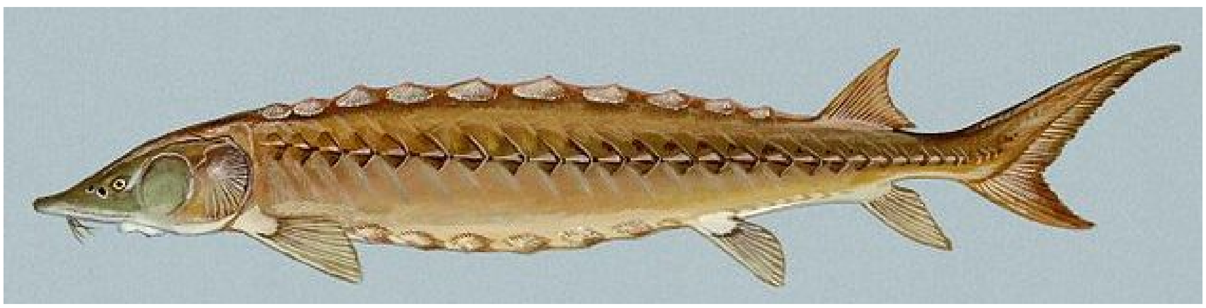
COSEWIC
Assessment and Status Report

on the

Shortnose Sturgeon
Acipenser brevirostrum

in Canada



SPECIAL CONCERN
2015

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2015. COSEWIC assessment and status report on the Shortnose Sturgeon *Acipenser brevirostrum* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 48 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Previous report(s):

COSEWIC 2005. COSEWIC assessment and update status report on the shortnose sturgeon *Acipenser brevirostrum* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 27 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Dadswell, M.J. 1980. COSEWIC status report on the shortnose sturgeon *Acipenser brevirostrum* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 18 pp.

Production note:
COSEWIC acknowledges Dr. Matthew K. Litvak for writing the status report on the Shortnose Sturgeon, *Acipenser brevirostrum* in Canada, prepared under contract with Environment Canada. This status report was overseen and edited by Dr. Rick Taylor, Co-chair of the COSEWIC Freshwater Fishes Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur L'esturgeon à museau court (*Acipenser brevirostrum*) au Canada.

Cover illustration/photo:
Shortnose Sturgeon — Cover image by Couch, Karen J., U.S. Fish and Wildlife Service [Public domain], via Wikimedia Commons.

Catalogue No. CW69-14/427-2015E-PDF
ISBN 978-0-660-02603-9

COSEWIC
Assessment Summary

Assessment Summary – May 2015

Common name
Shortnose Sturgeon

Scientific name
Acipenser brevirostrum

Status
Special Concern

Reason for designation
This large-bodied, slow-growing, late-maturing fish is found only in a single river estuary system in Canada where spawning fish aggregate in a single known location. Although there are no imminent threats toward the species, its limited distribution makes the species vulnerable to becoming Threatened if conditions thought to negatively impact it (variable flow patterns, pollution, bycatch in commercial fisheries, and poaching) are not managed effectively.

Occurrence
New Brunswick, Nova Scotia

Status history
Designated Special Concern in April 1980. Status re-examined and confirmed in May 2005 and in May 2015.

COSEWIC
Executive Summary

Shortnose Sturgeon
Acipenser brevirostrum

Wildlife Species Description and Significance

The Shortnose Sturgeon is one of five species of sturgeon in Canada. It has an elongate body, which is cylindrical at the abdomen, a heterocercal tail, and stiff paired fins. The Shortnose Sturgeon has four barbels that hang down in front of the mouth and is distinguished from the co-occuring Atlantic Sturgeon by a relatively short snout. The mouth is ventrally located and is protrusible. The Shortnose Sturgeon is a small-sized sturgeon growing to a maximum fork length of about 125 cm and may live to be over 60 years old.

Distribution

The Shortnose Sturgeon is distributed across 25 rivers along the east coast of North America from New Brunswick south to Florida, but in Canada it is known only from the Saint John River system in New Brunswick.

Habitat

The Shortnose Sturgeon spawns in fast flowing water over boulder and gravel substrates. In the Saint John River, Shortnose Sturgeon are suspected to spawn within a 10 km stretch below the Mactaquac Dam, which is 138 km upstream from the mouth of the Saint John River estuary. One major overwintering site has been confirmed in Canada; adults overwinter in fast moving water at the junction of the Kennebecasis and Hammond rivers at depths of 3 to 6 m. Little is known about the juveniles, but they have been caught between 35 and 120 km upstream from the mouth of the Saint John River estuary. Mean size of juveniles is smaller in upriver samples suggesting that younger fish use more upstream habitats.

Biology

Shortnose Sturgeon are relatively long-lived fishes; the oldest female and male Shortnose Sturgeon recorded from the Saint John River were 67 and 32 years of age, respectively. The largest recorded specimen captured in the Saint John River was 23.6 kg with a fork length of 122 cm. Males are generally lighter than females at the same lengths. The weight-length relationship is allometric, with larger fish being relatively heavier than smaller fish. The growth rate of adults is between 490-540 g per year. Males and females first become reproductive at 12 and 18 years old, respectively. Females produce up to 200,000 eggs and appear to spawn every three years. Shortnose Sturgeon spawn from mid-April to June and the eggs are demersal and adhesive. As is typical for sturgeons, survival through the early life history stages has been identified as a key factor controlling recruitment.

Population Sizes and Trends

There has been no total population estimate of the lower Saint John River estuary population of Shortnose Sturgeon since the 1970s when a population size of 18,000 adult fish was estimated over the 1973-1977 time period. Recent work on the overwintering population at the confluence of the Hammond and Kennebecasis rivers, however, suggests that the numbers at this site have been stable since 2005; abundance ranged between 3,852 and 5,222 fish greater than 50 cm in length. Catch per unit effort, using 5-6” stretched-mesh gill nets, at this site has not changed appreciably over the past 26 years. By contrast, some Aboriginal traditional knowledge suggests that there has been a decline in abundance across the entire river since the Mactaquac Dam was completed in 1968.

Threats and Limiting Factors

There are no well-documented imminent threats towards the Shortnose Sturgeon, but several potential threats exist. The Mactaquac Dam prevents the potential for migration and spawning upstream of the dam. There is currently no effective way to allow passage of Shortnose Sturgeon over this dam. The dam controls water flow and, therefore, some aspects of habitat availability and quality including water temperature. The Saint John River is a highly developed area with residential and industrial activities all impacting water quality. Because Shortnose Sturgeon are long-lived, bottom-dwelling fish and consume prey living in the sediments, they are exposed to contaminants in both sediments and the prey items. Shortnose Sturgeon are subject to by-catch in the Gaspereau, American Shad, American Eel and Atlantic Sturgeon fisheries. They are also caught in a recreational fishery, but the minimum size for retention (120 cm) protects the majority of the population. Muskellunge, an invasive, predatory fish species in the Saint John River, may prey upon Shortnose Sturgeon juveniles.

Protection, Status, and Ranks

The Shortnose Sturgeon was assessed as a species of Special Concern in Canada in 1980 and reassessed as such in 2005. The Shortnose Sturgeon was listed as Special Concern under Schedule 1 of the Canadian *Species at Risk Act* (SARA) in 2009 and under New Brunswick's SARA in 2013. Fisheries and Oceans Canada is currently developing a management plan for Shortnose Sturgeon as required under Canada's SARA. Recreational fishing activities on the river are regulated; the Maritime Provinces Fishery Regulations (SOR/93-55) Section 97 includes size restrictions for retention, and gear and seasonal closures. Angling closures are in effect for all non-tidal waters frequented by the Shortnose Sturgeon. The Shortnose Sturgeon has been listed as Endangered by the *Endangered Species Act* in the United States since March 1967. The Shortnose Sturgeon has had IUCN Red Book Status since 1996, when it was assessed as Vulnerable, and is listed on Appendix 1 of CITES.

TECHNICAL SUMMARY

Acipenser brevirostrum

Shortnose Sturgeon — Esturgeon à museau court

Range of occurrence in Canada (province/territory/ocean): New Brunswick (Saint John River and estuary) and Nova Scotia (Minas Basin).

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2008) is being used) Determined by calculating the average age of mature fish (see Table 3 in Dadswell 1979).	20.1 years
Is there a continuing decline in number of mature individuals? Appears stable in some areas (overwintering habitat)	Unknown
Estimated percent of continuing decline in total number of mature individuals Appears stable in some areas (overwintering habitat)	Unknown
Percent change in total number of mature individuals over the last 10 years Last population size estimate for entire river was in 1979; therefore, changes in total abundance are unknown. There has been little change in numbers at the one confirmed overwintering site over the past 10 years.	Unknown
Projected percent change in total number of mature individuals over the next 10 years, or 3 generations.	Unknown
Percent change in [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. Some ATK suggests that a decline may have occurred since completion of the Mactaquac Dam (1968).	Unknown
Are the causes of the decline clearly reversible and understood and ceased? No detectable decline at one overwintering site. If ATK suggestion of decline is correct, causes are not understood.	NA
Are there extreme fluctuations in number of mature individuals?	Unknown, but probably not

Extent and Occupancy Information

Estimated extent of occurrence Saint John River, estuary and adjacent lands only. If the record from the Minas Basin (Dadswell *et al.* 2013) represents a Saint John River fish, the EO would be approximately 14,576 km² of which about 3,550 km² encompasses aquatic habitat.	6,532 km²

Index of area of occupancy (IAO) (Always report 2x2 grid value). (based on estimates of known or suspected spawning areas downstream of Mactaquac Dam to about Fredericton. If spawning occurs as far downstream as Oromocto, the IAO would be 144 km^2. Known or suspected overwintering areas would generate an IAO of 4-40km^2).	~80 km^2
Is the population severely fragmented? Occurs only in the Saint John River in Canada, but may be more than one spawning site in this large system. Genetic information suggests that there is little migration among rivers across the North American range.	No
Number of locations Spawning may be limited to one or a few areas near the downstream end of the Mactaquac Dam. A single major overwintering site (where large numbers of fish aggregate) has been identified, but others, less well understood, exist within the Saint John River system.	Probably 1-2 and likely fewer than 10
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence? The construction of the Mactaquac Dam in the 1960s (within 2 generations of this population) fragmented this river and possibly interfered with the distribution and abundance of Shortnose Sturgeon upstream of the dam.	Unknown, probably not
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy? The construction of the Mactaquac Dam in the 1960s (within 2 generations of this population) fragmented this river and possibly interfered with the distribution and abundance of Shortnose Sturgeon upstream of the dam.	Unknown, probably not
Is there an [observed, inferred, or projected] continuing decline in number of populations? Potential population structure within the Saint John River area is unknown.	Probably not
Is there an [observed, inferred, or projected] continuing decline in number of locations?	Unknown, probably not
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? Increased flooding activity since the 1960s may continually degrade habitat (stranding, reduced substrate stability, siltation, scouring).	Possibly
Are there extreme fluctuations in number of populations?	Unknown
Are there extreme fluctuations in number of locations?	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Are there extreme fluctuations in index of area of occupancy?	Unknown

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Total Unknown but ~18,000 (95% CI 7,200 – 28,880) mature fish in entire lower Saint John River estimated in 1970s by Dadswell (1979) Population size at one known overwintering site between 3,852-5,222 over the last seven years (all fish > 50 cm total length, 2005 - 2011)	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]. See discussion in Population trends and abundance	Unknown

Threats (actual or imminent, to populations or habitats)

No imminent threats. Lower level threats include: Damming and water regulation By-catch fin commercial Gaspereau, American Shad, American Eel and Atlantic Sturgeon fisheries Recreational fishery (essentially a catch and release fishery because only fish larger than 120 cm fork length can be kept—a size that exceeds that of most Shortnose Sturgeon. Some hooking mortality is likely associated with the catch and release fishery) Compromised water quality (from industrial pollution, agricultural runoff, forestry and pulp and paper mills, municipal waste water) **Potential threats** Invasive species Sea level rise from global warming increasing water levels and promoting further seawater intrusion.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? US populations are Endangered	Endangered
Is immigration known or possible?	Not known, unlikely
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada?	Probably
Is rescue from outside populations likely? Populations are depressed outside Canada and there is low inferred (from genetic data) movement among populations	No

Data Sensitive Species

Is this a data sensitive species? Areas of concentration of adults during overwintering	Yes

Status History

COSEWIC: Designated Special Concern in April 1980. Status re-examined and confirmed in May 2005 and in May 2015.

