RECOVERY POTENTIAL ASSESSMENT FOR THE ATLANTIC STURGEON, ST. LAWRENCE POPULATION

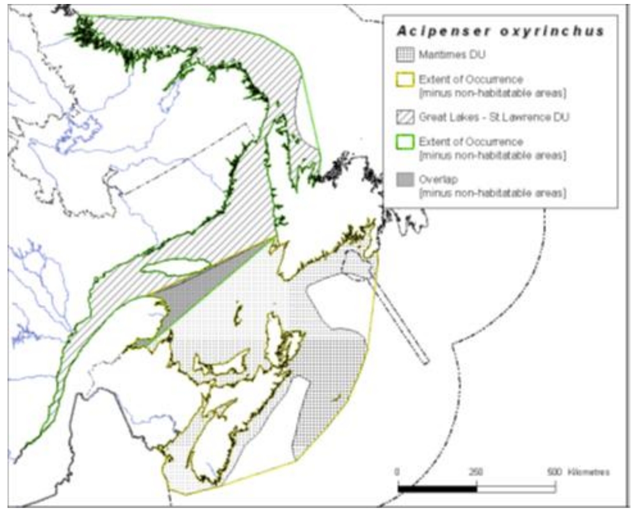

Figure 1. Extent of occurrence for St. Lawrence River and Maritimes DUs of the Atlantic Sturgeon (Acipenser oxyrinchus). The narrow rectangular outline and the easternmost dashed line represent fishery zones for various marine fishes.

Context:

In May 2011, the Atlantic Sturgeon, Acipenser oxyrinchus, St. Lawrence population, was designated as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). "This large-bodied, slow-growing and late-maturing fish consists of a small breeding population spawning within a relatively small area. The species is exploited in a regulated commercial fishery, but limited monitoring of the effects of this fishery make the viability of this population highly uncertain."

In order to provide the necessary information and scientific advice to meet the various requirements of the Species at Risk Act (SARA) and to develop, if necessary, a recovery program and an action plan, a Recovery Potential Assessment (RPA) process has been established by DFO Science. As part of a peer review held on February 21, 2012 in collaboration with the Ministère des Ressources naturelles et de la Faune du Québec (MRNF) and the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ), Fisheries and Oceans Canada reviewed the available information on abundance, distribution, habitat and threats to the Atlantic Sturgeon, St. Lawrence population.

SUMMARY

- The Atlantic Sturgeon, St. Lawrence population, is mainly found in the St. Lawrence River, downstream of Trois-Rivières and on into the Estuary and Gulf of St. Lawrence.
- The abundance of Atlantic Sturgeon, St. Lawrence population, has never been formally established. The current size is unknown. Based on data regarding spawning sturgeon collected in a study on the life cycle of Atlantic Sturgeon in the St. Lawrence between 1997 and 2000, Dadswell (2006) estimated the population of mature adults to be between 500 and 1,000 individuals. This was based on released fish (tagged and recaptured). However, since the data used to calculate abundance were not intended for this type of study, these results should be used with caution.
- The absence of an analytical model prevents us from accurately estimating the size of the minimum viable population (MVP) for the Atlantic Sturgeon in the St. Lawrence River. However, the results of various studies on the MVP indicate that an MVP of between 5,000 and 6,000 Atlantic Sturgeon adults would ensure the survival of the species for 500 years.
- Due to the existing uncertainties about demographic parameters required for modelling, no long-term projection has been made. However, based on an estimate of the abundance of the first cohort, which fully avoided being fished (19 years) (variation between 300 and 700) and by applying the natural mortality (M) rate found in the literature for different populations of sturgeon (variation between 0.05 and 0.09), it is possible to project abundance for each year and estimate the size of the population. Depending on various parameters, we obtain values ranging between 1,597 and 7,723 mature Atlantic Sturgeon after about 40 years if we consider that some individuals survive to 60.
- Six areas of adult concentration were identified, including four in the river estuary (between Trois-Rivières and Quebec) and two in the middle estuary (downstream of Île d'Orléans). Three of the four areas in the river estuary have been identified as potential spawning grounds (Richelieu Rapids, mouth of the Chaudière River, Saint-Antoine-de-Tilly), while the other three areas seem to be best suited for resting and feeding (Saint-Charles River estuary, Traverse du Milieu Channel, the north channel between Sault-au-Cochon and Petite-Rivière-Saint-François).
- The transition zone between fresh water and salt water in the St. Lawrence estuary is home to groups of benthic prey preferred by the Atlantic Sturgeon and is an important habitat for the breeding and feeding of juveniles. The extent of this habitat, strongly associated with the brackish water transition zone, was estimated at 76 km^2 and includes two main areas where juveniles are concentrated, between the towns of Saint-Jean (Île d'Orleans) and Cap-Saint-Ignace.
- Potential threats to the Atlantic Sturgeon, St. Lawrence population, are mainly associated with commercial fishing and the degradation and loss of preferred habitat. Dredging constitutes a major threat, especially in juvenile feeding areas. Acquiring new knowledge about the habitat of the Atlantic Sturgeon, particularly the precise location of spawning grounds, and the impact of certain threats is essential before appropriate mitigation measures can be implemented.

