, M. Cayar, I. Haltas, M. L. Kavvas, D. Cocherell, A. Kawabata, D. Kratville, S. Hamilton, T. MacColl, L. Kanemoto, J. Webber, J. J. Cech, C. Wilkinson, M. M. Rotondo, R. Padilla, J. Miranda, and R. Churchwell. 2007. Through-delta facility white sturgeon passage ladder study. Department of Water Resources. State of California. Sacramento, California. 82 pp.

Anishinabek/Ontario Fisheries Resource Centre (A/OFRC). 2007. 2006 Spring spawning sturgeon study. p. 5 *In* A/OFRC Fisheries News. Fall 2007. North Bay, Ontario.

Auer, N.A. 1996a. Response of spawning lake sturgeons to change in hydroelectric facility operation. Transactions of the American Fisheries Society 125: 66-77.

Auer, N.A. 1996b. Importance of habitat and migration to sturgeons with emphasis on lake sturgeon. Canadian Journal of Fisheries and Aquatic Sciences 53 (Supplement 1):152-160.

Auer, N. A. 1998. Duration of river residence of newly hatched lake sturgeon: implications for sea lamprey control. Great Lakes Fishery Commission Project Completion Report. Houghton, Michigan.

Auer, N.A. 1999. Population characteristics and movements of lake sturgeon in the Sturgeon River and Lake Superior. Journal of Great Lakes Research 25:282-293.

Auer, N.A. 2003. A lake sturgeon rehabilitation plan for Lake Superior. Miscellaneous Publication 2003-02. Great Lakes Fishery Commission. Ann Arbor, Michigan. 27 pp.

Auer, N.A. and E.A. Baker. 2002. Duration and drift of larval lake sturgeon in the Sturgeon River, Michigan. Journal of Applied Ichthyology 18:557-564.

Auer, N.A. and E.A. Baker. 2009. Streamside lake sturgeon culture for the Ontonagon River, Michigan. Revised Final Report by Nancy A. Aur (Michigan Technical University) and Edward A. Baker (Michigan Department of Natural Resources) Grant Number NA04NMF4050265. 19p.

Baldwin, N. A., R. W. Saalfield, M. R. Cochoda, H. J. Buettner and R. L. Eshenroder. 2002. Commercial fish production in the Great Lakes, 1867-2000. Great Lakes Fishery Commission, Ann Arbor, Michigan.

Barth, C.C., S.J. Peake, P.J. Allen, and W.G. Anderson. 2009. Habitat utilization of juvenile lake sturgeon, *Acipenser fulvescens*, in a large Canadian river. Journal of Applied Ichthyology. 25(Suppl. 2): 18-26.

Beamesderfer, R.C., and R. A. Farr. 1997. Alternatives for the protection and restoration of sturgeons and their Habitat. Environmental Biology of Fishes 48: 407–417.

Beamish, F.W.H., Jebbink, J.A., Rossiter, A. and D.L.G. Noakes. 1996. Growth strategy of juvenile lake sturgeon (*Acipenser fulvescens*) in a northern river. Canadian Journal of Fisheries and Aquatic Sciences 53: 481-489.

Beamish, F. W. H., D. L. G. Noakes, and A. Rossiter. 1998. Feeding ecology of juvenile lake sturgeon (*Acipenser fulvescens*) in northern Ontario. Canadian Field-Naturalist 112:459-468.

Benson, A. C., T. M. Sutton, R. F. Elliott and T. G. Meronek. 2005. Seasonal movement patterns and habitat preferences of age-0 lake sturgeon in the Lower Pheshtigo River, Wisconsin. Transactions of the American Fisheries Society 134:1400-1409.

Birstein, V. J., W. E. Bemis and J. R. Waldman. 1997. The threatened status of acipenseriform species: a summary. Environmental Biology of Fishes 48:427- 435.

Boogaard, M. A., T. D. Bills and D. A. Johnson. 2003. Acute toxicity of TFM and a TFM/Niclosamide mixture to selected species of fish, including lake sturgeon (*Acipenser fulvescens*) and mudpuppies (*Necturus maculosus*) in laboratory and field exposures. Journal of Great Lakes Research 29(Supplement 1):529-541.

Brousseau, C. S. 1987. The lake sturgeon (*Acipenser fulvescens*) in Ontario. p. 2-9 *In* C. H. Olver [ed.]. Proceedings of a Workshop on the Lake Sturgeon. Fisheries Technical Report Series No. 23. Ontario Ministry of Natural Resources. Toronto, Ontario.

Browne, D.R. 2007. Freshwater fish in Ontario's boreal: status, conservation, and potential impacts of development. Conservation Report No. 2. Wildlife Conservation Society of Canada. Toronto, Ontario. 98 pp.

Bruch, R.M. 1999. Management of lake sturgeon on the Winnebago system – long term impacts of harvest and regulations on population structure. Journal of Applied Ichthyology 15:142-152.

Bruch, R.M. and F.P. Binkowski. 2002. Spawning behaviour of lake sturgeon (*Acipenser fulvescens)*. Journal of Applied Ichthyology 18:570-579.

Bruch, R. M., G. Miller and M. J. Hansen. 2006. Fecundity of lake sturgeon (*Acipenser fulvescens*) in Lake Winnebago, Wisconsin. Journal of Applied Ichthyology 22 (Supplement 1):116-118.

Cada, G.F. 1998. Better science supports fish-friendly turbine designs. Hydro Review. November 1998: 52-61.

Carlson, D. M. 1995. Lake sturgeon waters and fisheries in New York state. Journal of Great Lakes Research 21:35-41.

Caroffino, D.C., T.M. Sutton, R.F. Elliott and M.C Donofrio. 2010. Predation on early life stages of Lake Sturgeon in the Peshtigo River, Wisconsin. Transactions of the American Fisheries Society 139:1846-1856.

Chiasson, W. B., D. L. G. Noakes and F. W. H. Beamish. 1997. Habitat, benthic prey and distribution of juvenile lake sturgeon (*Acipenser fulvescens*) in northern Ontario rivers. Canadian Journal of Fisheries and Aquatic Sciences 54:2866-2871.

Cleator, H., K.A. Martin, T.C. Pratt, C. Barth, B. Corbett, M. Duda and D. Leroux. 2010a. Information relevant to a recovery potential assessment of Lake Sturgeon: Winnipeg River-English River populations (DU5). Department of Fisheries and Oceans Canadian Science Advisory Secretariat Research Document 2010/084. vi + 34 pp.