Status and Reasons for Designation:

Status: Special Concern	**Alpha-numeric code:** Not applicable
Reasons for designation: This large-bodied, slow-growing, late-maturing fish is found only in a single river estuary system in Canada where spawning fish aggregate in a single known location. Although there are no imminent threats toward the species, its limited distribution makes the species vulnerable to becoming Threatened if conditions thought to negatively impact it (variable flow patterns, pollution, bycatch in commercial fisheries, and poaching) are not managed effectively.	

Applicability of Criteria

Criterion A: Not applicable as abundance trends are unknown.
Criterion B: Not applicable. Comes close to meeting Endangered for B2a as IAO (< 500 km²), and the number of known spawning locations (< 5) are below thresholds, but no other sub-criteria apply (e.g., no evidence of continuing decline in habitat quality, area, or number of mature individuals).
Criterion C: Not applicable. Exceeds thresholds.
Criterion D: Not applicable. Although the estimated number of spawning locations (< 5) is under the threshold for Threatened, there is no imminent threat that could make the species susceptible to becoming at least critically endangered over a short period of time.
Criterion E: Not applicable as data necessary for analysis are not available.

PREFACE

Since publication of the last COSEWIC Status Report on the Shortnose Sturgeon in 2005, research indicates that there is little gene flow between the Saint John population and the other 18 Shortnose Sturgeon genetically distinct populations along the east coast of North America. An overwintering site was discovered at the junction of the Kennebecasis and Hammond rivers in the Saint John River and confirmed through video observations. Fish overwintering at this site migrated upriver in early spring to a spawning site below the Mactaquac Dam at river kilometre 138. Further, recent work modelling time of hatching and time of reproduction from larvae caught below the Mactaquac Dam suggests that Shortnose Sturgeon spawn from April to June in the Saint John River. A study examining the cause of death of larvae caught in D-frame nets suggested that up to 25% died prior to collection, perhaps owing to environmental changes as a result of flow manipulation at the Mactaquac Dam. Shortnose Sturgeon forage heavily on benthic invertebrates throughout their life history until late fall, which is later than previously acknowledged. Gastric flushing and stable isotope analysis suggested that Shortnose Sturgeon in the Kennebecasis River and Long Reach contained benthic invertebrates from both shallow and deep habitats. Recent work on the overwintering site discovered at the confluence of the Kennebecasis and Hammond rivers suggests that the population in this region has been stable (3,500-5,800) over a seven-year period. There is still no information available on the possibility of individuals, or their attributes, living above Mactaquac Dam.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2015)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada — Environnement Canada
Canadian Wildlife Service — Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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2015

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific name: *Acipenser brevirostrum* Lesueur, 1818

Common names: Shortnose Sturgeon, Shortnosed Sturgeon and Little Sturgeon (Saint John River, NB), Pinkster and Roundnoser (Hudson River, NY), Bottlenose or Mammose (Delaware River), Salmon Sturgeon (Carolinas), Soft-shell or Lake Sturgeon (Altamaha River) (Dadswell *et al.* 1984) and Esturgeon à museau court.

<u>Taxonomy:</u>

Class: Osteichthyes

Subclass: Actinopterygii

Infraclass: Chondrostei

Order: Acipenseriformes

Family: Acipenseridae

Genus: Acipenser

Species: Acipenser brevirostrum

Maliseet name: Buzgus

Morphological Description

The Shortnose Sturgeon is a relatively small-bodied sturgeon with a maximum reported total length of 143 cm (Birstein 1993). The body of the Shortnose Sturgeon is elongate and cylindrical in the abdomen and tail, but somewhat depressed anterior of the pectoral girdle (Figure 1). The Shortnose Sturgeon is a heavily armoured fish with five rows of bony scutes (also called plates or bucklers), an inferior elongated protrusible wide mouth, four barbels anterior to mouth on the ventral surface of the rostrum, small eyes, and spiracles. The head is somewhat short and highly variable in shape (e.g., the head is more prominent in younger fish). The caudal peduncle is narrow, with the dorsal fin posterior to the paired pelvic fins. The caudal fin is heterocercal with a prominent long upper lobe and a short and broad lower lobe. The pectoral fins are large and relatively stiff. The first pectoral fin ray is thick and ossified. The body has no scales, but has minute denticles.

Figure 1. Lateral view of adult Shortnose Sturgeon. The distance between the white arrows represents fork length (121 cm), the distance between the white arrow at the snout and the angled black arrow represents total length (135 cm).

The skeleton of the Shortnose Sturgeon is cartilaginous with the exception of the presence of some true bone in the skull, jaws, and pectoral girdle. The notochord is unconstricted (Schmitz 1998), and the Shortnose Sturgeon possesses a swim bladder that is joined to the esophagus (physostomous condition). The esophagus is muscular and acts like a crop or gizzard to crush invertebrates. The Shortnose Sturgeon has a spiral valve for an intestine, similar to that found in fishes of the class Chondrichthyes (sharks, skates, rays, and ratfishes; Vladykov and Greeley 1963).

Shortnose Sturgeon possess 22-29 gill rakers on the first arch, 38-42 rays on the dorsal fin, 19-22 rays on the anal fin, 8-13 dorsal scutes, 22-33 lateral scutes, 7-11 ventral scutes, at least two plates between the dorsal fin and the caudal fulcrum, and usually one or two rows of pre-anal fin plates (Vladykov and Greeley 1963; Scott and Crossman 1973).

The colour of the Shortnose Sturgeon is variable. Fish have a dark, mottled chain-like patterning on the dorsal surface of the head over an olive-brown or green background. The lateral surfaces are lighter moving ventrally, with the ventral surface white in colour (Figure 1). The dorsal scutes are lighter brown while the lateral, ventral, and pre-anal scutes have a yellow tinge. The leading edges of fins are lighter and sometimes white.

The Atlantic Sturgeon (*Acipenser oxyrhynchus*) is most often found in association with the Shortnose Sturgeon, including within the Saint John River system. Mature adults are easily distinguished by size, as Atlantic Sturgeon are much larger than Shortnose Sturgeon. The largest recorded Atlantic Sturgeon was caught on the Saint John River; it was 4.59 m and weighed 364.9 kg (Vladykov and Greeley 1963). When juvenile Atlantic Sturgeon are caught with similar sized juvenile and adult Shortnose Sturgeon, discrimination between species is possible using the following characters: 1) proboscis of the young Atlantic Sturgeon is much longer and more tapered than that of the Shortnose Sturgeon (Figure 2); 2) relative mouth size of the Shortnose Sturgeon (>62% of the interorbital width) is larger than that of the Atlantic Sturgeon (<55% of the interorbital width) (Figure 2); 3) 19-22 anal fin rays in the Shortnose Sturgeon, whereas there are 25-30 anal fin rays present in the Atlantic Sturgeon; and 4) 19-22 dorsal fin rays for Shortnose Sturgeon and 38-46 for Atlantic Sturgeon (Vladykov and Greeley 1963; Scott and Crossman 1973; Scott and Scott 1988). Although Gorham and McAllister (1974) indicated that bony plates occurred above the anal fin in Atlantic Sturgeon and not Shortnose Sturgeon, which could be used as a potential key character for identification, they are sometimes lacking in Atlantic Sturgeon and this trait is, therefore, not recommended as a diagnostic feature. Atlantic Sturgeon adults tend to lose the point on their snout as they age and their head shape becomes more similar to the Shortnose Sturgeon, which may cause confusion for recreational anglers that catch the larger Atlantic Sturgeon.

Figure 2. View of mouths of juvenile Shortnose Sturgeon (left) and Atlantic Sturgeon (right). Shortnose Sturgeon mouths are relatively larger (wider) than those of the Atlantic Sturgeon especially when compared to interorbital width.

Shortnose Sturgeon larvae are approximately 7-11 mm total length when they hatch (Buckley and Kynard 1981). The larvae possess a large yolk-sac with a yolk plug in the spiral valve, which is released when feeding begins. They are considered “direct developers”, i.e., they do not metamorphose from a larval to juvenile body form. Larval Shortnose Sturgeon resemble the juvenile/adult form at approximately 20-25 mm in total length (Bain 1997).

Although Shortnose Sturgeon typically spawn before Atlantic Sturgeon, there is potential for temporal overlap in spawning period. The similarity between the species, particularly during the early life history stages, may cause difficulties in assessment and description of spawning sites and timing and therefore reproductive success and recruitment.

Population Spatial Structure and Variability

The Shortnose Sturgeon in Canada is found only within the Saint John River system in New Brunswick (NB, Figure 3). This river system is complex and fragmented by dams. Shortnose Sturgeon are distributed throughout the river from below the Mactaquac Dam at river kilometre (RKM) 138 to the lower estuary. Unfortunately, little is known about whether or not this species exists, or did exist, above the Mactaquac Dam. Raymond (1905) described reports in the 1600s of "sturgeon" being plentiful near Meductic, which is 55 km upstream of the Mactaquac Dam, but Shortnose and Atlantic sturgeon were not distinguished at that time. Further, the historical spawning grounds of Shortnose Sturgeon may have been at Grand Falls, about 100 km upstream of the current location of Mactaquac Dam (Shortnose Sturgeon Review Team 2010).

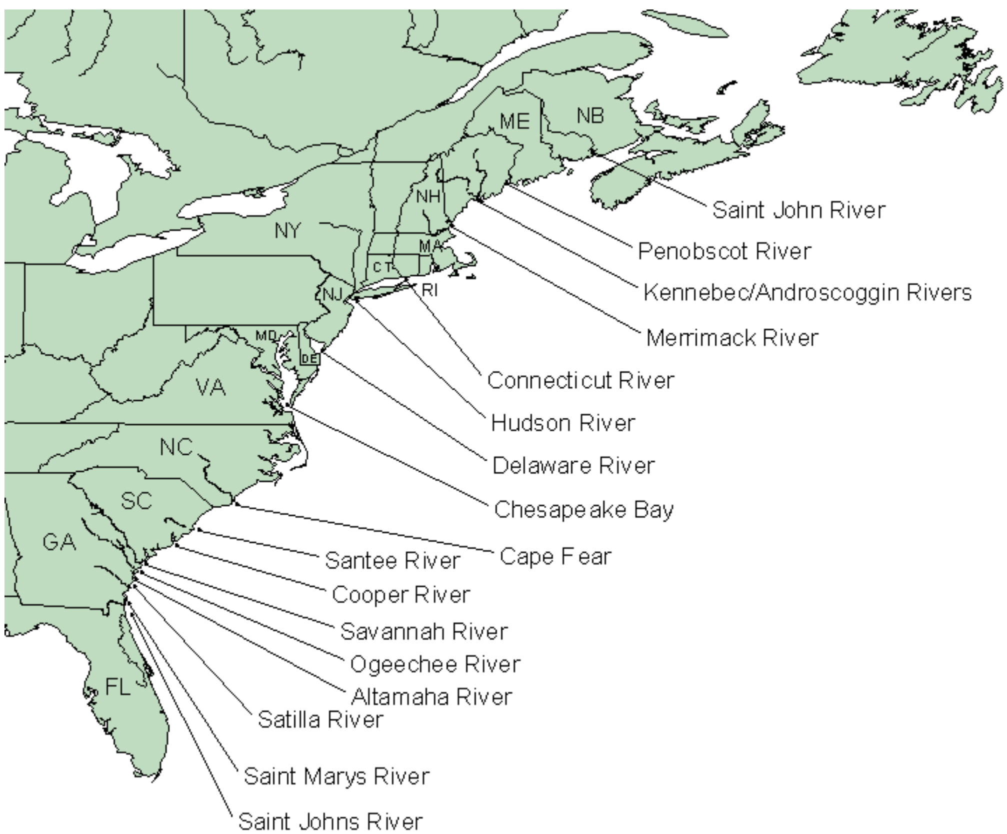

Figure 3. Distribution of the Shortnose Sturgeon in 17 of the 19 distinct population segment rivers in North America. Note that individual rivers within the ACE basin (Ashepoo, Combahee and Edisto Rivers) and Winah Bay, both in South Carolina and that also contain Shortnose Sturgeon, are not shown (see Table 1).