BACKGROUND

Biology and Ecology

The Atlantic Sturgeon, *Acipenser oxyrinchus,* is a large-bodied, slow-growing and late-maturing anadromous species which lives and grows in brackish and salty water but spawns in fresh water. Females have an average total length of 2 to 3 m and weigh between 100 and 200 kilograms. The male is slightly smaller, measuring between 1.4 and 2.1 m and weighing between 50 and 100 kg. Sexual maturity in the Atlantic Sturgeon varies by gender. The size of the fish may be more significant than its age in triggering maturation. In the St. Lawrence River, males reach maturity earlier and at a smaller size than females, that is to say between the ages of 16 and 26 years and at a fork length of about 1.5 m. Females may reach maturity around 27 or 28 years of age, and at a fork length of 1.8 to 2 m. The average age for 50% of the maximum egg production is estimated at 29 years for sturgeon in North America and the largest fish (160 kg) ever caught in the St. Lawrence River was estimated to be around 60 years of age. Because of its large size, the female Atlantic Sturgeon is extremely fertile. Vladykov and Greeley (1963) reported a female caught in the St. Lawrence River that weighed 148 kg, with ovaries weighing 41.4 kg and containing an estimated 3.7 million eggs. The sex ratio of St. Lawrence commercial fisheries shows a ratio close to 1:1 (M:F).

Males probably reproduce every 3-4 years, while this interval is longer for females. Males arrive at spawning grounds earlier and stay longer. Females stay for shorter periods of time in fresh water, just enough time to lay their eggs. In the St. Lawrence River, spawning occurs in June and July, after which the adults migrate further downstream in the estuary and the Gulf. The eggs hatch after 3-7 days and juveniles grow rapidly, reaching 20 to 35 cm at the end of their first year. Juveniles begin their migration once they've reached 80 to 120 cm. The Atlantic Sturgeon feeds primarily on benthic invertebrates, although large juveniles and adults also feed on small fish.

Description of Commercial Fisheries

A record of annual fisheries in the St. Lawrence River has been kept since 1939 (Trencia et al. 2002). Between 1940 and 1955, fishing for Atlantic Sturgeon was practiced in shallow water and was artisanal in nature. Fishers caught an average of 25 tons of fish per year. Landings varied, however, reaching as much as 45 tons annually. Between 1960 and 1966, captures began to decline, and completely plummeted in 1967. No captures, or hardly any, were documented between 1967 and 1975. Starting in 1976, the Atlantic Sturgeon gradually began to return to places where it had been historically caught. Capture techniques then became more efficient and fishing sites were expanded, which likely led to a higher exploitation of the resource. In 1992, about 140 tons of fish were caught by fishermen. As a result, management measures were gradually implemented starting in 1992 in order to regulate the amount fished. Currently, fisheries are managed with an individual annual quota that keeps overall fishing mortality under 60 tons per fishing season. Gillnet mesh is limited to 20.3 cm, a maximum size limitation of 150 cm is set for landed sturgeon and a sharing quota between the various fishing sectors has been implemented (Verreault and Trencia 2011). In addition, every fish landed must be tagged, measured and registered and fishers must submit a weekly report to the MRNF. To improve monitoring of fishing of the Atlantic Sturgeon, St. Lawrence population, the MRNF also commissioned two index fishermen to document the fishing effort and the size and number of fish released back into the water. These index fishermen caught an average of 44% (in quantity) and 47% (in weight) of annual landings since 2002.

The decline in landings observed since the early 1990s is not due to a decrease in abundance, but rather to the implementation of various management actions. The current fishing area mainly covers the region between Quebec City and Rivière-du-Loup. The two main fishing areas are Montmagny and Kamouraska, which share the quota at 75% and 25% respectively.

Based on estimates of length at age, gillnet and fishermen selectivity's and current regulations, fish are harvested anywhere between their 7^{th} and 17^{th} year. However, about 50% of 18-year-old fish are landed when captured. Sturgeons older than 19 years of age should escape to the fishery. Thus, a cohort of fish would be subject to being fished for 11 to 12 years before reaching a length of 150 cm. Beyond this point, it is protected under the current regulations.

RECOVERY POTENTIAL ASSESSMENT

Assess the Current/Recent Status

1. Evaluate present species status for abundance, range and number of populations.

The Atlantic Sturgeon, St. Lawrence population, is found downstream of Trois-Rivières and in the Estuary and Gulf of St. Lawrence. Several observations, however, have been reported upstream of Trois-Rivières (e.g. Lake Saint-Pierre, Verchères). A single breeding population was identified in the designatable unit, which is found in the St. Lawrence River (COSEWIC 2011) (Figure 1).

The abundance of Atlantic Sturgeon, St. Lawrence population, has never been formally established. The current size is unknown. Based on data on spawning sturgeon collected by Caron et al. (2002) in a study on the life cycle of Atlantic Sturgeon in the St. Lawrence between 1997 and 2000, Dadswell (2006) estimated the population of mature adults to be between 500 and 1,000 individuals. This estimate was based on released fish (tagged and recaptured). However, the data used by Dadswell to calculate abundance were not intended for this type of study and should not have been used to carry out this assessment.

2. Evaluate recent species trajectory for abundance (i.e. numbers and biomass focusing on mature individuals), range and number of populations.

Catch statistics for the St. Lawrence River have been available since 1939. However, the lack of information on changes in fishing effort over the years as well as the absence of restrictions on size before 1995 makes it difficult to assess trends in the adult population. Attempts to model the Atlantic Sturgeon, St. Lawrence population, have failed due to a lack of information for some of the model's input. Distribution of the species does not seem to have changed since it was first fished. The majority of Atlantic Sturgeon tagged in the St. Lawrence estuary in 1999 and 2000 were recaptured in this part of the St. Lawrence, while some individuals were caught in the Gulf of St. Lawrence or even in Newfoundland (Placentia Bay and Conception Bay) and in Nova Scotia (Georges Bay).