Cleator, H., K.A. Martin, T.C. Pratt, B. Bruederlin, M. Erickson, J. Hunt, D. Kroeker, D. Leroux, L. Skitt and D. Watkinson. 2010b. Information relevant to a recovery potential assessment of Lake Sturgeon: Red-Assiniboine rivers – Lake Winnipeg populations (DU4). Department of Fisheries and Oceans Canadian Science Advisory Secretariat Research Document 2010/083. vi + 38 pp.

Committee on the Status of Endangered Wildlife in Canada. 2006. COSEWIC assessment and update status report on the lake sturgeon (*Acipenser fulvescens)* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 107 pp (www.sararegistry.gc.ca/status/status_e.cfm)

Cohen, A. 1997. Sturgeon poaching and black market caviar: a case study. Environmental Biology of Fishes 48:423- 426.

D`Amours, J. S., S. Thibodeau and R. Fortin. 2001. Comparison of lake sturgeon (*Acipenser fulvescens), Stizostedion* spp*., Catostomus* spp*., Moxostoma* spp., quillback (*Carpiodes cyprinus*) and mooneye (*Hiodon tergisus*) larval drift in Des Prairies River, Québec. Canadian Journal of Zoology 79:1472-1489.

DeHaan, P.W., S.V. Librants, R.F. Elliott, and K.T. Scribner. 2006. Genetic population structure of remnant lake sturgeon populations in the Upper Great Lakes Basin. Transactions of the American Fisheries Society 135: 1478-1492.

DesJardine, R. L., T. K. Gorenflo, R. N. Payne and J. D. Schrouder. 1995. Fish community objectives for Lake Huron. Special Publication 95-1. Great Lakes Fishery Commission. Ann Arbor, Michigan. 38 pp.

Dick, T. 2004. Lake sturgeon studies in the Pigeon and Winnipeg rivers and biota indications. Report for Manitoba Hydro. 455 pp.

Dick, T. A., S. R. Jarvis, C. D. Sawatzky and D. B. Stewart. 2006. The lake sturgeon, Acipenser fulvescens, (Chondrostei: Acipenseridae): an annotated bibliography. Canadian Technical Report of Fisheries and Aquatic Sciences 2671. Central and Arctic Region. Fisheries and Oceans Canada. Winnipeg, Manitoba.

Drauch, A.M. and O.E. Rhodes, Jr. 2007. Genetic evaluation of lake sturgeon reintroduction program in the Mississippi and Missouri Rivers. North American Journal of Fisheries Management 27:434-442.

Dubreuil, R. and J. R. Cuerrier. 1950. Cycle de maturation des glandes génitales chez l'esturgeon de lac (*Acipenser fulvescens*). Rapport sur l'analyse du materiel recueilli au cours du printemps de 1949 ua barrage Fitzroy-Cuyon, lac Des Chênes, riviere Ottawa. Ministèrede l'Industrie et du Commerce du Québec et au Conseil National de Recherches. Ottawa, Ontario.

Duda, M. 2008. Unpublished data. Winnipeg River lake sturgeon (*Acipenser fulvescens*) assessment program. 2008. Ontario Ministry of Natural Resources. Kenora, Ontario.

Dumas, R., F. Trepanier and M. Simoneau. 2003. Fish problems and partnership solutions: the lake sturgeon case study in the L'Assomption watershed. Paper presented at the 133rd Annual Meeting of the American Fisheries Society. August 10-14, 2003. Québec City, Québec.

Dumont, P., R. Fortin, D. Desgardins and M. Bernard. 1987. Biology and exploitation of the lake sturgeon (*Acipenser fulvescens*) in the Quebec waters of the Saint-Laurent River. Pp 57-76 in C.H. Olver (ed.) Proceedings of a Workshop on Lake Sturgeon (*Acipenser fulvescens*). Ont. Fish. Tech. Rep. Ser. No. 23.

Dumont, P., J. Leclerc, S. Deloges, P. Bilodeau, Y. Malhiot, R. Dumas, M. LaHaye, R. Verdon and R. Fortin. 2004. The biology, status and management of lake sturgeon (*Acipenser fulvescens*) in Québec: a summary. In Proceedings of a Workshop on Lake Sturgeon (Acipenser fulvescens) in Lake St. Francis and surrounding waters. September 22-23, 2004. Cornwall, Ontario.

Dumont, P. and Y. Mailhot . In prep. The St. Lawrence River Lake Sturgeon Management in Quebec 1940s – 2000s. (draft manuscript)

Dumont, P., J D'Amours, S. Thibideau, N. Dubuc, R. Verdon, S. Garceau, P. Bilodeau, Y. Mailhot and R. Fortin. 2011. Effects of the implantation of a newly created spawning ground in the Des Prairies River (Quebec, Canada) on the reproductive success of lake sturgeon (*Acipenser fulvescens*). Journal of Applied Ichthyology 27: 394–404.

Dymond, J. R. and A. V. Delaporte. 1952. Pollution of the Spanish River. Research Report No. 25. Ontario Department of Lands and Forests. Sudbury, Ontario.

Ecologistics Ltd. 1987. A lake sturgeon yield study on the Kenogami River. Year 3 – Phase 1 Report prepared for the Ontario Ministry of Natural Resources. Geraldton, Ontario. 58 p.

Edwards, C. J., P. L. Hudson, W. G. Duffy, S. J. Nepzy, C. D. McNabb, R. C. Haas, C. R. Liston, B. Manny, and W-D. N. Busch. 1989. Hydrological, morphometrical and biological characteristics of the connecting rivers of the International Great Lakes: a review. p. 240-264 *In* D. P. Dodge [ed.]. Proceedings of the International Large River Symposium. Canadian Special Publication of Fisheries and Aquatic Sciences 106.

Environment Canada. 2004. How Much Habitat is Enough? A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern. Minister of the Environment. 52 pp + appendices.

Electric Power Research Institute (EPRI). 1997. Turbine entrainment and survival database-field tests. Prepared by Alden Research Laboratory, Inc. EPRI Report No. TR-108630. 13 pp. (plus two 3.5" diskettes), Palo Alto, CA.

ESG International Inc. 2003. Lake sturgeon population study, 2002 Little Long Reservoir Mattagami River. Prepared for Ontario Power Generation. EPSD-Environment Department. 32 pp + appendices.

Feist, G. W., M. A. H. Webb, D. T. Gundersen, E. P. Foster, C. B. Schreck, A. G. Moule and M. S. Fitzpatrick. 2005. Evidence of detrimental effects of environmental contaminants on growth and reproductive physiology of white sturgeon in impounded areas of Columbia River. Environmental Health Perspectives. 113: 1675-1682.