Evidence from mitochondrial and microsatellite DNA studies (see below) suggests that the Shortnose Sturgeon in Canada is genetically distinct from all other populations along the east coast of North America (see review by Shortnose Sturgeon Review Team 2010; DFO 2014a). Indeed, a variety of studies suggest that there is little mixing of Shortnose Sturgeon from the Saint John River with those other populations from the Gulf of Maine. By contrast, Wirgin *et al.* (2010) examined mitochondrial DNA variation in Shortnose Sturgeon and found that there was at least some mixing of fish among some areas. This was not surprising as recent telemetry work in Maine rivers shows that there is more movement among them than previously thought (Fernandes *et al.* 2010; Zydlewski *et al.* 2011; Dionne *et al.* 2013). Wirgin *et al.* (2010), however, also found that the Saint John River population shared few mitochondrial haplotypes with sturgeon from Maine rivers, and that the Saint John River population was significantly different ($p < 0.0001$) from the 18 other areas sampled. Female-mediated gene flow between the Penobscot and Saint John rivers was low and was estimated to be 1.9 migrants/generation and 2.1 migrants/generation by the Φ_{ST} and coalescent-based approaches, respectively (i.e., many fewer than one fish per year; Wirgin *et al.* 2010). When data from 11 microsatellite DNA loci were examined, Shortnose Sturgeon from the Saint John River, while still genetically distinct from 17 other localities examined, tended to be most similar to proximate rivers tributary to the Gulf of Maine, which may reflect historical rather than contemporary movements (DFO 2014a).

Designatable Units

The only known population of this species in Canada occurs in the Saint John River. It is genetically distinct from populations in the US (see above). Based on the Canadian National Freshwater Biogeographic Zone (NFBZ) classification adopted by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), the Canadian population is found within the Maritimes NFBZ. Given the existence of the Shortnose Sturgeon within a single NFBZ and the lack of evidence (genetic, behavioural, or life-history) of divergence within this area, the species is treated as a single designatable unit.

Special Significance

The Shortnose Sturgeon is one of 25 extant species within the Acipenseridae, derivatives of a relatively ancient lineage of ray-finned fishes, all of which are listed as Vulnerable through Endangered by the International Union for the Conservation of Nature (IUCN). The Shortnose Sturgeon is one of five species of sturgeon in Canada. The Saint John River, NB, Shortnose Sturgeon population is the only occurrence of this species in Canada and the most northern population in its North American range. The Shortnose Sturgeon in Canada is recognized as one of 19 “distinct population segments” defined for the global population of the species (National Marine Fisheries Service 1998; DFO 2014a). It is likely that the Shortnose Sturgeon was once, and unknowingly, exploited commercially to some extent in the Atlantic Sturgeon fishery before recognition of the Shortnose Sturgeon as a distinct species in 1950s (Liem and Day 1959).

DISTRIBUTION

Global Range

Nineteen genetically distinct Shortnose Sturgeon populations have been identified across 25 river systems along the eastern coastline of North America (National Marine Fisheries Service 1998), from Florida to NB (Figure 3). Populations range from 100 adults in Merrimack River, Massachusetts, to an estimated ~38,000 mature adults in the Hudson River, NY (Table 1).

Table 1. List of distinct population segments identified by the National Marine Fisheries Service (1998).

Distinct Population Segments	Rivers Inhabited by Shortnose Sturgeon
Saint John	Saint John River (New Brunswick, Canada)
Penobscot	Penobscot River (Maine)
Kennebec System	Sheepscot, Kennebec, and Androscoggin Rivers (Maine)
Merrimack	Merrimack River (Massachusetts)
Connecticut	Connecticut River (Massachusetts and Connecticut)
Hudson	Hudson River (New York)
Delaware	Delaware River (New Jersey, Delaware, Pennsylvania)
Chesapeake Bay	Chesapeake Bay, Potomac River (Maryland and Virginia)
Cape Fear	Cape Fear River (North Carolina)
Winyah Bay	Waccamaw, Pee Dee and Black Rivers (South Carolina, North Carolina)
Santee	Santee River (South Carolina)
Cooper	Cooper River (South Carolina)
“ACE” Basin	Ashepoo, Combahee and Edisto Rivers (South Carolina)
Savannah	Savannah River (South Carolina, Georgia), and hatchery stocks
Ogeechee	Ogeechee River (Georgia)
Altamaha	Altamaha (Georgia)
Satilla	Satilla River (Georgia)
St. Marys	St. Marys River (Florida)
St. Johns	St. Johns River (Florida)

Canadian Range

In Canada, the Shortnose Sturgeon is found in the Saint John River system in NB, including a major tributary—the Kennebecasis River (Figure 4). Shortnose Sturgeon have been known to move from natal rivers to coastal environments (Dadswell *et al.* 1984; Kynard 1997; Savoy 2004; Fernandes 2010; Zydlewski *et al.* 2011; Dionne *et al.* 2013). Although the extent of coastal movement for the Saint John River Shortnose Sturgeon is currently unknown, a single individual of unknown population origin was caught in a fishing weir in the Minas Basin, NS, during the summer of 2013 (Dadswell *et al.* 2013). Tag returns from Dadswell's (1979) study suggested, however, that there is little emigration from this population. Additionally, from 1998 to the present day, no ultrasonically tagged Shortnose Sturgeon has been observed leaving the Saint John River system (N = 64, M. Litvak unpubl. data).

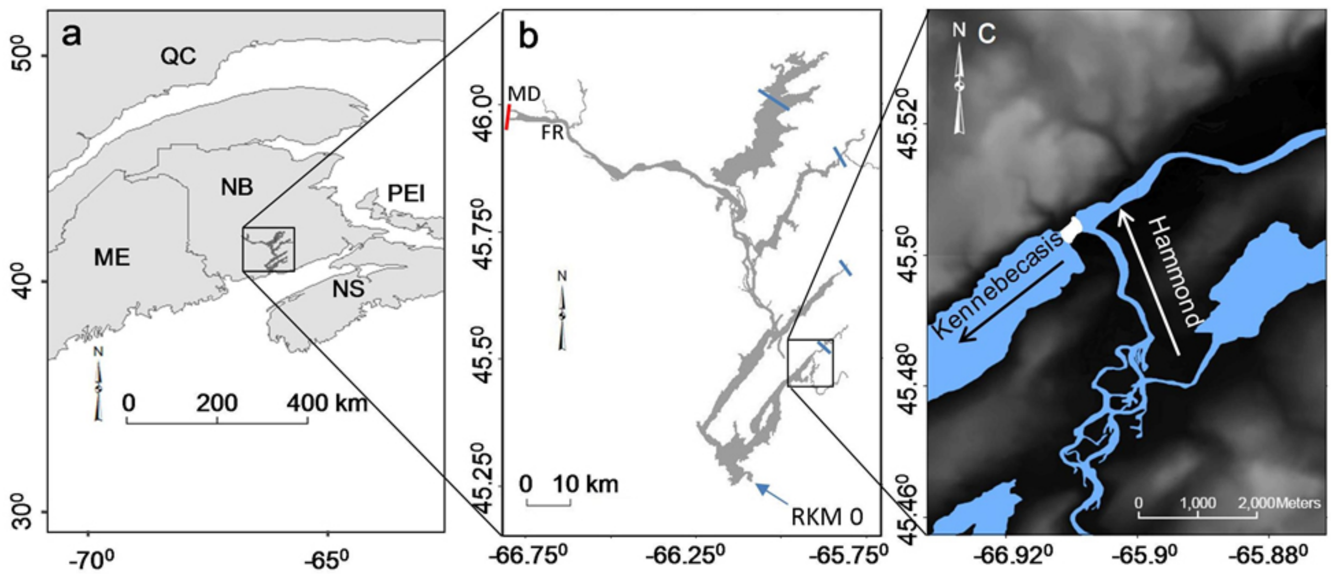

Figure 4. (a) The Atlantic coast, showing the Maritime Provinces of Canada, Québec, and Maine, (b) The Lower Saint John River where MD = approximate locations of Mactaquac Dam at river kilometre (RKM) 138, FR = Fredericton, BB = Belleisle Bay, OR = Oromocto, GA = Gagetown, GL = Grand Lake, WA = Washademoak, LR = Long Reach, SB = South Bay, SJ = Saint John, and the upstream boundaries of field sampling conducted by Dadswell (1979) as represented by the blue bars, (c) The confluence of the Kennebecasis-Hammond rivers (flow of the rivers is indicated by arrows). The white area on (c) is the one confirmed overwintering site for the Shortnose Sturgeon (modified from Usvyatsov *et al.* 2012a).

Extent of Occurrence and Area of Occupancy

Estimates of extent of occurrence and the index of the area of occupancy are 6,532 km^2 and 80 km^2, respectively (Appendix 1, 2). The IAO was based on using a 2x2 km^2 grid overlain upon mainstem river areas from the downstream end of Mactaquac Dam to about Frederiction that are suspected spawning areas (based on tracking mature adults and high catches of eggs and larval sturgeon—see **Reproduction**). If the spawning area extends down as far as Oromocto, the IAO would be 144 km^2 (Appendix 2). Using known or suspected overwintering areas as the most limiting habitat would generate an IAO of 4-40 km^2 (see Figure 4)**.**

Search Effort

The Shortnose Sturgeon was first discovered in the Saint John River in 1957 (Liem and Day 1959). The most extensive study to date was conducted between 1973 and 1977 by Dadswell (1979), who used gill nets to catch, measure, and mark 4,178 Shortnose Sturgeon throughout the lower portion of the Saint John River including various tributaries, lakes and the estuary (Figure 4). Dadswell's program included sampling in the Jemseg, Oromocto, Canaan, Kennebecasis and Hammond rivers as well as Grand Lake, Washademoak Lake, Otnabog Lake, Belleisle Bay and Darlings Lake (Figure 4). There are also a number of reports of Shortnose Sturgeon observed as by-catch in fisheries in the Saint John Harbour (Dadswell 1979; Litvak pers. obs.). Dadswell (1979) found large numbers of fish throughout the lower Saint John River with overwintering concentrations found in Grand Lake, Gagetown, Washademoak, Belleisle Bay, Long Reach, South Bay and the Kennebecasis River. More recent work began in 1998 focused on the mainstem of the Saint John and Kennebecasis rivers and sampled fish with gill nets (stretched mesh sizes between of 11 and 15 cm) and by angling using barbless circle hooks baited with worms (Litvak, unpubl. data). Li *et al.* (2007) and later Usvyatsov *et al*. (2012a) confirmed, through videosampling, the presence of an overwintering site with a large number of Shortnose Sturgeon at the confluence of the Hammond and Kennebecasis rivers (Figure 4). Weights and lengths of fish have also been taken since 1998 during catch and release fishing derbies that occur each fall in the Kennebecasis River. Unfortunately, no search effort has been made above Mactaquac Dam, but it is possible that a now land-locked population of Shortnose Sturgeon exists above this dam (see **Population Spatial Structure and Variability**). For instance, a landlocked population of Shortnose Sturgeon occurs upstream of the Holyoke Dam (river kilometre, RKM, 140) on the Connecticut River (Taubert 1980). In addition, there has been no concerted effort to assess the occurrence or likelihood of additional spawning areas.