3. Estimate, to the extent that information allows, the current or recent life history parameters (total mortality, natural mortality, fecundity, maturity, recruitment, etc.) or reasonable surrogates, and associated uncertainties for all parameters.

There is very little data on the natural mortality rate of Atlantic Sturgeon. Secor and Waldman (1999) established the natural mortality rate of Atlantic Sturgeon in Delaware Bay as 0.07. This natural mortality rate was determined by considering a life span of 60 years. Other natural mortality rates have been set for other species of sturgeon. Studies of anadromous white sturgeon, *Acipenser transmontanus*, off the Pacific coast indicate an instantaneous rate of natural mortality of about 0.05 for fish in the lower Fraser and 0.06 in the upper Columbia (Galbreath 1985; Ptolemy and Vennesland 2003). Schueller and Hayes (2010) estimated the natural mortality rate of lake sturgeon in Michigan at 0.05. In terms of the Atlantic Sturgeon, St. Lawrence population, the data available do not allow for an estimation of natural mortality due to the low selectivity of fishing gear for fish > 150 cm that are not fished.

See the section on the biology of the species in the beginning of the report for information on other parameters, when available.

4. Estimate expected population and distribution targets for recovery, according to DFO guidelines (DFO 2005 and 2011).

The lack of precise information on abundance and captures per unit of effort makes it difficult to determine reference points for this species. However, according to the preconditions of section 73(3) of SARA, the demographic sustainability criterion can be used to set recovery targets. Demographic sustainability is linked to the concept of the minimum viable population (MVP), which is defined as the minimum number of adult individuals needed to ensure the survival of the population with a certain level of probability.

The absence of an analytical model prevents us from accurately estimating the size of the MVP for the Atlantic Sturgeon in the St. Lawrence River. However, MVP estimates were made for a 30-year time span for different vertebrates. These median MVP estimates derived from population viability analyses ranged from approximately 1,400 adult individuals for a 90% probability of persistence over 100 years (Brook et al*.* 2006; 1,198 species, including 115 species of fish) to 5,800 individuals for a 99% probability of persistence over 250 years (Reed et al*.* 2003; 102 species of vertebrates). These differences are partly explained by the use of survival probabilities and varying time scales, as well as by the confidence intervals considered (Traill et al*.* 2007). Brook et al*.* (2006) reported that the MVP is strongly correlated with local environmental variations, and not with the intrinsic characteristics of a species.

In general, demographic and evolutionary constraints on the population impose population sizes of at least 5,000 adults (Frankham 1995; Traill et al*.* 2007 and 2010). Nevertheless, none of these MVP estimate studies represent the taxonomic group of fish well.

Finally, among the few studies done to estimate the MVP of sturgeon populations, Jager et al*.* (2010) estimated an MVP for white sturgeon populations in the western United States and Canada to be approximately 5,580 individuals over 83 cm, for a 90% probability of persistence over 500 years. Considering the different estimates available in the literature, a recovery target of between 5,000 and 6,000 Atlantic Sturgeon adults would ensure the survival of the species for 500 years.

5. Project expected population trajectories for the Atlantic Sturgeon over at least three generations, and trajectories over time to the recovery target (if possible to achieve), given current parameters for population dynamics parameters and associated uncertainties using DFO guidelines on long-term projections (Shelton et al*.* 2007).

The absence of a model for the Atlantic Sturgeon, St. Lawrence population, makes it difficult to determine the population trajectory over three generations. However, through the monitoring of captures by the MRNF, it is possible to estimate the minimum number of Atlantic Sturgeon that annually escapes to the fishery since 2002, the year when the monitoring of captures was standardized. By retaining only the first cohort, which fully avoided being fished (19 years), and by applying the rate of natural mortality (M) found in the literature for different populations of sturgeon (variation of 0.05 to 0.09) up to 60 years, and considering that 50% maturity is attained at age 27 and full maturity at age 32, it is possible to project abundance for each year (N_t) using he following equation:

$$N_{(t=1)} = N_t - N_t(1-e^{-(M)}).$$

The abundance values for the first cohort that avoided being fished were calculated using the raw abundance values obtained by index fishermen for fish 19 years of age. These abundance values were modified to reflect the recapture rate (3%) of fish by fishers, the selectivity of the net and the proportion of the biomass harvested by index fishermen compared to the total biomass harvested. It is estimated that an average of 465 (± 107) 19-year Atlantic Sturgeon have avoided being fished annually since 2002. Using the equation above, we obtain values of between 2,475 and 5,130 mature Atlantic Sturgeon after roughly 40 years if we consider that some individuals survive to age 60. If we vary the amount of Atlantic Sturgeon in the first cohort that avoided being fished to be between 300 and 700, we obtain the following values for different mortality rates:

Table 1: Abundance of mature Atlantic Sturgeon over 41 years based on the rate of natural mortality (M) and the amount of Atlantic Sturgeon that avoided being fished at 19 years of age.

No. of Atlantic Sturgeon in the first cohort that avoided being fished (19 years)	*M* = 0.05	*M* = 0.07	*M* = 0.09
300	3,310	2,263	1,597
465	5,130	3,507	2,476
500	5,516	3,771	2,662
700	7,723	5,280	3,727

In some cases, the estimated values approach or even exceed the recovery target established in item 4. It should also be noted that the values identified are the minimum values since the proportion of the fishable population to fishing sites is not known. In all likelihood, this proportion is less than 1, because captures were steady between 2003 and 2011, although very few individuals between 130 and 150 cm have been released back into the water since 2002. The cumulative area of harvested sites is less than 10% of this population's distribution area.