Ferguson, M. M. and G. A. Duckworth. 1997. The status of lake sturgeon. *Acipenser fulvescens*, in the Canadian provinces of Manitoba, Ontario and Quebec: a genetic perspective. Environmental Biology of Fishes 48: 299-309.

Fielder, D. G., A. Liskauskas, L. Mohr, and J. Boase. 2008. *In* State of Lake Huron in 2004. J. Bence and L. Mohr [*eds*]. Great Lakes Fisheries Commission Special Publication 08-01. Pp 47-59.

Fortin, R, J. Mongeau, G. Desjardins and P. Dumont. 1993. Movements and biological statistics of lake sturgeon (*Acipenser fulvescens*) populations from the St. Lawrence and Ottawa River system, Quebec. Canadian Journal of Zoology 71: 638-650.

Fortin, R., J. D’amours and S. Thibodeau. 2002. Effets de l’amenagement d’un nouveau secteur de frayere sur l’utisation du milieu en periode de fraie et sur le succes de reproduction de l’esturgeon jaune (*Acipenser fulvescens*) a la frayere de la riviere des Prairies. Rapport synthese 1995-1999. Pour l’Unite Hydraulique et Environnement, Hydro-Quebec et la Societe de la faune du Quebec, Direction de l’amenagement de la faune de Montreal, de Laval et de la Monteregie. Departement des Sciences biologiques, Universite du Quebec a Montreal.

Friday, M.J. 2004. Population characteristics of Black Sturgeon River lake sturgeon (*Acipenser fulvescens*). Technical Report 2004-01. Upper Great Lakes Management Unit. Ontario Ministry of Natural Resources. Thunder Bay, Ontario. 25 p.

Friday, M.J., 2005. The migratory and reproductive response of spawning Lake Sturgeon to controlled flows over Kakabeka Falls on the Kaministiquia River, 2005. Upper Great lakes Management Unit. Lake Superior QUIK Report 05.01. 16 pp.

Friday, M.J. 2006a. An assessment of growth of young-of-the-year lake sturgeon in the Kaministiquia River. Technical Report No. 06-06. Upper Great Lakes Management Unit. Ontario Ministry of Natural Resources. Thunder Bay, Ontario. 12p.

Friday, M.J. 2006b. The migratory and reproductive response of spawning lake sturgeon to controlled flows over Kakabeka Falls on the Kaministiquia River, Ontario. Upper Great Lakes Management Unit Report. Ontario Ministry of Natural Resources. Thunder Bay, Ontario.

Friday, M.J. and M. Chase. 2010. The migratory and reproductive response of spawning Lake Sturgeon to controlled flows over Kakabeka Falls on the Kaministiquia River, 2008. Upper Great lakes Management Unit. Lake Superior. Technical Report 2008-01. 13 pp.

Gibson, D.W., S. Aubrey, and E.R. Armstrong. 1984. Age, growth and management of lake sturgeon (*Acipenser fulvescens*) from a section of the Abitibi River. MS Rep. Ontario Ministry of Natural Resources. 33 pp.

Great Lakes Fishery Commission (GLFC). 2010. Recommendations for the Rehabilitation of lake Sturgeon in Lake Ontario, the lower Niagara River and the Upper St. Lawrence River (Draft). 21 pp.

Golder Associates Ltd. 2010a. Groundhog River Lake Sturgeon Monitoring 2010. Submitted to Xstrata Nickel. 23 pp.

Golder Associates Ltd. 2010b. Waterpower science and Information summit. Prepared for the Ontario Waterpower Association. 13 pp + appendices.

Harkness, W. J. K. 1923. The rate of growth and food of the lake sturgeon (*Acipenser fulvescens*) University of Toronto Studies. Biological Series 24. Publication of the Ontario Fisheries Research Laboratory. Toronto, Ontario.

Harkness, W. J. K. and J. R. Dymond. 1961. The lake sturgeon: The history of its fishery and problems of conservation. Fish and Wildlife Branch. Ontario Department of Lands and Forests. Toronto, Ontario. 121 pp.

Hatin, D., S. Lachance, and D. Fournier. 2007. Effect of dredged sediment deposition on use by Atlantic sturgeon and lake sturgeon at an open water disposal site in the St. Lawrence River estuarine transition zone. American Fisheries Society Symposium 56:235-255.

Haxton, T.J. 2002. An assessment of lake sturgeon (*Acipenser fulvescens*) in various reaches of the Ottawa River. Journal of Applied Ichthyology 18: 449-454.

Haxton, T.J. 2006. Characteristics of a lake sturgeon spawning population sampled a half century apart. Journal of Great Lakes Research 32: 124-130.

Haxton, T. J. 2008. A synoptic review of the history and our knowledge of lake sturgeon in the Ottawa River. Science and Information Branch. Ontario Ministry of Natural Resources. Peterborough, Ontario. 31 pp.

Haxton, T.J., and C.S. Findlay. 2008. Variation in lake sturgeon (*Acipenser fulvescens*) abundance and growth among river reaches in a large regulated river. Canadian Journal of Fisheries and Aquatic Sciences. 65: 645-657.

Haxton, T. J. and C.S. Findlay. 2009. Variation in large-bodied fish community structure and abundance in relation to water management regime in a large regulated river. Journal of Fish Biology. 74:2216-2238.

Hay-Chmielewski, E. M. 1987. Habitat preferences and movement patterns of the lake sturgeon (*Acipenser fulvescens*) in Black Lake, Michigan. Fisheries Research Report No. 1949. Michigan Department of Natural Resources. Lansing, Michigan.

Hay-Chielewski, E. M. and G. Whelan, eds. 1997. Lake sturgeon rehabilitation strategy. Michigan Department of Natural Resources, Fisheries Division, Special Report No. 18. 51 pp.

Holtgren, J. M. and N. A. Auer. 2004. Movement and habitat of juvenile lake sturgeon (*Acipenser fulvescens*) in the Sturgeon River/Portage Lake system, Michigan. Journal of Freshwater Ecology 19:419-432.

Holtzkamm, T. E., V. P. Lytwyn and L. G. Waisberg. 1988. Rainy River sturgeon: an Ojibway resource in the fur trade economy. Canadian Geographic 32(2):194-205.

Holtzdamm, T. E. and L. G. Waisberg. 2004. Native utilization of sturgeon. p. 22-39 *In* G. T. O. LeBreton, F. W. H. Beamish and R. S. McKinley [eds.]. Sturgeons and Paddlefish of North America. Kluwer Academic Publishers. Boston, Massachusetts.