HABITAT

Habitat Requirements

The Shortnose Sturgeon has been described as anadromous or amphidromous, i.e., making only short forays to sea (Kynard 1997). In the southern portions of their range, they concentrate in estuaries and are anadromous, but in the more northern regions they concentrate in fresh water and are amphidromous (Kieffer and Kynard 1993). In the Saint John River, adults are found both in fresh water and in areas under tidal influence (Dadswell 1979, 1984; Dadswell *et al.* 1984). Shortnose Sturgeon from the Saint John River have been caught along the coast, but this is rare (Dadswell *et al.* 1984, 2014). They are generally restricted to brackish and freshwater sections of their natal rivers. Tagging by

Dadswell (1979) and sonic tracking (Litvak unpubl. data) research on the lower Saint John River population below Mactaquac Dam suggests that fish remain in their natal river and estuary. This is similar to results of studies on US populations (Buckley and Kynard 1985; Hall *et al.* 1991; Kieffer and Kynard 1993; O'Herron *et al.* 1993; Kynard 1997).

Overwintering habitat was thought to occur in either the lower reaches of the Saint John River in deep, brackish (~10 ppt) water, or further upriver for fish destined to spawn that spring (Dadswell 1979) (multi-stage spawning migration—see below). Even sites further upriver are under tidal influence, but salinity is low (~10 ppm). Kynard (1997) suggested that Shortnose Sturgeon adults in reproductive condition are widely separated from those adults that will not spawn the following spring. Litvak (unpubl. data), however, used sonic tracking of tagged fish to show that many of the fish that overwinter in the lower reaches of the Saint John River still undergo a spawning migration in the spring.

One confirmed overwintering site for the Saint John River population is at the junction of the Hammond and Kennebecasis rivers (tributaries of the lower Saint John River), which has been used consistently since it was discovered in 2005 (Li *et al.* 2007; Usvyatsov *et al.* 2012a). An underwater videocamera system combined with Kriging (a spatial statistical approach) was used to confirm, count and map the distribution of Shortnose Sturgeon at this site (Li *et al.* 2007; Usvyatsov *et al.* 2012a). This site was not one of the more saline habitats used by wintering adults reported in the 1970s (Dadswell 1979) and is about 2 ha in size, 3-6 m deep, 0 ppt salinity, with high water velocities, and sandy substrates. No fish tagged in this region have gone to other potential overwintering areas identified by Dadswell (1979). Usvyatsov (pers. comm. 2013) ultrasonically tagged Shortnose Sturgeon further upriver during the winter of 2011 and tracked fish to an area in the Saint John River near Gagetown 5 km upstream of an overwintering site identified by Dadswell (1979).

Spawning is thought to occur in areas with high water velocity (also see **Reproduction** section below). Water velocity at spawning sites in the US populations ranged between 0.4 and 0.7 m/s, and were generally over gravel and/or boulder substrate and at water temperature that ranged between 8^{o}C and 13^{o}C (Buckley and Kynard 1985; Kieffer and Kynard 1996; Kynard 1997; National Marine Fisheries Service 1998; Shortnose Sturgeon Status Review Team 2010). Shortnose Sturgeon tagged in the Kennebecasis River were found to migrate upstream and spawn in the spring below the Mactaquac Dam at RKM 138; the only known spawning site of the Shortnose Sturgeon population in the Saint John River (COSEWIC 2005; Litvak unpubl. data). The importance of this area as a spawning site was confirmed by Usvyatsov *et al.* (2012b, 2013a), who caught thousands of larvae using D-frame nets set across the river at 12.5 and 17 km downstream of the dam during 2008-2011. The water velocity at the upstream transect ranged between 0.7 and 2.6 m/s. The specific area(s) in which the Shortnose Sturgeon spawn within this reach below the dam has not yet been identified and, therefore, the river velocities during reproduction have not been characterized for the Saint John River Shortnose Sturgeon.

Dadswell (1979) reported that the youngest juvenile fish caught on the Saint John River other than larvae was 2 years old. With the exception of larvae, there are no recorded captures of fish aged 1 year or younger and therefore no information on habitat use by post-larval juvenile fish (i.e., under about 45 cm fork length) in the Saint John River. Dadswell (1979) found that older juveniles were distributed in the riverine habitat from Oak Point (RKM 35) to Fredericton (RKM 120), but were concentrated between Evandale (RKM 45) and Oromocto (RKM 90). Mean size of juveniles was smaller in the upper reaches compared with downriver and most fish were associated with sand, mud, and clay substrates and higher salinities with sand and/or mud mixture (Dadswell 1979; Dadswell *et al.* 1984). Bain (1997) suggested that juveniles reside upstream of the salt-water wedge in the Hudson River, NY. Crossman and Litvak (unpubl. data) tracked six juvenile Shortnose Sturgeon throughout the year and found that juvenile Shortnose Sturgeon spent time at the salt/fresh water interface (see also Bain 1997).

Habitat Trends

Historically, urban development, forestry, and agricultural and industrial effluents contribute to siltation and pollutant loads in the Saint John River (see **Threats and Limiting Factors**). A late summer die-off of sturgeon and other species was observed in 1974 in a eutrophic area of the estuary with a high density of vegetation (Dadswell *et al.* 1984). It was assumed that this mortality was caused by oxygen depletion due to vegetative blooms resulting from elevated nutrient levels (Dadswell *et al.* 1984). While the Saint John River water quality has improved somewhat since serious problems were noted in the 1970-80s, especially downstream of Fredericton, it is still rated only as “fair” or “usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels” (e.g., see Environmental Reporting Series 2007, New Brunswick Watersheds, Saint John River; Kidd *et al.* 2011). Also, there are currently over 200 dams or water control structures, more than 100 sources of municipal wastewater and ~70 more non-municipal effluent sources (Kidd *et al.* 2011). The completion of the Mactaquac Dam in 1968 cut off the upper portions of the Saint John River, which eliminated the possibility of even transient use of that area by Shortnose Sturgeon. New Brunswick Power is embarking on a study to determine the future of the Mactaquac Dam with a decision to be made by 2016 (NB Power 2014). The fate of this dam, to be either decommissioned or refurbished, and the potential impacts as a result of either of these choices will be important to the status of the Shortnose Sturgeon population in the Saint John River. In addition, and for unknown reasons, there appears to have been an increase in the frequency and magnitude of large floods in the Lower Reach of the Saint John River since about 1968 (Cunjak *et al.* 2011), but the impacts of changes in flood behaviour in this area on Shortnose Sturgeon are unknown.

BIOLOGY

Life Cycle and Growth

The oldest Shortnose Sturgeon caught on the Saint John River was a female estimated to be 67 years old (Dadswell 1979). Sturgeon can be aged by counting the alternating translucent (winter) and opaque (summer) annuli of a cross section through the "bony" first pectoral fin ray (Currier 1951; Collins and Smith 1996). The validity of this technique has come into question for Lake Sturgeon (*Acipenser fulvescens*), however, because the use of pectoral spines generally underestimates age as fish approach maturity (Bruch *et al.* 2009). The best way to accurately estimate the age of sturgeon is through destructive sampling and examining sagittal otoliths (Bruch *et al.* 2009).

The largest recorded specimen caught on the Saint John River was a female weighing 23.6 kg with a fork length (FL) of 122 cm (Dadswell 1979). Subsequently, a fish of 124.6 cm FL has been captured (Litvak, unpubl. data). Litvak (unpubl. data) reported a size range of between 50 and about 125 cm FL for fish caught in the Saint John River between 1998 and 2002 (Figure 5). The length-weight relationship for Saint John River Shortnose Sturgeon has remained stable over 25 years and the relationships between weight (W) and FL are: Log_{10} W = 3.21 (Log_{10} FL) – 5.45 (n=2890, $p<0.001$, r^2=0.99) for the 1970s time period (Dadswell 1979), and Log_{10} W = 3.11 (Log_{10} FL) – 5.36 (n = 860, $p<0.001$, r^2=0.87) for the 1998-2001 time period (Litvak, unpubl. data, Appendix 3). Both these relationships suggest an allometric relationship between weight and length; i.e., longer fish are relatively heavier than shorter fish.

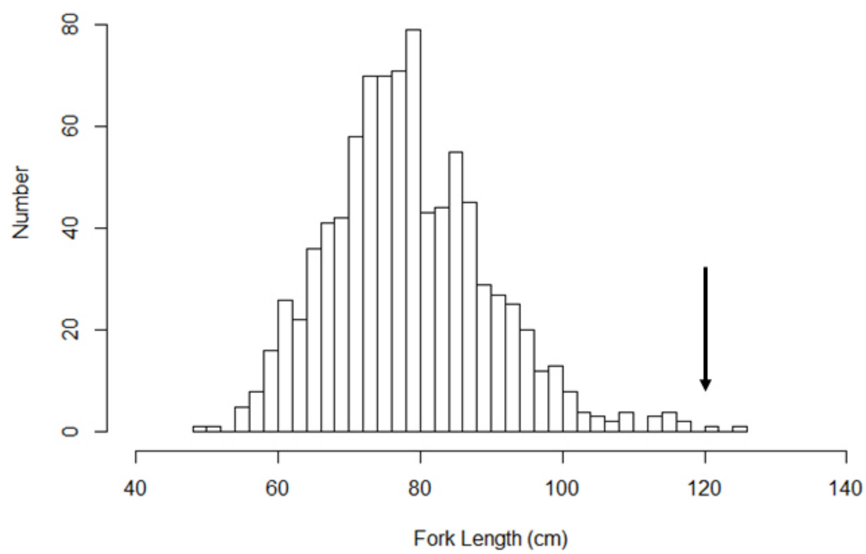

Figure 5. Fork length frequency distribution of Shortnose Sturgeon caught in the Saint John River using a 12.5 cm stretch gill net, 1998-2002. The current size limit for retention in the recreational fishery is any fish that is at least 120 cm fork length (arrowhead).

Dadswell (1979) found no difference in weight between males and females at similar sizes. Litvak (unpubl. data), however, sexed 40 adults; 14 females and 26 males of known weight and length. The weight-length relationship (Appendix 3) of the Shortnose Sturgeon population suggests that males are significantly lighter than females at an equivalent length (*t*-test of residuals, df=38; p<0.05, Litvak, unpubl. data). Although no external sexually dimorphic characters have been discovered to date, the Shortnose Sturgeon is sexually dimorphic in terms of weight.

Dadswell (1979) estimated growth rates from 106 tagged and recaptured fish between 1973 and 1978. During this period Shortnose Sturgeon were found to gain 490 grams per year (1.32 g/day). Shortnose Sturgeon in the Saint John River (1998-2002) had an average annual mean weight gain of 540 g (gaining 1.48 g per day $\pm$1.2 SE) or a specific growth rate (following Ricker 1975) of 0.017% ± 0.067 per day (COSEWIC 2005). Von Bertalanffy growth curves for weight were determined for females and males of the Saint John population to be $W_t(\text{female})=24.8(1-e^{-0.042(t-0.8)})^3$ and $W_t(\text{males})=13.9(1-e^{-0.063(t-.51)})^3$, respectively (Dadswell 1979). Corresponding von Bertalanffy L_∞ was estimated to be 127.0 cm for females and 108.7 cm for males (Dadswell 1979).

Reproduction

Age and size at maturity

Dadswell (1979) reported that Shortnose Sturgeon matured at between 50 and 80 cm FL. Fifty percent of male and female Shortnose Sturgeon reach maturity at ages of 12.4 and 17.2 years old, respectively (Dadswell 1979). The generation time was estimated by calculating the average age of mature fish in the 1975 sample of Dadswell (1979) and was 20.1 years (*N*, adjusted for effort gillnet selectivity, = 10,008, range of ages = 14 - 62 years of age). Males first matured at about 12 years and the oldest male found was 32 years of age. Females first matured at about 18 years and the oldest female sampled was 67 years of age (Dadswell 1979).