6. Evaluate residence requirements for the Atlantic Sturgeon, if any.

Current information suggests that Atlantic sturgeon do not have a residence as defined by SARA: *"A dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating."*

Assess the Habitat Use

7. Provide functional descriptions (as defined in DFO 2007a) of the required properties of the aquatic habitat for successful completion of all life-history stages.

The Atlantic Sturgeon spends most of its life in brackish and salty water but migrates to fresh water during spawning periods. In general, the preferred habitats of the Atlantic Sturgeon include rivers with access to the sea, preferably with deep channels, estuaries that serve as a transition zone between fresh and salt water, and continental shelf regions. Data on the habitat of Atlantic Sturgeon in the St. Lawrence are still quite limited. However, some relatively recent studies have helped expand knowledge.

Potential Spawning Grounds

Although no spawning grounds have been found in the St. Lawrence, summertime telemetric monitoring between 1998 and 2001 of 69 adults tagged with ultrasonic transmitters identified three potential spawning areas (Hatin et al*.* 2002). Breeding adults were found here from June to mid-July at temperatures of between 15 and 23ºC. These areas, located within the river estuary between Trois-Rivières and Quebec, are: the Richelieu Rapids site, the Saint-Antoine-de-Tilly site, and a site at the mouth of the Chaudière River (Figure 2). The majority of sites were used annually between 1998 and 2001, with the exception of the Richelieu Rapids, where sturgeon were only seen in 1998.

The Richelieu Rapids site, upstream of Portneuf, is characterized by a depth of 20-23 m and by bedrock. The current speed varies with the tides (0.25 m/sec to 2.2 m/sec). Sturgeons were found here at depths of between 14 and 23 m. The second site, located at the confluence of the St. Lawrence and Chaudière rivers, has a topography and substratum similar to the first site, but the fish were found at greater depths, between 13 and 60 m. In the case of the third site, Saint-Antoine-de-Tilly, fish were found at a depth of between 6 and 22 m. The estimated total length of each potential spawning ground would be 3 to 4 km or more.

Juvenile Habitat

The juvenile Atlantic Sturgeon stays in riparian and estuarine environments for a period of up to six years, which could be related to the salt tolerance of younger fish. Water bodies with a wide mesohaline estuary like the St. Lawrence would offer a good potential habitat for the young-of-the-year and juveniles. The transition zone between fresh water and salt water in the St. Lawrence estuary presents conditions that also favour the development and retention of zooplankton and benthic organisms. This portion of the estuary, which includes groups of benthic prey preferred by the Atlantic Sturgeon, seems to be a crucial habitat for the breeding and feeding of juveniles. The strong dependence of the Atlantic Sturgeon on gammaridea and oligochaeta suggests that the areas where these benthic groups are found are important feeding areas for fish aged 0, juveniles and subadults.

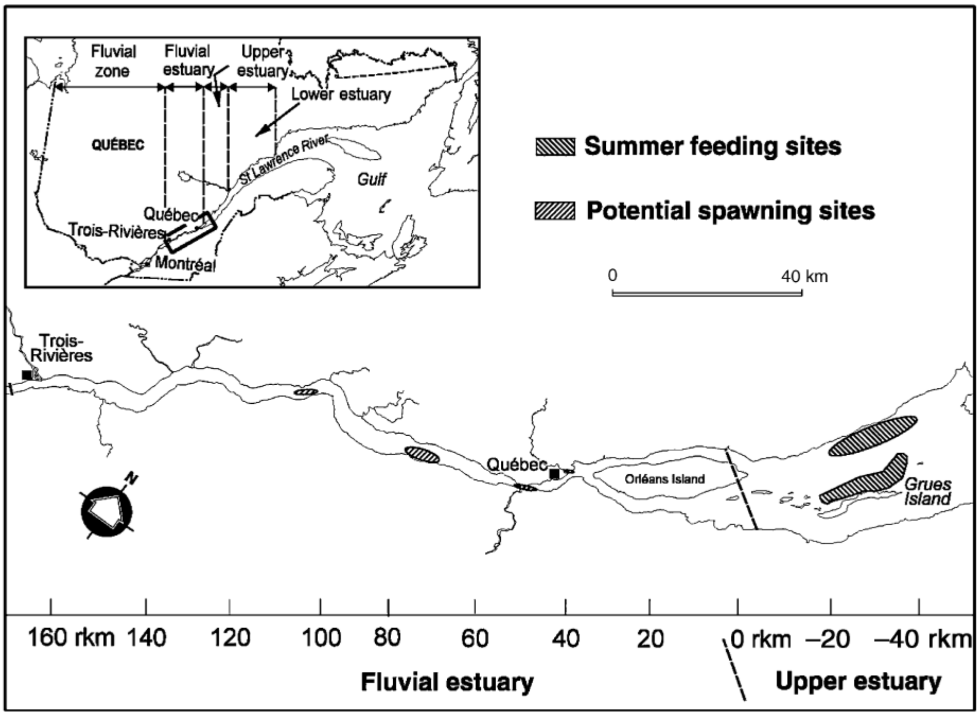

Figure 2. Potential spawning grounds of Atlantic Sturgeon in the St. Lawrence and summer resting and feeding areas (from Caron et al*. 2002)*