Hopper, M. and G. Power. 1991. The fisheries of an Ojibway community in northern Ontario. Arctic 44:267-274.

Horns, W. H., C. R. Bronte, T. R. Busiahn, M. P. Ebener, R. L. Eshenroder, T. Gorenflo, N. Kmiecik, W. Mattes, J. W. Peck, M. Petzold and D. R. Schreiner. 2003. Fish community objectives for Lake Superior. Special Publication 03-01. Great Lakes Fishery Commission. Ann Arbor, Michigan. 78 pp.

Houston, J.J. 1987. Status of lake sturgeon, *Acipenser fulvescens*, in Canada. Canadian Field naturalist 10: 171-185.

Hubbs, C.L, and K.F. Lagler. 1964. Fishes of the Great Lakes Region. University of Michigan Press, Ann Arbor, MI.

Jeane, G. S. and R. E. Pine. 1975. Environmental effects of dredging and spoil disposal. Journal of the Water Pollution Control Federation 47:553-561.

Johnson, D. A., J. W. Weisser and T. D. Bills. 1999. Sensitivity of lake sturgeon (*Acipenser fulvescens*) to the lampricide 3-trifluoromethyl-4-nitrophenol (TFM) in field and laboratory exposures. Technical Report 62. Great Lakes Fishery Commission. Ann Arbor, Michigan.

Johnson, J. H., S. R. LaPan, R. M. Klindt and A. Schiavone. 2006. Lake sturgeon spawning on artificial habitat in the St. Lawrence River. Journal of Applied Ichthyology 22:465-470.

Johnston, S. A. 1981. Estuarine dredge and fill activities: a review of environmental impacts. Environmental Management 5:427-440.

Johnston, T. A., M. N. Gaboury, R. A. Janusz and L. R. Janusz. 1995. Larval fish drift in the Valley River, Manitoba: influence of abiotic and biotic factors and relationships with future year class strengths. Canadian Journal of Fisheries and Aquatic Sciences 52:2423-2431.

Kempinger, J. J. 1988. Spawning and early life history of lake sturgeon in the Lake Winnebago system, Wisconsin. American Fisheries Society Symposium 5:111-122.

Kempinger, J.J. 1996. Habitat, growth, and food for young lake sturgeon in the Lake Winnebago system, Wisconsin. North American Journal of Fisheries Management. 16: 102-114.

Kerr, S. J. 2002. Atlas of lake sturgeon waters in Ontario. Fish and Wildlife Branch. Ontario Ministry of Natural Resources. Peterborough, Ontario. 12 pp.

Kerr, S. J., M. J. Davison, and E. Funnell. 2011. A review of lake sturgeon habitat requirements and strategies to protect and enhance sturgeon habitat. Fisheries Policy Section, Biodiversity Branch. Ontario Ministry of Natural Resources. Peterborough, Ontario. 58 pp. + appendices.

Kjartanson, S. L. 2008. Population structure and genetic diversity of lake sturgeon (*Acipenser fulvescens*) in Canada: evaluation of designable units for conservation. M.Sc. Thesis. University of Toronto. Toronto, Ontario. 123 pp.

Kynard, B., S.O. Conte, D. Pugh and T. Parker. 2010. Passage and behaviour of lake sturgeon in a prototype side-baffle fish ladder. Presentation at 3rd Annual North American Conference of the World Sturgeon Conservation Society, Pray, Montana.

LaHaye, M., A. Branchaud, M. Gendron, R. Vendron and R. Fortin. 1992. Reproduction, early life history and characteristics of spawning grounds of the lake sturgeon (*Acipenser fulvescens*) in Des Prairies and L`Assomption rivers near Montreal, Québec. Canadian Journal of Zoology 70:1681-1689.

LaPan, S. R., R. M. Klindt, J. H. Johnson and A. Schiavone. 1997. Lake sturgeon spawning on artificial habitat in the St. Lawrence River. p. 13.1-13.9 *In* Annual Report of the St. Lawrence River Subcommittee to the Lake Ontario Committee. Great Lakes Fishery Commission. March 1997.

LaPan, S. R., R. M. Klindt, J. H. Johnson and A. Schiavone. 2000. Lake sturgeon spawning on artificial habitat in the St. Lawrence River. p. 7 *In* T. E. Brooking [ed.]. Update on Lake Sturgeon in New York Waters. January 27, 2000. Syracuse, New York.

Lane, J.A., C.B. Portt and C.K. Minns. 1996. Spawning habitat requirements of Great Lakes fishes. Can. MS Rpt. Fish. Aquat. Sci. 2368. 48 pp.

Lawrie, A. H. and J. F. Rahrer. 1973. Lake Superior – a case history of the lake and its fisheries. Technical Report 19. Great Lakes Fishery Commission. Ann Arbor, Michigan.

Lord, K. 2007. Movements and habitat use of juvenile lake sturgeon in the North Channel of the St. Clair River. M.Sc. Thesis. University of Michigan. 39 pp.

Love, G. F. 1972. The lake sturgeon (*Acipenser fulvescens*) of Lake Nipissing, 1971 study. Manuscript report. Ontario Ministry of Natural Resources. North Bay, Ontario. 16 p. + appendices.

Lyons, J. and J. J. Kempinger. 1992. Movements of adult lake sturgeon in the Lake Winnebago system. Research Report 156. Wisconsin Department of Natural Resources. Madison, Wisconsin. 18 pp.

Macins, V. 1972. The fisheries of Lake of the Woods. Ontario Ministry of Natural Resources, Sport Fisheries Branch, Toronto, ON. 39 pp.

Magnin, E. 1977. Croissance, regime alimentaire et fécondité des esturgeons (*Acipenser fulvescens*) du bassin hydrographique de la Grande Rivère, Québec. Le Naturaliste Canadien 104:419-427.

Mann, K.A., J.M. Holtgren, N.A. Auer and S.A. Ogren. 2011. Comparing size, movement, and habitat selection of wild and streamside reared lake sturgeon. North American Journal of Fisheries Management 31: 305-314.

Manny, B.A. and G.W. Kennedy. 2002. Known lake sturgeon (*Acipenser fulvescens*) spawning habitat in the channel between lakes Huron and Erie in the Laurentian Great Lakes. Journal of Applied Ichthyology. 18: 486-490.