Sexual Differentiation

Anatomical differentiation of Shortnose Sturgeon gonads in Saint John River fish occurs by 6 months of age (Flynn and Benfey 2007). The sex determining mechanism is still unknown, but based on gynogenetic studies it appears that females are not the homogametic sex (Flynn *et al.* 2006).

Eggs

The Shortnose Sturgeon is a highly fecund, iteroparous (spawning more than once in its lifetime) fish, producing many demersal and adhesive eggs (27,000-208,000; Dadswell 1979). Egg production is directly related to female size; each female on average produces 11,600 eggs per kg of fish (Dadswell 1979). Eggs are black to brown and are approximately 3.5 mm in diameter at release and expand to 4 mm after fertilization and adhesion to the substrate (Kynard 1997). There are no published accounts of spawning behaviour in captivity or in the wild.

Reproductive migration

Reproductive adults in the Saint John River, like other Shortnose Sturgeon populations, undergo a spawning migration in the spring. These spawning migrations occur when the river temperature reaches 8-9^{o}C. Dadswell (1979) originally suggested that Shortnose Sturgeon spawned between Oak Point and Fredericton in the Saint John River and in the Kennebecasis River. This was given credence by the capture of three larvae at the Oromocto shoals at RKM 105 (Taubert and Dadswell 1980). No eggs and larvae, however, have been caught in the Kennebecasis River. Dadswell (1984) later suggested that another spawning site occurred between Fredericton and the Mactaquac Dam. Kynard (1997) predicted that they would spawn at or near the Mactaquac Dam because almost every other Shortnose Sturgeon population that occurs on large dammed rivers spawn at the first river blockage. Sonically tagged Shortnose Sturgeon have been tracked to just below the Mactaquac Dam (RKM 138; Litvak unpubl. data) as Kynard (1997) hypothesized. These fish were tagged the previous fall, overwintered in the Kennebecasis River that is in the lower reaches of the Saint John River, and travelled rapidly upstream during the spring.

From 1998-2002, 14 larvae were caught using a towed and weighted bongo net 2-4 km below the dam. In 2003, using D-frame drift nets, hundreds of eggs and larvae were caught all within 5 km of the dam (Litvak, unpubl. data). Usvyatsov *et al.* (2012b, 2013a) used the D-frame technique and set-out a series of transects along the river below the dam and caught 6,900 wild Shortnose Sturgeon larvae during 2008-2011. Dadswell (1979) suggested that Shortnose Sturgeon spawn from mid-May to mid-June. By contrast, Usvyatsov *et al.* (2012b) used Hardy and Litvak's (2004) data on effect of temperature on growth of Shortnose Sturgeon to develop a Gompertz growth regression model to back-calculate predicted date of hatching. Date of reproduction was determined in similar fashion; they ran a series of experiments to examine the effect of temperature on development rate prior to hatching to develop a second Gompertz growth model to determine the date of reproduction in the wild. Larvae collected during 2008-2010 were used to estimate that the peak spawning period occurred in late April and early May.

Shortnose Sturgeon may vary in their pre-spawning migrations (Kieffer and Kynard 1993). Kieffer and Kynard (1993) suggested three patterns: 1) a short 1-step migration in the spring only a few weeks before spawning; 2) a long 1-step migration in the late winter/early spring before spawning; 3) a short 2-step migration composed of a longer fall migration putting the fish closer to the spawning habitat for overwintering and then a short migration as in 1). Dadswell (1984) suggested that Shortnose Sturgeon spawned in deep water channels and that they engage in the two-step spawning migration-strategy (i.e., 3 above). Litvak (unpubl. data) used sonic tags and has only observed fish employ strategy 2), but this may be a reflection of the segment of the Saint John River population that was studied.

Dadswell (1979) suggested that adults remain upriver until a 2-3^{o}C decline in water temperature in the fall stimulates a downstream migration. Kynard (1997) indicated that adults disperse downriver after spawning. Litvak (unpubl. data) has found that sonically tagged spawning fish have used both strategies in the Saint John River.

<u>Sex ratio and spawning periodicity</u>

The sex ratio in the Saint John River is approximately 2:1, females to males (Dadswell 1979). The oldest male recorded from the Saint John River was 32 years old (Dadswell 1979). This finding, in conjunction with samples of juveniles indicating a 1:1 ratio of females to males, suggests that males do not live as long as females (Dadswell 1979). Males and females become reproductive later than those from southern populations (Dadswell 1984). Little information exists on spawning periodicity, but it has been suggested that females spawn less frequently, once every 3-5 years, than males, which spawn every other year (Dadswell 1979). In more southern populations, Shortnose Sturgeon of both sexes tend to spawn more often (Dasdwell *et al.* 1984). Males from the Saint John River held in captivity do produce semen annually (P. Soucy, pers. comm. 2003; B. Hogans, pers. comm. 2014).

Larval Behaviour

Usvyatsov *et al.* (2013a) deployed D-framed nets in transects across the river channel to examine larval distribution and timing of larval downstream migration. While they did not find a consistent pattern of larval distribution across the channel, they did find a consistent, significant preference for nighttime (dusk to dawn) over daytime dispersal. This is consistent with two lab studies on Shortnose Sturgeon larval dispersal (Richmond and Kynard 1995; Parker 2007) that suggested a preference for nighttime dispersal. Generalized linear models were used to examine the timing and extent of larval migration in the Saint John River during the study period. Logistic models incorporating water temperature and Mactaquac Dam discharge provided good predictions of the timing of larval migration. The probability of larval presence was highest when water temperature reached 15^{o}C. At this temperature, larvae were predicted to disperse when nighttime total dam discharge was 20×10^6 to 30×10^6 m^3. The extent of larval migration was described using negative binomial models, which suggested that dam discharge and transect location significantly influenced the number of drifting larvae.

Survival

Shortnose Sturgeon have a large body size, a tough leathery skin, and bony scutes that should lower mortality rates from predation during the juvenile and adult stages. Early life mortality in sturgeon is not well understood, yet is most likely the most important determinant of year-class strength. For instance, recent analysis suggests that for three species of North American sturgeon, Atlantic Sturgeon, White Sturgeon (*A. transmontanus*), and Shortnose Sturgeon, population dynamics are most sensitive to changes in survival during the first few years of life (Gross *et al.* 2002). Usvyatsov *et al.* (2013b) found a large portion of drifting larvae caught in the nets were damaged or dead. They examined the degree of decomposition to estimate the source of this mortality and found that 4-25% of the larvae caught in their D-frame nets were dead prior to capture. The cause(s) of this mortality are not known, but it may be caused by nightly reductions in flow at the Mactaquac Dam. Nighttime discharge in regulated rivers is often lowered due to reduced electricity demand. This may result in stranding of embryos and larvae, which can kill or damage them if they are in areas higher than the water level after flow reduction. Lower flow rates may also cause the larvae to drift at lower velocities, which may result in three outcomes: (1) larvae remain hidden in the substrate for a longer time, waiting for flood events that will increase nighttime discharge; (2) larvae may have to spend a longer time drifting in order to reach their nursery grounds (constant drifting distance); and/or (3) larvae may settle closer to the dam than they would have under natural conditions (constant drifting time). The three outcomes may be deleterious due to starvation, increased predation risk, and settling in a suboptimal habitat, respectively (Usvyatsov *et al.* 2013a).

Hardy (2000) examined growth and starvation resistance of larval Shortnose Sturgeon in response to delayed feeding. He found starvation affected growth and survival, yet despite the degree of starvation, larvae were able to resume growth and experience high survivorship following feeding. Specific growth rates (dry weights) directly following feeding were highest among the groups of fish that were denied food for the longest time periods. This suggests that Shortnose Sturgeon possess a compensatory mechanism in response to starvation. A point-of-no-return (i.e., when starved fish could no longer resume growth) of 56% weight loss, however, was reached 41 d post-fertilization, which is long compared to many other fish species with *r*-selected life-history patterns. This work suggests that starvation, depending on food availability, may not be a major determinant of early life history survival, suggesting that future work should focus on mortality from predation. Low survival of larval sturgeon may be the major factor affecting long-term health of populations and may represent recruitment bottlenecks (Gross *et al.* 2002; Smith *et al.* 2002).

Physiology and Adaptability

Temperature effects

Shortnose Sturgeon growth rates vary inversely with latitude; fish from northerly populations grow more slowly than fish from southern populations (National Marine Fisheries Service 1998). This has been related to higher water temperatures and a longer growing season in southern environments rather than a genetic attribute of specific populations (Dadswell *et al.* 1984). Hardy and Litvak (2004) reared Shortnose and Atlantic sturgeon at different water temperatures (13, 15, 18, 21^{o}C) after hatching and measured yolk utilization rate and efficiency, maximum standard length, survival and development of the escape response (a characteristic swimming behaviour in response to being attacked by predators). Newly hatched Atlantic Sturgeon were smaller in size, more efficient at utilizing yolk (incorporating yolk to body tissue) and reached developmental stages sooner than Shortnose Sturgeon reared at the same temperatures (13 and 15^{o}C). Within each species, decreasing temperature delayed yolk absorption, escape response initiation, time to reach maximum size, and time to 100% mortality. Yolk utilization efficiencies and the size of larvae, however, were independent of rearing temperature for both species. These results suggest that even though an increase in temperature drives metabolic processes and speeds up development, these two species are still efficient at transferring yolk energy to body tissues. The lower efficiencies experienced by larval Shortnose Sturgeon may reflect differences in yolk quality between the two species or the Atlantic Sturgeon's innate higher conversion efficiencies.

Salinity tolerance

Embryos and larvae of the Shortnose Sturgeon lack tolerance to salinity, but tolerance improves with age (Jenkins *et al.* 1993). Under estuarine-like salinity conditions (< 15 ppt), 22 day old Shortnose Sturgeon experienced 90% mortality at 11 ppt, but 39 day old fish experienced 100% survival after 96 hr at 7 ppt (Jenkins *et al.* 1993). Fish as old as 330 days experienced 100% mortality at 30 ppt, but survived well at 20-25 ppt (Jenkins *et al*. 1993). Jarvis *et al.* (2001) examined the effect of salinity on growth of Shortnose Sturgeon produced from Saint John River broodstock and grown in culture. They raised juveniles (mean weight 273 g) at four salinities (0, 5, 10, and 20 ppt) for 10 weeks at 18^{o}C. Weight gain and feed conversion rate decreased with increasing salinity. Fish reared at 0 ppt salinity showed significantly more weight gain and a higher feed conversion rate than the fish raised at all other salinities. Fish reared at 20 ppt exhibited the poorest growth. Shortnose Sturgeon in the Saint John River, however, become more tolerant of salinity as they age and do occur in estuarine regions of the Saint John River (Dadswell 1979). Ziegeweid *et al.* (2008) confirmed Dadswell's (1979) observation because they found that there was an interaction between temperature and salinity during Shortnose Sturgeon growth experiments. Survival of juveniles decreased with increasing temperature and salinity, but tolerance of these factors increased with body size (Ziegeweid *et al.* 2008). Similarly, Penny and Kieffer (2014) examined oxygen consumption and haematology of juvenile (200-300 g wet weight) Saint John River Shortnose Sturgeon during an acute 24 hour saltwater challenge. They found that all fish survived in the brackish water and full seawater treatments, but also that cortisol levels in fish in the full strength seawater treatment increased significantly as did plasma protein levels. They suggested that juvenile Shortnose Sturgeon in the Saint John can withstand changes in salinity that would be associated with the extreme tides in the estuary but that they are not ideally suited to inhabit saline environments indefinitely.