From telemetric monitoring of juveniles carried out between 2000 and 2002 (Hatin et al. 2007a), the range of the summer habitat used by juveniles aged 2 years (Figure 3) was estimated at 76 km^2. This habitat consists of two main areas of concentration covering 6 km^2, located between the towns of Saint-Jean (Île d'Orleans) and Cap-Saint-Ignace. The summer range is estimated between 1 and 8 km^2 per individual. The average daily distance travelled varies between 0.4 and 13.5 km based on the size of the sturgeon. The distribution of juveniles in the estuary appears to be strongly related to the salt front. Salinity and distance from the salt front are also the most important variables in habitat selection. Juveniles aged 2 years were mainly found in fresh water (< 0.5‰), close to the salt front and in an area of weak current (0.26 to 0.50 m/s), near a channel at a depth of 6 to 10 m and overtop a substratum of silt and clay. Juveniles aged 0 were found in similar current, depth and salinity conditions, but overtop a sandy substratum. This could be explained by a difference in preferred prey (gammaridea for juveniles aged 0 and oligochaeta for individuals aged 2).

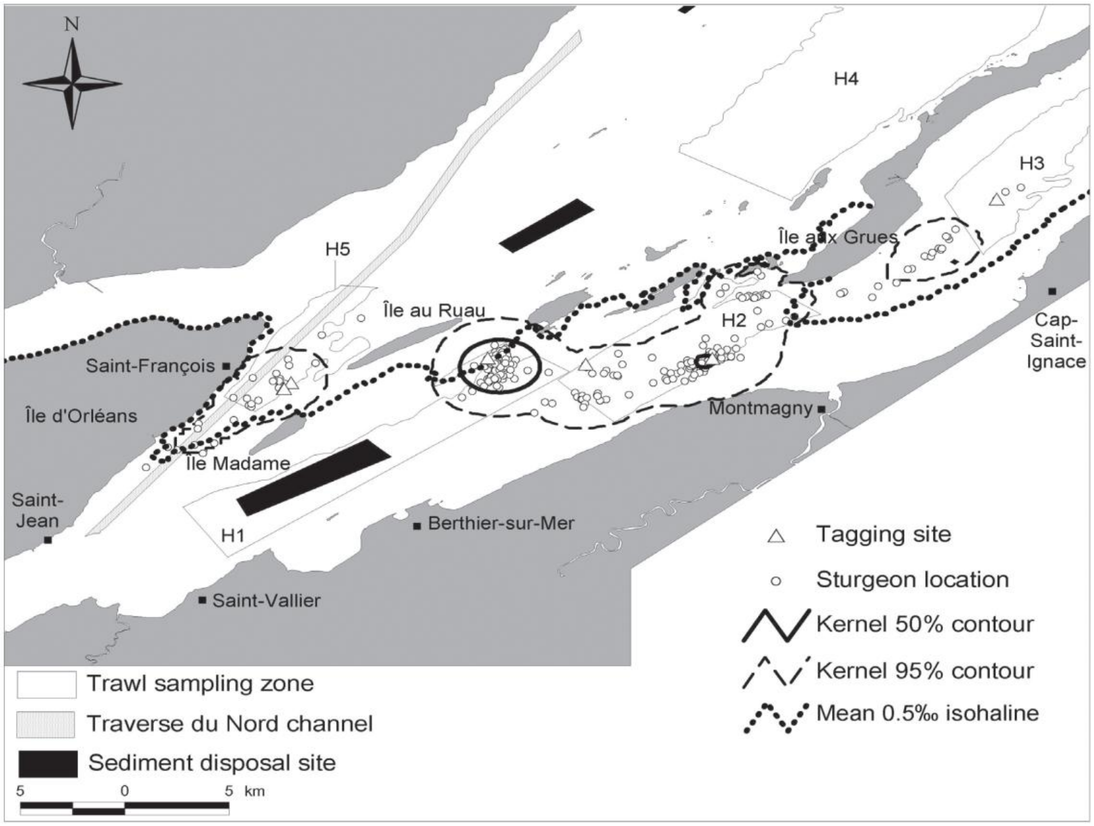

Figure 3. Telemetry locations, overall areas (kernel 95%) and areas of concentration (kernel 50%) used by juvenile Atlantic Sturgeon (age 2), St. Lawrence population, in 2001 and 2002 (source: Hatin et al*. 2007a).*

Summer Feeding Areas for Adults and Fall Migration

In the St. Lawrence estuary, the daily movements of the Atlantic sturgeon, St. Lawrence population, appear to be influenced by the tidal cycle. Adult sturgeons frequent the deep regions of the St. Lawrence (above 10 m at low tide), especially channels and trenches.

Three summer aggregation areas used by post-spawning and non-breeding adults and subadults, which may correspond to resting and feeding areas, were found in the fluvial estuary and upper estuary during the telemetric monitoring conducted between 1998 and 2001 (Figure 2) (Caron et al*.* 2002). We observe that, after leaving the potential spawning grounds, the majority of individuals migrate rapidly to brackish waters, gathering in the Traverse du Milieu Channel and the north channel between Sault-au-Cochon and Petite-Rivière-Saint-François. On the other hand, some individuals make a stop in the Saint-Charles River estuary for periods ranging from several days to more than a month before leaving the river estuary and subsequently using the two brackish water areas of concentration for the rest of the summer. Sturgeons were observed from late June to early August in the Saint-Charles River estuary. This estuary, located in Quebec's port area, is a deep bay with clay soil and a weak current (< 0.2 m/s). The Traverse du Milieu Channel and the north channel between Sault-au-Cochon and Petite-Rivière-Saint-François seem to be other gathering places where sturgeon feed mainly on oligochaeta at the end of the summer (mid-July to the end of September) before migrating further downstream. These could also be transition zones between fresh water and salt water. The Traverse du Milieu Channel is the largest summer area of concentration in the

St. Lawrence River estuary. Salinity in this area varies between 0.2 and 5‰ based on the tidal cycle, and the substratum consists mainly of clay. Significant concentrations of oligochaeta have been observed here.