Manny, B. A., J. Read, D. Denison, R. Reider, G. Kennedy, N. Caswell, J. Boase and J. McClain. 2005. Creation of lake sturgeon spawning habitat in the Detroit River. U.S. Fish and Wildlife Service and U.S. Geological Service.

Maraldo, D. 1997. Recovery of lake sturgeon (*Acipenser fulvescens*) in Lake Nipissing, Ontario. Paper presented at the 59th Midwest Fish and Wildlife Conference. December 7-10, 1997. Milwaukee, Wisconsin.

Mathers, A., B. Trometer, D. Dittman, D. Carlson, K Wagner, R. Klindt and S. Lapan. 2010 Draft. Recommendations for the Rehabilitation of Lake Sturgeon in Lake Ontario, the Lower Niagara River and the Upper St. Lawrence River. 34pp + appendices.

McDermid, J., K. Wozney, S. Kjartanson, and C. Wilson. 2011. Quantifying historical, contemporary, and anthropogenic influences on the genetic structure and diversity of lake sturgeon (*Acipenser fulvescens*) populations in northern Ontario. Journal of Applied Ichthyology (in press).

McKinley S., G Van Der Kraak and G. Power. 1998. Seasonal migrations and reproductive patterns in the lake sturgeon, *Acipenser fulvescens* in the vicinity of hydroelectric stations in northern Ontario. Environmental Biology of Fishes 51: 245-256.

McLeod, D.T. 1999. An assessment of lake sturgeon populations in the Lower Seine River system, Ontario. 1993-95. Ontario Ministry of Natural Resources. Fort Francis District Report Series No. 43. 28 pp.

McLeod, D.T. 2008a. A population estimate of lake sturgeon in Little Eva Lake, Ontario 2007. Ontario Ministry of Natural Resources. Fort Francis District Report Series No. 79. 23 pp + appendices.

McLeod, D.T. 2008b. A population estimate of lake sturgeon in the Namakan River, Ontario 2006-2008. Ontario Ministry of Natural Resources. Fort Francis District Report Series No. 81. 39 pp + appendices.

McLeod, D., and C. Debruyen. 2009. Movement and Seasonal Distribution of Lake Sturgeon in the Namakan River, Ontario. Preliminary Report 207-08. Ontario Ministry of Natural Resources, Fort Francis, Ontario. Fort Francis District Report series No. 82. 56 pp.

McQuown, E., C.C. Krueger, H.L. Kincaid, G.A.E. Gall, and B. May. 2003. Genetic comparison of lake sturgeon populations: differentiation based on allelic frequencies at seven microsatellite loci. Journal of Great Lakes Research 29: 3-13.

Michanlenko, G., L. Marcogliese and the Muskrat Band. 1991. The subsistence lake sturgeon (*Acipenser fulvescens*) fishery of the Indian village of Muskrat Dam in northern Ontario, Canada. p. 447-458 *In* P. Williot [ed.]. Acipenser. Cemagrief Publications.

Minnesota Department of Natural Resources. 2009. Lake Sturgeon Management Plan for Lake of the Woods and Rainy River (Draft). 17 pp.

Mohr, L. 2000. Lake sturgeon monitoring in Ontario waters of Lake Huron- 2000. Lake Huron Management Unit, Ontario Ministry of Natural Resources. Owen Sound, ON. 5 pp.

Mohr, L. C., A. Mathers, M. Friday and R. Drouin. 2008. Great Lakes Branch lake sturgeon status statement. Great Lakes Branch, Ontario Ministry of Natural Resources. Peterborough, Ontario. 18 pp.

Mosindy, T. 1987. The lake sturgeon *(Acipenser fulvescens*) fishery of Lake of the Woods, Ontario. Pp. 44-45 *In:* Olver C.H. [ed.]. Proceedings of a workshop on the lake sturgeon (*Acipenser fulvescens*). Ontario Fisheries Technical Report Series No. 23.

Mosindy, T. S. and J. Rusak. 1991. An assessment of lake sturgeon populations in Lake of the Woods and the Rainy River, 1987-90. Lake of the Woods Fisheries Assessment Unit Report 1991-01. Ontario Ministry of Natural Resources. Kenora, Ontario. 66 pp.

Munro, J. 2000. Integrated assessment of impacts on concentrations of juvenile Atlantic sturgeon (*Acipenser oxyrinchus*) and lake sturgeon (*Acipenser fulvescens*) associated with disposal of dredged sediment in the St. Lawrence River upper estuary. Research proposal to Environmental Science Strategic Research Fund. Department of Fisheries and Oceans. Ottawa, Ontario. 12 pp.

N.E.A. 1992. Carmichael Falls Hydroelectric project: Year 1 of Long—term Monitoring program. Prepared for Wm. R. Walker Engineering Inc. 86 pp + appendices.

Nicols, S. J., G. Kennedy, E. Crawford, J. Allen, J. French III, G. Black, M. Blouin, J. Hickey, S. Chernyák, R. Haas and M. Thomas. 2003. Assessment of lake sturgeon (*Acipenser fulvescens*) spawning efforts in the lower St. Clair River, Michigan. Journal of Great Lakes Research 29:383-391.

Nilo, P., P Dumont, and R. Fortin. 1997. Climatic and hydrological determinants of year-class strength of St. Lawrence River lake sturgeon. Canadian Journal of Fisheries and Aquatic Sciences. 54: 774-780.

Nilo, P., S. Tremblay, A. Bolon, J. Dodson, P. Dumont and R. Fortin. 2006. Feeding ecology of juvenile lake sturgeon in the St. Lawrence River system. Transactions of the American Fisheries Society 135:1044-1055.

Nowak, A.M. and Hortiguela, M. 1986. Status of the lake sturgeon fishery in two reaches of the Mattagami River, Cochrane. Ontario Ministry of Natural Resources Technical Report. 25 pp.

Ochiichagwe'babigo'ining Ojibway First Nation. 2009. Ochiichagwe'babigo'ining Ojibway First Nation Lake Sturgeon Stewardship Project. 2009 report. 11 pp.

Ontario Game and Fisheries Commission. 1912. Annual report of the Game and Fisheries Commission, 1909-1911. King's Printer for Ontario. Toronto, Ontario.

Ontario Ministry of Natural Resources. 2002a. Waterpower, Water Management Planning Guidelines for Waterpower. Queens Printer for Ontario. 36 pp + appendices.

Ontario Ministry of Natural Resources. 2002b. Guidelines for Stocking Fish in Inland Waters of Ontario. Fisheries Section, Fish and Wildlife Branch. Peterborough, Ontario. 43 pp.