Exercise physiology

Kieffer *et al.* (2001) examined the physiological responses to exercise of Atlantic Sturgeon and Shortnose Sturgeon. They measured the rates of oxygen consumption and ammonia excretion in both species and a variety of physiological parameters in both muscle (e.g., lactate, glycogen, pyruvate, glucose and phosphocreatine concentrations) and blood (e.g., osmolality and lactate concentration) in juvenile Shortnose Sturgeon following 5 min of exhaustive exercise. In both species, oxygen consumption and ammonia excretion rates increased approximately twofold following exhaustive exercise. Post-exercise oxygen consumption rates decreased to control levels within 30 min in both sturgeon species, but post-exercise ammonia excretion rates remained high in Atlantic Sturgeon throughout the 4 h experiment. Resting muscle energy metabolite levels in Shortnose Sturgeon were similar to those of other fish species, but the levels decreased only slightly following the exercise period and recovery occurred within an hour. Under resting conditions, muscle lactate levels were low (<1 μmol g^{-1}) but they increased (to approximately 6 μmol g^{-1}) after exercise, returning to control levels within 6 h. Unlike similarly stressed teleost fishes, such as the Rainbow Trout (*Oncorhynchus mykiss*), plasma lactate levels did not increase substantially and returned to resting levels within 2 hours. Plasma osmolality was not significantly affected by exercise in Shortnose Sturgeon. Taken together, these results suggest that Shortnose and Atlantic sturgeon do not exhibit the physiological responses to exhaustive exercise typical of other fish species. They may possess behavioural or endocrinological mechanisms that differ from those of other fishes and that lead to a reduced ability to respond physiologically to exhaustive exercise.

In terms of swimming capability, Shortnose Sturgeon are considered to be relatively poor swimmers relative to many teleosts (Deslauriers and Kieffer 2011). They do, however, compensate by holding station in close contact with the substrate at high water flow levels (Adams *et al.* 1999, 2003). Deslauriers and Kieffer (2012) examined the effects of temperature on young of the year Saint John Shortnose Sturgeon swimming capacity and endurance. They found that temperature (5-25^{o}C treatment groups) did affect swimming capacity (U_{crit}), but did not have an effect on swimming endurance.

<u>Oxygen tolerance</u>

Collins *et al.* (2000) suggested that poor water quality may affect production of Shortnose Sturgeon juveniles and that low oxygen levels in juvenile feeding areas, in particular, may become a recruitment bottleneck. Secor and Nicklitschek (2001) suggested that absence or reduced populations of both Shortnose Sturgeon and Atlantic Sturgeon were a result of low oxygen levels. They also hypothesized that the apparent recovery of Shortnose Sturgeon in the Hudson River was due to a return to normal oxygen levels. Baker *et al.* (2005) examined the response of juvenile Saint John Shortnose Sturgeon to acute hypoxic conditions. They found that Shortnose Sturgeon were able to offset acute environmental hypoxia to some extent through hyperventilation.

Dispersal and Migration

<u>Early life history dispersal</u>

Yolk sac larvae of the Shortnose Sturgeon are photonegative and seek cover (Kynard and Horgan 2002). Shortnose Sturgeon from the Hudson and Connecticut rivers migrated over a three-day period (Kynard and Horgan 2002) after yolk-sac absorption. Kynard and Horgan (2002) suggested that Shortnose Sturgeon may engage in a two-step migration during the early life history stage: 1) a brief active/passive larval movement, and 2) an active early juvenile downstream migration to nursery areas. Shortnose Sturgeon larvae from the Saint John River appear to engage in an active/passive migration during their early life history stages (Usvyatsov *et al.* 2012b, 2013a). They drift mainly at night and unlike that reported by Kynard and Horgan (2002) will do so during the yolk-sac stages.

Juvenile dispersal

Juvenile sturgeon usually move upstream during the summer months and downstream in the fall and winter (Dadswell *et al.* 1984; Hall *et al.* 1991). Ultrasonically-tagged juvenile Shortnose Sturgeon (<56 cm) engaged in summer migrations in response to changing river temperatures in the Savannah River (Collins *et al.* 2000). They moved upriver when temperatures exceeded 22^{o}C and moved downriver into the Savannah Harbour when temperatures were below this threshold. Collins *et al.* (2000) did not observe any diel migration of juvenile Shortnose Sturgeon. Preliminary work on the Saint John River population also found little difference in diel activity; juveniles did not occur in shallow areas of the reaches in which they were observed (Crossman and Litvak unpubl. data).

Adult movements based on genetic approaches

Dadswell *et al.* (1984) and Kynard (1997) both suggested that some adults move out of their natal rivers and that this may facilitate gene flow between populations. Although there was a higher probability of emigration in the northern populations, gene flow was viewed as low compared to other anadromous species and it is generally considered that all localities should be managed as discrete populations (Grunwald *et al.* 2002; Quattro *et al.* 2002). This was recently confirmed for the Saint John River population (Wirgin *et al.* 2010; Shortnose Sturgeon Status Research Team 2010—see also **Population Structure and Variability**).

Diet

In general, sturgeons are bottom, suctorial feeders. Shortnose Sturgeon juveniles feed mainly on crustaceans and insects and the adults in the lower Saint John estuary eat mainly molluscs, the Soft Shell Clam, *Mya arenearia,* in particular (Dadswell 1979; Pottle and Dadswell 1979; Dadswell *et al.* 1984). According to Dadswell (1979), foraging decreased substantially once water temperatures fell below 10°C, and in the freshwater part of the lower Saint John River no foraging occurred throughout the winter, but finer-scale spatial and seasonal changes in diet composition were not studied. Usvyatsov *et al.* (2012c) used gastric flushing and sampled more fish from more areas than had been done previously and found that Shortnose Sturgeon foraged heavily into late November at temperatures between 8-10^{o}C. At freshwater sites, Usvyatsov *et al.* (2012c) found much higher occurrences of Amphipoda, Ephemeroptera, Trichoptera, and Diptera in the diet than has been described previously for sturgeon from the Saint John River and in South Carolina (Dadswell *et al.* 1984). In a saline environment, Dadswell *et al.* (1984) reported bivalves to be the main prey items, but also high occurrences of Amphipoda, Isopoda, and Diptera. The differences in Shortnose Sturgeon gut contents between the Usvyatsov *et al.* (2012c) study and previous reports of the Saint John River and other rivers may be due to differences in composition of the benthos or differences in study methods. The gut contents of sturgeon captured in Long Reach and the Kennebecasis River sites in the summer and late fall contained both groups of benthos, which suggests that the fish moved between the deep, saltwater areas and shallower, freshwater areas. In contrast, in early fall, fish contained fewer bivalves and more Chironomidae and Isopoda, which possibly indicates a higher use of shallow areas.

Interspecific Interactions

There is potential for competition for food between sympatric Shortnose Sturgeon and Atlantic Sturgeon, particularly during the juvenile stages (Bain 1997). Analysis of gut contents of juvenile Shortnose Sturgeon and Atlantic Sturgeon captured in the Saint John River system by Pottle and Dadswell (1979) revealed that similar organisms were found in both species.

If competitive ability varies within and among fish species, growth may be affected as more aggressive individuals or species may acquire a larger portion of available food (Beacham 1993; Cutts *et al.* 1998; McCarthy 2001). Giberson (2004) found that when juvenile Shortnose Sturgeon and Atlantic Sturgeon are grown together, the foraging activity and growth rates of Shortnose Sturgeon were depressed. Giberson (2004) examined the importance of food availability on growth rate and change in the coefficient of variation in weight of juvenile Atlantic Sturgeon and Shortnose Sturgeon grown in mixed and single species groups. Atlantic Sturgeon held in mixed and single species treatment groups exhibited significantly higher specific growth rates (%/d) than did Shortnose Sturgeon at two food availability levels (3% body weight per day [BW/d]) or 1% BW/d). Shortnose Sturgeon held in mixed species treatment groups had significantly lower growth rates than those held in single species groups at both food levels. Atlantic Sturgeon growth rates were unaffected by the presence of Shortnose Sturgeon at both high and low food availability levels. These results suggest that Atlantic Sturgeon may be a superior competitor compared to Shortnose Sturgeon when either habitat or food is limited.

There are no records of Shortnose Sturgeon being preyed upon in the Saint John River. Yellow Perch (*Perca flavescens*), however, are potential predators of larvae (Dadswell 1984). Muskellunge (*Esox masquinongy*), a recent invader to the Saint John River system (Kidd *et al.* 2011), could eat juvenile Shortnose Sturgeon. Seals are present in the Saint John River and are potential predators of adults (Dadswell 1984).

Behaviour/adaptability

Although sturgeon species are derived from one of the most ancestral lineages within the ray-finned fishes (Bemis *et al.* 1997), they may have a more complex system of social behaviours and interactions than previously thought. The juvenile stage of the sturgeon life history is particularly important because survival at these stages directly affects the number of individuals that are recruited into the adult population (Gross *et al.* 2002; Smith *et al.* 2002). Giberson (2004) paired Atlantic Sturgeon and Shortnose Sturgeon in contest competition experiments. She found that Atlantic Sturgeon were the first to start foraging, and engaged in more foraging events. Even when paired with a larger Shortnose Sturgeon, Atlantic Sturgeon started foraging earlier and initiated more foraging events.

Shortnose Sturgeon appear to be social fish; they exhibit shoaling behaviour a few days after hatching (Litvak pers. obs.). This shoaling behaviour only exists when there is a flow of water; larvae form tight well-spaced schools to swim against the current. This schooling behaviour breaks down when there is no flow. Scuba-diving observations of adults in the wild suggest that they exhibit shoaling behaviour (L. Sabatis pers. comm. 2013). Shortnose Sturgeon have been observed to form tight and dense aggregations at the Saint John River overwintering site (Li *et al.* 2007; Usvyatsov *et al.* 2012a).

Dadswell (1979) observed that when groups of tagged fish were recaptured using a gill net they were often recaptured one or more years later with many of the same fish. He calculated that the probability of this event occurring at random was 1.88×10^{-24} (Dadswell 1979). These observations suggest that Shortnose Sturgeon may be social and potentially pair bond as adults (Dadswell 1979). If Shortnose Sturgeon and Atlantic Sturgeon partition available resources, it is likely based on species-specific preferences for different salinities (National Marine Fisheries Service 1998). Giberson and Litvak (unpubl. data), however, developed an angular flume to provide individual sturgeon with a choice of different flow rates. In all instances Shortnose Sturgeon chose to swim in higher water velocities than did the Atlantic Sturgeon, suggesting that differences in flow preference may also play a role in habitat partitioning.

POPULATION SIZE

Sampling Effort, Methods and Abundance

<u>Mark and recapture approaches:</u>

There have been two mark and recapture population size estimates on the Saint John River, both below the Mactaquac Dam. Dadswell (1979) conducted his study during the period of 1973 – 1977 on the mainstem of the Saint John River below Oromocto, and in tributaries including Grand Lake, Washademoak Lake, Belleisle Bay, and the Kennebecasis River from Darlings Lake to the main stem of the Saint John River. He estimated population size to be approximately 18,000 adults (±30% SE; 95% confidence intervals (Manly 1984) 7,200 – 28,880 adults) in the lower Saint John River. Litvak (unpubl. data) also conducted a mark-recapture population estimate between 1998 and 2004 focusing largely on the Kennebecasis River below Darlings Lake using a Jolly Seber approach (Krebs 1999) and estimated that there were 2,068 fish (95% CI: 801 to 11,277) in this tributary of the Saint John River. The wide confidence intervals of the population size estimate for the Kennebecasis River may be a function of immigration from and emigration to other tributaries of the Saint John River. While this approach is informative it probably does not provide a precise enough estimate to be useful in tracking population changes over time. Although the studies used similar approaches they are not comparable because they were not conducted on the same spatial scale.