According to the literature, the Atlantic Sturgeon is known to migrate to salt water during the fall. Adults in the St. Lawrence population may winter in habitats located downstream of the middle estuary, in the lower estuary or in the Gulf of St. Lawrence. Sightings have been reported in the Gulf of St. Lawrence, particularly as part of the monitoring done between 1998 and 2001. Four tagged sturgeon in the upper estuary between 1999 and 2000 were recaptured in 2000-2001 after migrating to sea off the coast of Newfoundland (Placentia Bay and Conception Bay) and Nova Scotia (Georges Bay). Recapture tagging data indicate that of the 3,214 sturgeon tagged in the Montmagny archipelago, 571 were recaptured, ten of which were outside of the estuary (Fournier and Bernard 2005). Some ten captures were also reported in the Gulf as bycatch in commercial fisheries. No mention of Atlantic Sturgeon moving between the St. Lawrence and the United States has been reported according to United States East Coast tracking data.

8. Provide information on the spatial extent of the distribution areas that are likely to have these habitat properties.

Areas likely to have the habitat properties sought for the survival and recovery of Atlantic Sturgeon in the St. Lawrence are concentrated in the St. Lawrence estuary and are defined in Figures 2 and 3. The overall area used by juveniles in the summer was evaluated at 76 km^2 based on telemetric monitoring of juveniles conducted between 2000 and 2002 as part of a study on the impacts of dredging near Île Madame (Hatin et al. 2007a). This is a minimum estimate of the area used. The two heavily-used sites located within this area were estimated at 5.7 and 0.3 km^2 respectively. Potential spawning grounds were not defined with as much precision. These potential spawning grounds were identified in river segments measuring 3-4 km in length. It should also be noted that these figures should be considered minimum values since some tagged sturgeon were not found during monitoring.

9. Identify the activities most likely to threaten the habitat properties that give the sites their value, and provide information on the extent and consequences of these activities.

Potential threats to the habitat of the Atlantic sturgeon, St. Lawrence population, are mainly associated with activities that could cause degradation of the key features of these habitats or reduced availability of preferred habitats. Dredging and sediment disposal seem the highest threat, especially in juvenile feeding areas. The combined effect of all threats should also be considered, although it is difficult to quantify the extent. The effect of a threat could also be amplified by the concentration of Atlantic Sturgeon in certain areas at certain stages of life.

Dredging and sediment disposal

Dredging for the maintenance of the Saint Lawrence Seaway and the port areas is carried out each year. The stretch between Trois-Rivières and Quebec, where potential spawning grounds have been identified, is the segment most affected by these operations (Robitaille et al. 1988). In addition to re-suspending sediments and contaminants, this work significantly alters the habitat by depositing dredged sediments into the aquatic environment, creating an underwater environment of sand dunes.

Between 1971 and 1974, significant work was carried out to deepen the Traverse du Nord Channel, southeast of Île d’Orléans, which led to the formation of sand dunes across some 12 km, stretching from the disposal site located south of Île Madame to the main juvenile feeding grounds located southeast of Île au Ruau. In total, more than 6.5 million m^3 were deposited between 1971 and 1974. It has been shown that the Atlantic Sturgeon tends to avoid deposit sites due to changes in the distribution and abundance of organisms that make up its diet. Sediments added annually at the Île Madame site through maintenance dredging (18,000 m^3/year) gradually move into the juvenile habitat. However, the Île Madame disposal site has not been used since 2009. The alternative for the moment would be to dump more sediment at another site further downstream, off the coast of Sault-au-Cochon, although no assessment of the impact on Atlantic Sturgeon has been done for this site. Another deposit site located off the coast of Cap-Saint-Ignace, used in the dredging of the Île aux Grues quay, is also part of the juvenile habitat. Recently, dredging has been done in the area near the Berthier-sur-mer quay. An inventory done as part of this project confirmed the presence of juveniles near the sediment disposal site.

Considering the importance of the transition zone in the St. Lawrence estuary as a juvenile breeding and feeding habitat, the impact of dredging on this habitat is considered a major threat to the survival and recovery of the Atlantic Sturgeon, St. Lawrence population.

Port development

Port maintenance, renovation and expansion projects are carried out regularly in the St. Lawrence estuary. These projects are likely to affect the Atlantic Sturgeon, particularly by invading the aquatic environment and altering the habitat. One feeding area for adults was also located in the Saint-Charles River estuary, in Quebec's port area. This should receive increased attention in the context of efforts to protect the habitat of the Atlantic Sturgeon.

Contamination

Contaminants found in the St. Lawrence River mainly originate from large urban and industrial areas but also from municipal discharges, agricultural activities and local industries, as well as dredging activities that re-suspend sediments and contaminants. Several studies have addressed contamination of various species of fish in the St. Lawrence. The results particularly show that such contaminants may affect the growth, reproduction and survival of fish. The synergistic effect of these contaminants may also increase their toxicity. No studies, however, have focused on the Atlantic Sturgeon.