Ontario Ministry of Natural Resources. 2004. OMNR Northwest Science and Information. Thunder Bay, Ont. 100 pp + appendices.

Ontario Ministry of Natural Resources. 2009. The lake sturgeon in Ontario. Fish and Wildlife Branch. Peterborough, Ontario. 48 pp + appendices.

Ontario Ministry of Natural Resources. 2009b. A Population Assessment of Lake Sturgeon (*Acipenser fulvescens*) in Sturgeon Lake, Quetico Provincial Park Progress report: 2008-2009. 20 pp.

Ontario Waterpower Association. 2009. Best Management Practices Guide for Water Power Projects, Lake Sturgeon. Prepared by AECOM Canada Limited. 79 pp + appendices.

Patrick et al. 2009. Lethality of sea lamprey parasitism on lake sturgeon. Transactions of the American Fisheries Society 138:1065–1075.

Rainy River First Nation. 2002. Historical measures of Rainy River District fisheries-Rainy River First Nations perspective. Report presented to the Rainy River Peaking Working Group. Rainy River First Nations Watershed Program. 7pp.

Peake, S. 1999. Substrate preferences of juvenile hatchery-reared lake sturgeon (*Acipenser fulvescens*). Environmental Biology of Fishes 56:367-374.

Peake, S., F.W.H. Beamish, R.S. McKinley, D.A. Scruton and C. Katapodis. 1997. Relating swimming performance of lake sturgeon, *Acipenser fulvescens*, to fishway design. Canadian Journal of Fisheries and Aquatic Sciences. 54: 1361-1366.

Peterson, D. L., P. Vecsei and C. A. Jennings. 2007. Ecology and biology of the lake sturgeon: a synthesis of current knowledge of a threatened North American *Acipenseridae*. Reviews in Fish Biology and Fisheries 17:59-76.

Payne, D.A. 1987. Biology and population dynamics of lake sturgeon (*Acipenser fulvescens*) from the Frederick House, Abitibi and Mattagami Rivers in the Cochrane District. p. 10-19 *In* C.H. Olver [ed]. Proceedings of a Workshop on the Lake Sturgeon. Ontario Fisheries Technical Report Series No. 23.

Phoenix, D. 1991. Movements of lake sturgeon in the upper Groundhog River (1988-1989). Draft Manuscript. OMNR Technical Report. 42 pp.

Pratt, T. C. 2008. Population status and threats of lake sturgeon in Designatable Unit 8 (Great Lakes/St. Lawrence River watershed). Department of Fisheries and Oceans. Sault Saint Marie, Ontario. 24 pp.

Randall, R. G. 2008. Narrative description and quantification of the habitat requirements of lake sturgeon (*Acipenser fulvescens*) in the Great Lakes and upper St. Lawrence River. Research Document. Fisheries and Oceans Canada.

Rochard, E., G. Catelnaud and M. Lepage. 1990. Sturgeons (Pisces*: Acipenseridae*): Threats and prospects. Journal of Fish Biology 37 (Supplement A):123-132.

Roussow, G. 1957. Some considerations concerning sturgeon spawning periodicity. Journal of the Fisheries Research Board of Canada 14:553-572.

Rusak, J. A. and T. Mosindy. 1997. Seasonal movements of lake sturgeon in Lake of the Woods and the Rainy River, Ontario. Canadian Journal of Zoology 74:383-395.

Ryan, P. A., R. Knight, R. MacGregor, G. Towns, R. Hooper and W. Culligan. 2003. Fish community goals and objectives for Lake Erie. Special Publication 03-2. Great Lakes Fishery Commission. Ann Arbor, Michigan.

Sandilands, A. P. 1987. Biology of the lake sturgeon (*Acipenser fulvescens*) in the Kenogami River, Ontario. p. 33-46 *In* C. H. Olver [ed.]. Proceedings of a Workshop on the Lake Sturgeon. Fisheries Technical Report Series No. 23. Ontario Ministry of Natural Resources. Toronto, Ontario.

Saunders, D. A. 1981. Recommendations on the Mattagami River sturgeon fishery. Ontario Ministry of Natural Resources. Cochrane, Ontario. 46 p.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Bulletin 184. Fisheries Research Board of Canada. Ottawa, Ontario. 966 pp.

Scribner, K. and E. Baker. 2008. Assessment of simulated lake sturgeon supplementation in Michigan drainages of the Great Lakes. Department of Fish and Wildlife. Michigan State University. East Lansing, Michigan.

Seelye, J. G., D. A. Johnson, J. G. Weise and E. L. King. 1989. Guide for determining application rates of lampricides for control of sea lamprey ammocoetes. Technical Report No. 52. Great Lakes Fishery Commission. Ann Arbor, Michigan. 23 pp.

Seyler, J., Evers, J., McKinley, S., Evans, R., Prevost, G., Carson, and D. Phoenix. 1996. Mattagami River lake sturgeon entrainment: Little Long generating station facilities. Technical Report TR- 039, Northeast Science and Technology. Ontario Ministry of Natural Resources. Timmins, Ontario.

Seyler, J.C. 1997a. Population dynamics and habitat utilization by lake sturgeon (*Acipenser fulvescens*) in a northern clay belt river. Paper presented at the 59th Midwest Fish and Wildlife Conference. December 7-10, 1997. Milwaukee, Wisconsin.

Seyler, J.C. 1997b. Biology of Selected Riverine Fish Species in the Moose River Basin. OMNR Northeast Science and technology. Timmins, Ontario. IR-024. 100 pp.

Shaw, S.L. 2010. Lake sturgeon (*Acipenser fulvescens*) population attributes, reproductive structure and distribution in Namakan Reservoir, Minnesota and Ontario. MSc Thesis. South Dakota State University. 77 pp + appendices

Smith, A. L. 2009. Lake sturgeon (*Acipenser fulvescens*) stocking in North America. Fish and Wildlife Branch. Ontario Ministry of Natural Resources. Peterborough, Ontario. 17pp + appendices.

Smith, K. M. 2003. Spawning stock abundance and larval production of lake sturgeon (*Acipenser fulvescens*) in Black Lake, Michigan. M.Sc. Thesis. Central Michigan Unversity. Mount Pleasant, Michigan.

Smith, K. M. and D. K. King. 2005a. Dynamics and extent of larval lake sturgeon (*Acipenser fulvescens)* drift in the Upper Black River, Michigan. Journal of Applied Ichthyology 21:161-168.