Dadswell and Litvak (unpubl. data) compared catch-per-unit-effort (CPUE) data for fish caught in the Kennebecasis River using gill nets with mesh of similar size caught in the summer during each study. They found that there was no significant difference in CPUE (*t*-test, df = 46, p = 0.83) between the two studies in this region of the river over a 26 year period. Mean CPUE was 0.027 and 0.024 fish per metre of net per hour, for Dadwell's (1979) and Litvak's (unpubl. data) studies, respectively.

<u>Video sampling approaches:</u>

Shortnose Sturgeon aggregate in the winter and this provides an excellent opportunity to derive better estimates of their population size (Li *et al.* 2007). Li *et al.* (2007) used a sonic tracking technique to follow Shortnose Sturgeon to their overwintering ground in 2005. They drilled holes in the ice and used an underwater videocamera to determine the number of fish below each hole. This information was used to map the distribution and abundance of the fish at the overwintering site at the confluence of the Kennebecasis and Hammond rivers. They used both general linear models and ordinary Kriging to determine habitat type and population size, respectively. They estimated that there were 4,836 (95% CI = 4,701 – 4,971) adult Shortnose Sturgeon at this 2 ha site. The bottom at this location was a flat, sandy substrate. This population size was within the confidence intervals established with the tagging study of the Kennebecasis River described above, but with a very high level of precision, suggesting that this approach is better to assess changes in population size in Shortnose Sturgeon in the Saint John River.

Usvyatsov *et al.* (2012a) repeated this work to determine if there was consistent use of this site. They also added lasers to the underwater video approach to determine fish size and to provide a crude approximation of age class structure. They found that, like Li *et al.* (2007), there were high concentrations of Shortnose Sturgeon overwintering at this site, ranging from 3,852-5,222 in 2009 and 2011 (Table 2). The fork length ranged from 54 to 119 cm. The sizes of these fish suggest that they would range from 11 to 57 years of age (Usvyatsov *et al.* 2012a).

Table 2. Comparison of three semivariogram models (exponential, spherical and Gaussian), applied to 2009 and 2011 and only the exponential applied to the 2005 calculation of overwintering density data, showing model parameters (nugget, sill and range) and the resulting overall abundance (± standard error) (from Li *et al.* 2007 and Usvyatsov *et al.* 2012).

Model	Year	Minimized SS	Nugget	Sill	Range	Abundance	SE
Exponential	2005	NA	0	0.2	10	4836	69
Exponential	2009	0.001	0.015	0.059	26.000	4085.3	50.5

Model	Year	Minimized SS	Nugget	Sill	Range	Abundance	SE
	2011	0.004	0.069	0.152	25.999	3852.1	92.9
Spherical	2009	0.001	0.017	0.048	45.416	4769.2	48.7
	2011	0.002	0.054	0.136	31.777	5163.8	90.8
Gaussian	2009	0.001	0.023	0.044	26.000	4450.3	48.1
	2011	0.002	0.069	0.120	15.370	5222.4	90.3

Angling:

A mean number of 144 (SE = 7.8) fishers participated in the Kennebecasis River fishing derby tournament conducted annually since 1998. On average, they caught 0.36 (SE = 0.06) fish per angler per year over the 6 h tournament. The mean size of the fish caught by anglers was 76.7 cm FL (SE $\pm$ 2.1, M. Litvak, unpubl. data).

FLUCTUATIONS AND TRENDS

No direct comparisons can be made between the mark-recapture estimates of Dadswell (1979) and Litvak (unpubl. data) as they were on different spatial scales. The similar CPUE, the same weight-length relationships, and growth rates between the two studies suggest, however, that the Saint John River population has not changed appreciably over the 25 year period between these studies (approximately one generation). The number of Shortnose Sturgeon overwintering in the Kennebacasis River has also not varied much over the seven year study period (i.e., about 3,800 to 5,200 fish, 2005-2012). In contrast, representatives from the Oromocto First Nation's fisheries technician team indicated, based on casual observations, that they have perceived a decrease in numbers of Shortnose Sturgeon over the past thirty years (L. Sabattis, H. Paul and B. Paul pers. comm. 2013). Further, Dadswell (1979) hypothesized that one-third of the Saint John River female population spawned each year and that there were 12,000 females producing on average 94,000 eggs each, which provides an estimated production of approximately 3.76×10^9 eggs per year. In contrast, Usvyatsov *et al.* (2013a) incorporated fieldwork and modelling to examine the timing and extent of Shortnose Sturgeon larval dispersal with the primary objective of estimating the abundance of migrating larvae in the Saint John River. They found that there were dramatically lower numbers of larvae produced in the Saint John River during the years 2008-2011 (21,000 to 245,000 per annum) than suggested by

Dadswell (1979). Differences in inferred production levels may be related, at least in part, to method of capture, overestimation of the number of females or larvae, or to a decline in the number of females or their fecundity since 1979.

There is a fish lift at the Mactaquac Dam that has been in place since the dam's completion in 1968. Shortnose Sturgeon have never been caught in this fish lift (R. Price, pers. comm. 2013) and the fish lift intake is only 6' deep over a water depth of 40' and may not be deep enough to capture Shortnose Sturgeon. No information is currently available for Shortnose Sturgeon potential presence or abundance above the Mactaquac Dam. Shortnose Sturgeon have, however, been observed as landlocked populations upstream of the Holyoke Dam (RKM 140) on the Connecticut River (Taubert 1980).

Stokesbury *et al.* (2014) calculated the Species Ability to Forestall Extinction (SAFE) Index to estimate the conservation status of Saint John River Shortnose Sturgeon. This index has been proposed as a heuristic measure of the "distance" that a species is from extinction based on population size estimates and assuming a minimum viable population size of 5,000 adults (Stokesbury *et al.* 2014). Essentially, the SAFE index represents the difference between the estimated adult population size (N) and the minimum viable population size (MVP); a SAFE index value of 0 represents the transition between a threatened status (values less than 0) and not-threatened status *sensu* IUCN (values greater than 0; Clements *et al*. 2011). Stokesbury *et al*. (2014) calculated a SAFE index of about 0.55 for the Saint John River Shortnose Sturgeon, which was lower than that estimated for the Hudson River (1.0), but higher than estimates for two rivers in Georgia and one in South Carolina (~ -0.4 to -1.2). These differences in the SAFE indices were associated with very low estimates of adult population sizes in the latter three populations in the threatened zone (range from 290 – 1,500) and the very large estimated population size in the Hudson River (57,000, Stokesbury *et al*. 2014). Consequently, the SAFE value calculated for the Saint John River Shortnose Sturgeon (0.55) could be interpreted to suggest that the population surpasses a quantitative threshold for being threatened (as Stokesbury *et al.* (2014) did for the SAFE value of 1.29 for the entire Atlantic basin population). It should be noted, however, that the SAFE index for the Saint John River population used only the mean estimated adult population size (18,000) generated back in 1979 (Dadswell 1979). Using the lower 95% confidence interval (7,200 – see above) would generate a SAFE index (= $\log_{10}(N) - \log_{10}(MVP)$, Clements *et al*. 2011) of only 0.16. Using the upper 95% confidence interval (28,880) yields a SAFE index estimate of 0.76. In addition, the SAFE approach used a single generic minimum viable population size (5,000) that was largely based on estimates for non-fish taxa (only 8 of 212 estimates of MVP were for fishes). In fact, MVP estimates for fishes are relatively scarce, but those that are available all exceeded 200,000 (see Traill *et al.* 2007 and also Flather *et al*. 2011). Using the lower 95% confidence interval for N (7,200) and increasing the MVP only slightly to 8,000 adults would result in a SAFE index of -0.05 below the threshold for "threatened". Clearly, while the SAFE approach is an interesting one, it requires much more precise parameterization (i.e., both for N and MVP) and some estimate of variance before it can be applied to quantitative assessment criteria for the Shortnose Sturgeon.

Rescue Effect

Telemetry research on rivers of Maine shows that there is more movement of Shortnose Sturgeon among rivers than previously thought (Fernandes *et al.* 2010; Zydlewski *et al.* 2011; Dionne *et al.* 2013). Recent work by Wirgin *et al.* (2010) and the Shortnose Sturgeon Status Research Team (2010) suggests that although there is more mixing between populations among the 19 river segments than suggested by the National Marine Fisheries Service (1998), the Saint John population was the most genetically distinct system among the populations analyzed. Thus, the probability of rescue of the Saint John population of Shortnose Sturgeon from the Gulf of Maine population complex should the Saint John River population collapse is low to unlikely as the number of migrants calculated from genetic work was fewer than 2.5 per generation (i.e., << one fish per year, Wirgin *et al.* 2010).

THREATS AND LIMITING FACTORS

The Saint John River population of Shortnose Sturgeon is the most northerly distributed population of the species, which probably places natural limits on productivity of the population given that the species, like the vast majority of fishes, are ectotherms. Indeed, the relative carrying capacities of various river systems was estimated by Stokesbury *et al*. (2014). Here, the estimated carrying capacity of the Saint John River population was estimated as 0.51 adults/hectare, lower than that estimated for two more southern rivers: the Delaware River (0.64) and the Hudson River (1.29).

There are no well-documented, imminent threats to the Shortnose Sturgeon, but several potential threats exist. Fish are targeted in a recreational fishery, but only individuals over 120 cm total length can be kept when caught by anglers, which protects most of the population (Section 97 in the Maritime Provinces Fishery Regulations under the *Fisheries Act,* see also Figure 5). Size distribution data recorded as fork length, which is a smaller measurement than total length such that a 120 cm fork length fish will have a longer total length by ~ 10% of FL (see Figure 1), suggest that while most fish would be protected by this size regulation, some fish could clearly be retained (Figure 5, DFO 2014b). Further, there may be some hooking and handling mortality associated with catch-and-release angling (cf. COSEWIC 2013). By-catch from commercial and recreational fisheries exists throughout the east coast (Dadswell 1979; Collins *et al.* 1996; Kynard 1997; Bahn *et al.* 2012). For instance, Dadswell (1979) reported a total of 121 tagged fish returned by commercial fishers in the Saint John River between 1973 and 1978. Bahn *et al.* (2012) reported by-catches of 71, 53, and 486 Shortnose Sturgeon in American Shad (*A. sapidissima*) fisheries in the Altamaha River, Georgia, in 2007-2009. The total population size of Altamaha River Shortnose Sturgeon was estimated as ~1,800 adults and mortality from by-catch in nets was estimated as 8% (although post-release mortality was not monitored). Although there is no directed commercial harvest of Shortnose Sturgeon, and the extent of illegal fishing and markets is unknown, it is thought to be significant in US rivers. There is, however, no evidence that illegal fishing occurs or is a significant issue for the Saint John River population (Kynard 1997; DFO 2014b).

In the Saint John River, Shortnose Sturgeon are caught incidentally by Gaspereau (*Alosa pseudoharengus*), American Shad, American Eel (*Anguilla rostrata*), and Atlantic Sturgeon commercial fishers. Fish are most often released unharmed, but they are vulnerable to capture during their spawning migration, which is coincident with the Gaspereau runs. Capture and release during spawning migrations may interrupt spawning and lead to abandonment of migrations (National Marine Fisheries Service 1998).

Shortnose Sturgeon are vulnerable to chemical contaminants. Chambers *et al.* (2012) tested the sensitivities of Shortnose and Atlantic sturgeon during early life stages to doses of polychlorinated biphenyl 126 (PCB126) and 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). They found that both species were among the most sensitive fishes, which may make Shortnose Sturgeon especially vulnerable because of their long life span as benthic predators. Hence, there is great potential for bioaccumulation of heavy metals and other toxicants (Dadswell 1979). Kocan *et al.* (1996) studied the effects of coal tar leachate (PAHs) on embryo and larval development and such exposure resulted in extremely high mortality within 18 days. Although there are exceptions, especially near the city of Saint John and areas upstream of the Mactaquac Dam (Edmundston to Grand Falls), water quality (defined by various measures of metals, pH, dissolved oxygen, bacterial counts) has improved since concerns were first raised in the 1950s-60s and appears to be fair to good for aquatic life in much of the Saint John River (Environmental Reporting Series 2007; Curry *et al*. 2011).