Maritime accidents

The St. Lawrence–Great Lakes corridor is a major shipping channel through which petroleum products and other chemicals are transported. In the event of a spill, the entire ecosystem would be affected, as well as the Atlantic Sturgeon population, be it directly or indirectly. For example, in 1988, a Liberian ship, the Czantoria, hit the Ultramar quay in Saint-Romuald and tons of crude oil were spilled into the St. Lawrence. In 1999, the bulk carrier Alcor ran aground near the eastern tip of Île d'Orléans. While the vessel was being refloated, the Traverse du Nord was closed and several ships were left at anchor. Once the Traverse du Nord was re-opened, a collision between two ships was just narrowly avoided.

Climate change and variations in freshwater flow

Across the Estuary and Gulf of St. Lawrence, variations in physico-chemical parameters may affect various biological and ecological aspects of populations and communities. In particular, the impact that a variation in freshwater flow would have on the movement of the salt front may affect the extent of the habitat available for juveniles. In general, severe hypoxia could cause mass mortality or emigration of certain fish, as well as a decrease in biodiversity and ecosystem productivity. Recent findings also show acidification in the St. Lawrence (Dufour et al*.* 2010). The impact of these variations on the Atlantic Sturgeon, St. Lawrence population, is still unknown.

Threat assessment

In order to assess the threats that affect the Atlantic Sturgeon, these threats were classified in terms of probability of occurrence (known, likely, unlikely or unknown) and their level of impact (high, moderate, low or unknown) (Tables 2 and 3). This information was combined to prioritize threats (high, medium and low priority). This classification was peer-reviewed at the recovery potential assessment meeting. The cumulative effect of the various threats, however, was not taken into account.

Table 2. Definition of classes used to assess the probability of occurrence and level of impact of habitat threats

Probability of Threat Occurrence	
Known	This threat has been observed
Likely	There is more than a 50% chance that this threat will occur
Unlikely	There is less than a 50% chance that this threat will occur
Unknown	There are no data or information available indicating that this threat could occur

Level of Impact of the Threat	
High	The presence of the threat jeopardizes the survival or recovery of the species
Moderate	The presence of the threat is likely to jeopardize the survival or recovery of the species
Low	The presence of the threat is not likely to jeopardize the survival or recovery of the species
Unknown	There are no data or information available indicating that this threat could jeopardize the survival or recovery of the species

Table 3. Threat assessment

	Probability	Level of Impact	Priority
Dredging and sediment disposal	Known	Moderate	High
Port development	Likely	High	High
Contamination	Likely	Low	Low
Maritime accidents	Unlikely	High	Low
Climate change and variations in freshwater flow	Unknown	Unknown	Low

10. Quantify how the biological function(s) that specific habitat feature(s) provide to the species varies with the state or amount of the habitat, including carrying capacity limits, if any.

No information is available to specifically address this issue.

11. Quantify the presence and extent of spatial configuration constraints, if any, such as connectivity, barriers to access, etc.

There are no barriers to the free passage of Atlantic Surgeon in the St. Lawrence.

12. Provide advice on how much habitat of various qualities/properties exists at present.

See item 8.

13. Provide advice on the degree to which supply of suitable habitat meets the demands of the species both at present, and when the species reaches biologically-based recovery targets for abundance and range and number of populations.

One of the essential components for the survival and recovery of the Atlantic sturgeon, St. Lawrence population, is the presence of quality habitats for juvenile breeding and feeding. Work carried out in recent years has identified several areas corresponding to these needs. However, current knowledge is not sufficient to identify spawning grounds and to assess whether the area of currently-identified habitats is sufficient to meet the needs of the species in the future.

14. Provide advice on the feasibility of restoring habitat to higher values, if supply may not meet demand by the time recovery targets would be reached, in the context of all available options for achieving recovery targets for population size and range.

Ending sediment disposal resulting from maintenance dredging of the St. Lawrence Seaway at certain sites historically popular with the Atlantic Sturgeon, St. Lawrence population, should eventually allow for the natural recovery of these sites over time. However, we must ensure that depositing at alternative disposal sites does not have a negative impact on the Atlantic Sturgeon.

15. Provide advice on risks associated with habitat "allocation" decisions if any options would be available at the time when specific areas are designated as critical habitat.

The limited area of potential breeding grounds, juvenile habitat and summer feeding areas and fall migration sites of adults makes it currently impossible to exclude some parts as non-essential to the recovery of the species. Instead, efforts should be undertaken to ensure that they are clearly identified and are not damaged or destroyed.

16. Provide advice on the extent to which various threats can alter the quality and/or quantity of habitat that is available.

See item 9.

Scope for Management to Facilitate Recovery

17. Assess the probability that the recovery targets can be achieved under current rates of parameters for population dynamics, and how that probability would vary with different mortality (especially lower) and productivity (especially higher) parameters.

See item 5.

18. Quantify to the extent possible the magnitude of each major potential source of mortality identified in the pre-COSEWIC assessment, the COSEWIC Status Report, information from DFO sectors, and other sources.

The main source of mortality for the stock measuring between 100 and 150 cm is commercial fishing. The Atlantic sturgeon, St. Lawrence population, has been commercially exploited for its meat for decades. This fishery primarily targets juveniles and subadults aged between 7 and 18 years. Fisheries statistics indicate that since 2002, an average of 48 t or 3,600 Atlantic Sturgeon have been landed.