Smith, K. M. and D. K. King. 2005b. Movement and habitat use of yearling and juvenile lake sturgeon in Black Lake, Michigan. Transactions of the American Fisheries Society 134:1159-1172.

Smith, A.L. and D. Hobden. 2011. A synopsis of lake sturgeon (*Acipenser fulvescens*) culture, marking and stocking techniques. Biodiversity Branch. Ontario Ministry of Natural Resources. Peterborough, Ontario. 36 pp.

State of the Great Lakes. 2009. Environment Canada and United States Environmental Protection Agency. 426 pp.

Stewart, T. J., R. F. Lange, S. D. Orsatti, C. P. Schnieder, A. Mathers and M. E. Daniels. 1999. Fish community objectives for Lake Ontario. Special Publication 99-1. Great Lakes Fishery Commission. Ann Arbor, Michigan. 56 pp.

Stewig, J. D. 2005. A population assessment of the lake sturgeon in Lake of the Woods and the Rainy River, 2004. Minnesota Department of Natural Resources. St. Paul, Minnesota.

Talmage, P., T. Heinrich, D. Topp and K. Peterson. 2009. Lake Sturgeon Management Plan for Lake of the Woods and Rainy River. Minnesota Department of Natural Resources Division of Fish and Wildlife, Fisheries Management Section. 17 pp.

Thomas, M.V. and R.C. Haas. 2002. Abundance, age structure, and spatial distribution of lake sturgeon (*Acipenser fulvescens*) in the St. Clair system. Journal of Applied Ichthyology 18:495-501.

Threader, R. W. and C. S. Brousseau. 1986. Biology and management of the lake sturgeon in the Moose River, Ontario. North American Journal of Fisheries Management 6:383-390.

Threader, R. W. 1981. Age, growth and proposed management of the lake sturgeon (*Acipenser fulvescens*) in the Hudson Bay Lowland. Technical report. Ontario Ministry of Natural Resources. Cochrane, Ontario.

Threader, R.W., R.J. Pope and P.R.H. Schaap. 1998. Development of a habitat Suitability Index Model for Lake Sturgeon. Ontario Power Generation Report No. H-07015.0-0012.

Thuemler, T. F. 1988. Movements of young lake sturgeon stocked in the Menominee River, Wisconsin. Paper presented at the 11th Annual Larval Fish Conference. American Fisheries Society Symposium 5:104-109.

Traffic. 2003. Caviar and conservation – Traffic examines management and trade of North American sturgeon and paddlefish. Washington, D. C. 4 pp.

Velez-Espino, L. A. and M. A. Koops. 2008. Recovery potential assessment for the lake sturgeon (*Acipenser fulvescens*) in Canadian designatable units. North American Journal of Fisheries Management 29:1065-1090.

Wang, Y.L., F.P. Binkowski and S.I. Doroshov. 1985. Effects of temperature on early development of white and lake sturgeon (*Acipenser transmontanus* and *fulvescens*). Environmental Biology of Fishes 14:43-50.

Webb, M. A. H., G.W. Feist, M.S. Fitzpatrick, E.P. Foster, C.B. Schreck, M. Plumlee, C. Wong, and D.T. Gundersen. Mercury concentrations in gonad, liver, and muscle of white sturgeon (*Acipense transmontanus*) in the Lower Columbia River. Arch. Environ. Contam. Toxicol. 50: 443-451.

Welsh, A., and J.R. McClain. 2004. Development of a management plan for lake sturgeon within the Great Lakes basin based on population genetics structure. Final Project Report. Great Lakes Fishery Trust Project Number: 2001.75.

Welsh, A. and D.T. McLeod. 2010. Detection of natural barriers to movement of lake sturgeon (*Acipenser fulvescens*) within the Namakan River, Ontario. Canadian Journal of Zoology 88: 390-397.

Welsh, A., R. Elliot, C. Krueger, H. Quinlan and B. May. 2007. Draft. Genetic guidelines for the stocking of lake sturgeon (*Acipenser fulvescens*) in the Great Lakes basin. 46 pp.

Welsh, A., T. Hill, H. Quinlan, C. Robinson, and B. May. 2008. Genetic assessment of lake sturgeon population structure in the Laurentian Great Lakes. North American Journal of Fisheries Management 28: 572-591.

Werner, R.G. and J. Hayes. 2005. Contributing Factors in Habitat Selection by Lake Sturgeon (*Acipenser fulvescens*). Submitted to United States Environmental protection Agency - Great lakes National program Office.19 pp.

Williamson, D. F. 2003. Caviar and conservation: status, management and trade of North American sturgeon and paddlefish. World Wildlife Fund. Washington, D. C.

Winemiller, K.O., and K.A. Rose. 1991. Patterns of life-history diversification in North American fishes: implications for population regulation. Canadian Journal of Fisheries and aquatic Sciences 49: 2196-2218.

Wozney, K.M., T.J. Haxton, S. Kjartanson and C.C. Wilson. 2010. Genetic assessment of lake sturgeon (*Acipenser fulvescens)* population structure in the Ottawa River. Environmental Biology of Fishes 90: 183-195.

## PERSONAL COMMUNICATIONS

Auer, N.A. (MTU). 2010. September 30, 2010. Personal communication.

Corbett, B. (OMNR). 2011. March 11, 2011. Personal communication.

Ecclestone, Andrew. (OMNR). November 1, 2010. Personal communication.

Friday, Mike. (OMNR). November 1, 2010. Personal communication.

Hunter, J. (Rainy River First Nation). August 30, 2010. Personal communication.

Matkowski, S. (Manitoba Hydro). March 23, 2011. Personal communication.

Mohr, L (OMNR). December 10, 2010. Personal communication.

Mohr, L (OMNR). March 23, 2011. Personal communication

Pratt, Tom (DFO). August 19, 2010. Personal communication.

## APPENDIX 1

Lake Sturgeon maturation in selected Ontario waters.

| Waterbody | Length (cm) | | Earliest Age (years) | | Information Source |
|---|---|---|---|---|---|
| | Male | Female | Male | Female | |
| Groundhog River | 775 - 1510 (sexes combined) | | 17 | 29 | Golder Associates Ltd. (2010a) |
| Kenogami River | 82.0 | 105.0 | 20 | 25 | Ecologistics Ltd. (1987) |
| Lake Huron | - | - | 10<br>12 (50% maturity) | 12<br>21 (50% maturity) | L. Mohr (pers. comm.. 2011) |
| Lake Nipissing | - | - | 10 | 12 | Love (1972) |
| Lake of the Woods | - | - | 17 | 23 | Macins (1972) |
| Lake of the Woods | 123.8 | 140.9 | 11 | 20 | Mosindy and Rusak (1991) |
| Mattagami River | 76.0 - 96.5 | 84.0 - 96.5 | 14 | 17 | Saunders (1981) |
| Moose River | 123.2 | 118.5 | 14+ | 20+ | Threader (1981) |
| North Channel<br>(L. Huron) | - | - | 12.0 | 15.0 | Mohr (2000) |
| | 99.4 | 110.8 | 10 | 14 | J. Speers (unpublished data) |
| Ottawa River (Lac Deschênes) | 76.2 - 78.7 | 83.8 - 86.4 | 19 | 26 | Dubreuil & Cuerrier (1950) |
| Ottawa River | 106.7 | 112.2 | 20.4 (50% maturity) | 25.4 (50% maturity) | Haxton (2008) |

## APPENDIX 2

Dates and water temperatures recorded for Lake Sturgeon spawning in selected Ontario waters.

| Waterbody | Spawning Dates | Water Temperatures (ºC) | Source of Information |
|---|---|---|---|
| Groundhog River | - | 13 | Phoenix (1991) |
| Groundhog River | May 9 - 24 | 10 - 14.5 | Golder (2010a) |
| Kaministiquia River | May 19 – June 27 | 13.4 - 17.2 | Friday (2004, 2005, 2006a) |
| Lake Nipissing | May 27 - June 15 | - | Love (1972) |
| Lake of the Woods | May 7 – June 10 | 12.8 - 15.6 | Macins (1972), Mosindy and Rusak (1991) |
| Mississagi River | May 17 – 21 | 9.9 - 11.3 | L. Mohr (pers. comm. 2011) |
| Ottawa River | June 4 - July 9 | 16 - 20 | Haxton (2008) |
| St. Clair River | May 20 - June 14 | 12 - 13 | Thomas and Haas (2004) |
| St. Lawrence River | June 17 – 28 | 15 - 16 | LaPan et al. (1997) |
| Trent River | May 3 – 10 | 17 - 18 | Mathers (2000) |

## APPENDIX 3

Lake Sturgeon recovery criteria/targets (existing recovery/management plans).

| Recovery Criteria | Scale | Reference |
| --- | --- | --- |
| • 1500 adults;<br>• Equal sex ratio;<br>• 20 or more year classes; and<br>• Measurable recruitment of age 0-5 fish | • Lake Superior and includes Ontario tributaries<br>• Fish ascending a common tributary | Auer (2003) |
| • 40 year classes;<br>• Densities of age 2 and older fish of 250 fish per mile in rivers and 1.5 fish/acre in lakes;<br>• Male fish age 40 years;<br>• Female fish to age 70 years;<br>• Some females exceeding 1,770mm; and<br>• Annual fishing mortality of less than 5 percent | • Lake of the Woods and the Rainy River | Talmage et al. (2009) |
| • 750 sexually mature adults | • Each spawning run [tributary] of Lake Ontario | Mathers et al. (2010) |
| • Maintain genetic integrity (100 adult fish);<br>• Develop populations consisting of 500 adult fish<br>• Maintain fishing mortality <3 percent (recovering) and <6 percent (healthy) | • Spawning populations in Michigan rivers and lakes | Hay-Chielewski Whelan (1997) |
| • 413 spawning females (4,130 adults)/year<br>• 1,193 ha (lotic) and 2,386 ha (lentic) of suitable habitat | • Each Lake Sturgeon management unit (DU4) | Cleator et al. (2010b) |
| • 413 spawning females (4,130 adults)/year<br>• 1,886 ha (lotic) and 3,772 ha. (lentic) of suitable habitat | • Each Lake Sturgeon management unit (DU5) | Cleator et al. (2010a) |
| • 11,880 spawning adults/year | • Each Lake Sturgeon management unit (DU8) | Pratt (2008) |

# APPENDIX 4

Lake Sturgeon designated units, sturgeon management units and their corresponding drainages within Ontario.

| COSSARO Lake Sturgeon Designation (COSEWIC Designatable Unit) | Sturgeon Management Unit | Drainage(s) |
|---|---|---|
| Northwestern Ontario Population (DU4) | MU6 | Berens River |
| Northwestern Ontario Population (DU5) | MU1 | Wabigoon River[1] |
| Northwestern Ontario Population (DU5) | MU2 | English River |
| Northwestern Ontario Population (DU5) | MU3 | Winnipeg River (Norman GS – Whitedog Falls) |
| Northwestern Ontario Population (DU5) | MU4 | Winnipeg River (Whitedog Falls – Manitoba border) |
| Northwestern Ontario Population (DU6) | None designated | Lake of the Woods-Rainy River and upstream water bodies |
| Southern Hudson Bay-James Bay (DU7) | None designated | Severn River, Winisk River, Attawapiskat River, Albany River, Moose River |
| Great Lakes-Upper St. Lawrence River (DU8) | SMU1 | Lake Nipigon |
| Great Lakes-Upper St. Lawrence River (DU8) | SMU2 | Pigeon River, Kaministiquia River, Black Sturgeon River, Nipigon River, Gravel River, Pic River, White River, Michipicoten River, central and western Lake Superior |
| Great Lakes-Upper St. Lawrence River (DU8) | SMU3 | Batchawana River, Chippewa River, Goulais River and eastern Lake Superior |
| Great Lakes-Upper St. Lawrence River (DU8) | SMU4 | St. Marys River, Garden River, Thessalon River, Mississagi River, Spanish River, French River, Key River, Magnetawan River, Naiscoot River, Moon River, Go Home River, Severn River, Sturgeon River, and north channel of Lake Huron |
| Great Lakes-Upper St. Lawrence River (DU8) | SMU5 | Nottawasaga River and Georgian Bay |
| Great Lakes-Upper St. Lawrence River (DU8) | SMU6 | Lake Nipissing, South River, Sturgeon River |
| Great Lakes-Upper St. Lawrence River (DU8) | SMU7 | Lake Huron / Erie Corridor, Main basin Lake Huron, St. Clair River, Lake St. Clair, Detroit River and Lake Erie |
| Great Lakes-Upper St. Lawrence River (DU8) | SMU8 | Lower Niagara River, Lake Ontario / upper St. Lawrence River , Trent River, and Lake St. Francis |
| Great Lakes-Upper St. Lawrence River (DU8) | SMU9 | Ottawa River |

[1] It is unknown if Lake Sturgeon was historically present in the Wabigoon River or occurs there now (Cleator et al. 2010b).