Regarding mortality due to bycatch in Canadian commercial fisheries, it remains negligible. According to data from DFO at-sea observers (1999-2011), there have only been a dozen or so reports of Atlantic Sturgeon captures during gillnet cod and flounder fishing. No sport fishing is practiced in Quebec, while only one permit was issued for Aboriginal fishing allowing for the capture of 16 individuals.

19. Quantify to the extent possible the likelihood that the current quantity and quality of habitat is sufficient to allow population increase, and would be sufficient to support a population that has reached its recovery targets.

See item 13.

20. Assess to the extent possible the magnitude by which current threats to habitats have reduced habitat quantity and quality.

See section on dredging and sediment disposal in item 9.

Scenarios for Mitigation and Alternative to Activities

21. Using input from all DFO sectors and other sources as appropriate, develop an inventory of all feasible measures to minimize/mitigate the impacts of activities that are threats to the species and its habitat (steps 18 and 20).

See next item.

22. Using input from all DFO sectors and other sources as appropriate, develop an inventory of all reasonable alternatives to the activities that are threats to the species and its habitat (steps 18 and 20).

To minimize and mitigate the impacts of activities that are threats to the Atlantic Sturgeon, mitigation measures and alternatives to activities are proposed (Table 4). Some have been identified using the generic mitigation measures for 19 Pathways of Effects, developed by DFO Fish Habitat Management (Coker et al. 2010). They were completed and peer-reviewed in the recovery potential assessment meeting.

Table 4. Mitigation measures and alternatives to activities

Threat	Mitigation Measures and Alternatives to Activities	Life Stage Improved
Fishery	Maintain current management measures and revise the TAC. Obtain environmental data (water level and flow) to assess their impact on Catch per Unit of Effort (CPUE).	Juveniles and subadults (7 to 18 years)
Dredging and sediment disposal	Assess the impact of dredging and disposal sites currently used in the juvenile habitat. Research other sites for the disposal of dredged sediments that would not impact the Atlantic Sturgeon. Examine the possibility of managing dredged sediments differently, including the addition of land-based sites.	Juvenile to adult
Port development	Ensure vigilance and protection of habitat for the Atlantic Sturgeon in the context of port maintenance, renovation and expansion projects.	Adults
Contamination	Promote better agri-environmental practices. Ensure effective treatment of municipal and industrial effluents. Develop bio-indicators for better monitoring.	All
Maritime accidents	Enforce rules in the shipping sector. Ensure the implementation of an effective system for responding to maritime accidents.	All

23. Using input from all DFO sectors and other sources as appropriate, develop an inventory of activities that could increase the productivity or survivorship parameters (steps 3 and 17).

See item 22.

24. Estimate, to the extent possible, the reduction in mortality rate expected by each of the mitigation measures in step 21 or alternatives in step 22 and the increase in productivity or survivorship associated with each measure in step 23.

The information needed to answer this question is not available.

25. Project expected population trajectory (and uncertainties) over three generations (or other biologically reasonable time), and to the time of reaching recovery targets when recovery is feasible; given mortality rates associated with specific scenarios identified (as above). Include scenarios which provide as high a probability of survivorship and recovery as possible for biologically realistic parameter values.

The forecasts presented in section 5 (Table 1) show that attaining the recovery target is more or less possible in the long term based on the variation in the number of fish that avoid being fished. A revision of the quota could help reduce the time required to attain the recovery target. However, it should be noted that we do not know the precise number of Atlantic Sturgeon that currently avoid being fished. It is possible that with the management measures in place, the number of Atlantic Sturgeon that avoid being fished is more than sufficient to reach the recovery target in forty or so years.

26. Recommend parameter values for population productivity and starting mortality rates, and where necessary, specialized features of population models that would be required to allow exploration of additional scenarios as part of the assessment of economic, social, and cultural impacts of listing the species.

As a first step, work should be done to develop a model for the Atlantic Sturgeon, St. Lawrence population.

Allowable Harm Assessment

27. Evaluate the maximum human-induced mortality which the species can sustain and not jeopardize survival or recovery of the species.

The values presented in section 5 (Table 1) show that reaching the recovery target with the current management measures (average harvest of 48 t/year or 3,600 individuals/year) is likely or at least possible. Adjustments to the management measures could help increase the likelihood of reaching the target or reducing the time without compromising the chances of recovery.

Sources of Uncertainty

Although significant efforts have been made in recent years to better understand the biology of the Atlantic Sturgeon, St. Lawrence population, there are still many gaps in our knowledge of this population. Moreover, many of the life-history parameters presented in this report are extrapolated from other populations of Atlantic Sturgeon or even other species of sturgeon. They should be used with caution. For years, too little information was collected on commercial fishing to estimate the abundance of the population. The lack of information on the productivity and age structure of this stock is also an important source of uncertainty.

Uncertainties also exist about the state of knowledge regarding the preferred habitat of the Atlantic Sturgeon, particularly in terms of the location of spawning grounds and their characteristics. It seems important to confirm and delineate potential spawning grounds through the observation of eggs and to research other spawning grounds. As for habitat-related threats, it is still difficult to quantify their impact and their cumulative effect on the population. The concentration of Atlantic Sturgeon in certain areas at certain stages of life could make them more vulnerable to certain threats. In general, gaining more extensive knowledge on the habitat of the Atlantic Sturgeon and the impact of habitat-related threats appears to be crucial to the implementation of appropriate mitigation measures.

SOURCES OF INFORMATION

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