The damming of major rivers in North America has unquestionably had negative impacts on most if not all migratory species (e.g., Larinier 2001; Pringle 2003; COSEWIC 2013). Hydroelectric dams may reduce Shortnose Sturgeon habitat by altering river flows and/or temperature required for spawning and incubation of eggs (National Marine Fisheries Service 1998; Cunjak *et al.* 2011). In almost all of the Shortnose Sturgeon populations, dams block the passage of fish upriver and therefore confine spawning activities below this point (Kynard 1997). This leaves all of the early life stages vulnerable to changes in river conditions influenced by dam operations and consequent variation in flow regimes (Usvyatsov *et al.* 2013b). Research on at least some other species, such as salmonids (Bell *et al.* 2005; Korman and Campana 2009; Warren *et al.* 2009) and catostomids (Weyers *et al.* 2003; Peterson and Jennings 2007) demonstrated the potential for adverse effects of flow management patterns on the abundance, growth, and survival of age-0 fish. For instance, highly variable flows may reduce food abundance in the affected habitats (Korman and Campana 2009). In fact, recruitment failure associated with altered and variable flow regimes associated with hydroelectric developments is considered a key factor driving at risk status of the White Sturgeon in Canada (COSEWIC 2013). How, or if, the flow regime of the Mactaquac Dam influences survival or growth of Shortnose Sturgeon is, however, unknown.

There are a number of industrial activities on the Saint John River such as pulp mills, agriculture, and forestry. There is also one land-based sturgeon aquaculture facility on the Saint John River that grows Shortnose Sturgeon, Atlantic Sturgeon and their hybrids that could transfer disease to wild populations if effluent streams are not treated properly before release. Further, these operations rely on occasional capture of wild fish as broodstock. While there is potential for escapes from this facility, the risk is likely very low because the facility is land-based. The Shortnose Sturgeon may be particularly vulnerable to stochastic events (flooding, chemical spills) during time periods when they aggregate in large groups over relatively small areas (e.g., the one known overwintering site).

Muskellunge, a recent invader to the Saint John River system, is now regularly caught by anglers downstream of Fredericton (Kidd *et al*. 2011). Muskellunge are known to inhabit slow river stretches with submergent and emergent vegetation, which is similar habitat exploited by Shortnose Sturgeon (Scott and Crossman 1973). Muskellunge predation on adult Shortnose Sturgeon is highly unlikely given the latter's size and protective armour, but juvenile Shortnose Sturgeon may be at risk of predation by Muskellunge.

Based on the IUCN threats assessment calculator (Appendix 4, IUCN 2015), the assigned cumulative threat status of the Shortnose Sturgeon was estimated to be "LOW" because of the considerable uncertainty of the extent and intensity of the numerous potential threats.

Number of Locations

The Saint John River is the only area in which the Shortnose Sturgeon occurs in Canada. Within this river system one spawning site, below the Mactaquac Dam, has been documented. Given that spawning areas involve aggregations of adults as well as newly spawned and tiny larvae, the one known spawning site likely represents the area where the species is most vulnerable. In addition, while other spawning areas may exist and the river has not been well-searched for other spawning sites, sturgeon as a whole tend to specialize on a relatively small number of spawning areas determined by specific flow and substrate conditions. For instance, the White Sturgeon comprises four designatable units within the Fraser River, British Columbia. Here, the total index of area of occupancy exceeds 10,000 km^2 (compared to ~ 50 km^2 for the Shortnose Sturgeon in the Saint John River) and only seven spawning sites (with up to 21 suspected) have been documented (COSEWIC 2013). Similarly, the Atlantic Sturgeon comprises two designatable units with a combined index of area of occupancy of about 700 km^2. The number of spawning areas for the designatable unit most comparable to the Shortnose Sturgeon (the St. Lawrence populations with an index of area of occupancy of 104 km^2) was considered to have three spawning areas (COSEWIC 2011; spawning areas in the other designatable unit were not estimated). Consequently, while the Shortnose Sturgeon may spawn in areas of the Saint John River other than below the Mactaquac Dam, the number of spawning areas is unlikely to be large. Accordingly, the number of locations, based on susceptibility to stochastic flooding and abrupt changes in water quality at or near the known spawning area is estimated to be one and almost surely five or fewer.

In terms of overwintering areas, Dadswell (1979) identified several overwintering sites in large deep lakes and deepwater areas of the lower Saint John River and an adjacent section of the Bay of Fundy (seven sites in total). One particularly well characterized site occurs at the confluence of the Hammond and Kennebecasis rivers, both tributaries of the lower Saint John River. There have been no confirmed re-detections of Shortnose Sturgeon at the other overwintering sites reported in Dadswell (1979) with the exception of low densities of fish aggregating at Gagetown, but overall search effort has been modest at best (DFO 2014a).If overwintering sites were used to define locations and given the robust population size estimates for some overwintering sites and the clear aggregations of fish in these areas, each is considered as a single location owing to the vulnerability of a large number of fish to habitat degradation or toxic spills that could occur over a small area for a total of no more than seven to ten locations (if defined based on overwintering sites). Overall, given that early reproductive stage Shortnose Sturgeon are likely to be the most vulnerable life history stage and the documented mortality of young sturgeon near the single, known spawning area, probably from flooding (see **Survival**), the number of locations is estimated to be one.

Protection, Status and Ranks

The Shortnose Sturgeon was assessed as a species of Special Concern in Canada in 1980 and was reassessed as such in 2005. The species was listed as Special Concern in Schedule 1 of Canada's *Species at Risk Act* (SARA) in 2009 and NB's SARA in 2013 (O.C. 2013-143). Fisheries and Oceans Canada (DFO) is currently finalizing a management plan for the species as required under Canada's SARA (DFO, pers. comm. 2013). Additionally, no recreational fishing is allowed within a 10 km stretch downstream of the Mactaquac Dam, which should protect Shortnose Sturgeon during reproduction. Shortnose Sturgeon has been classified as Endangered by the *Endangered Species Act* in the United States since March 1967. The National Marine Fisheries Service generated a Final Recovery Plan for the US Shortnose Sturgeon in 1998. The Shortnose Sturgeon has been listed in Appendix I of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES) since 1975. Appendix I of CITES includes those species that are presently threatened with extinction and trade is only authorized in exceptional circumstances. Commercial trade is limited to captive-bred specimens from CITES-registered aquaculture facilities.

Non-Legal Status and Ranks

The Shortnose Sturgeon has had an IUCN Red Book Status since 1996 when it was assessed as Vulnerable because it: 1) has had a reduction in area of occupancy, extent of occurrence and/or quality of habitat; 2) is severely fragmented; 3) has had a continued decline in area, extent and/or quality of habitat and number of locations or subpopulations. Nature Conservancy Ranks (NatureServe 2015) are as follows:

Global – G3 (last assessed 2011)

National US – N3 (last assessed 1996), Canada N2 (last assessed 2013),

Canada: NB – S2;

Regional US: SX (DC); SH (NH, RI); S1 (CT, FL, MD, MA, NJ, NY, NC, PA); S2 (GA); S3 (ME, SC), S3N (DE), SHB, SN1 (VA)

Habitat Protection and Ownership

Shortnose Sturgeon are angled recreationally in the Saint John River and their population and habitat are, therefore, protected by the federal *Fisheries Act* (McLean, pers. comm. 2013).

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

Participants of DFO's Shortnose Sturgeon draft management plan workshop; DNR NB; Oromocto First Nation; Fishway Manager Mactaquac DFO; Rod Bradford (DFO); and Mark McLean (DFO).

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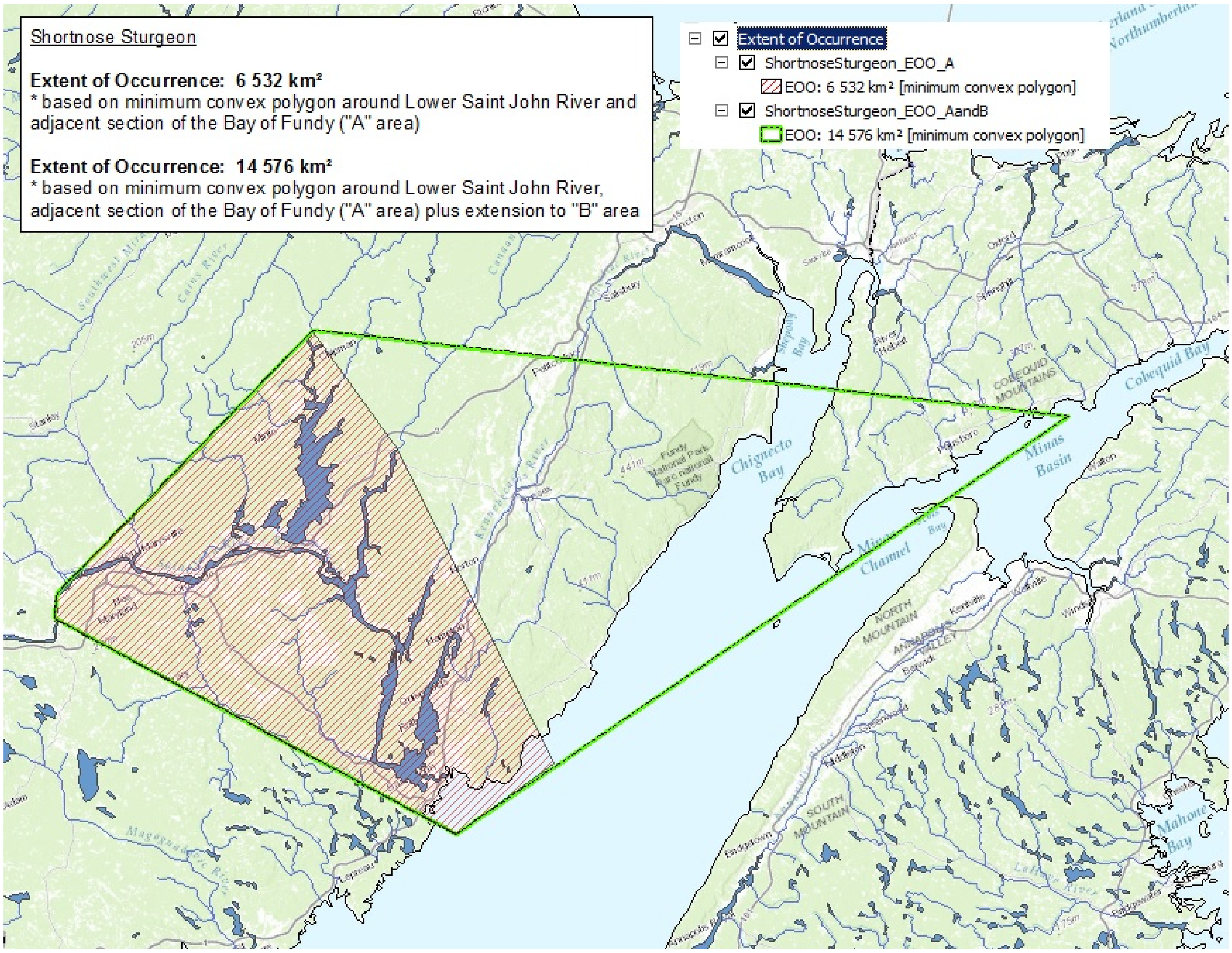
BIOGRAPHICAL SUMMARY OF REPORT WRITER

Dr. Matthew K. Litvak received his B.Sc. from York University in 1981 and his M.Sc. and Ph.D. from University of Toronto, in 1984 and 1990, respectively. He is currently a professor of biology at Mount Allison University, Sackville, NB. He and his graduate and undergraduate students have been working on Shortnose Sturgeon ecology since 1998. His lab was the first in Canada to successfully rear both Shortnose and Atlantic sturgeon larvae in captivity.

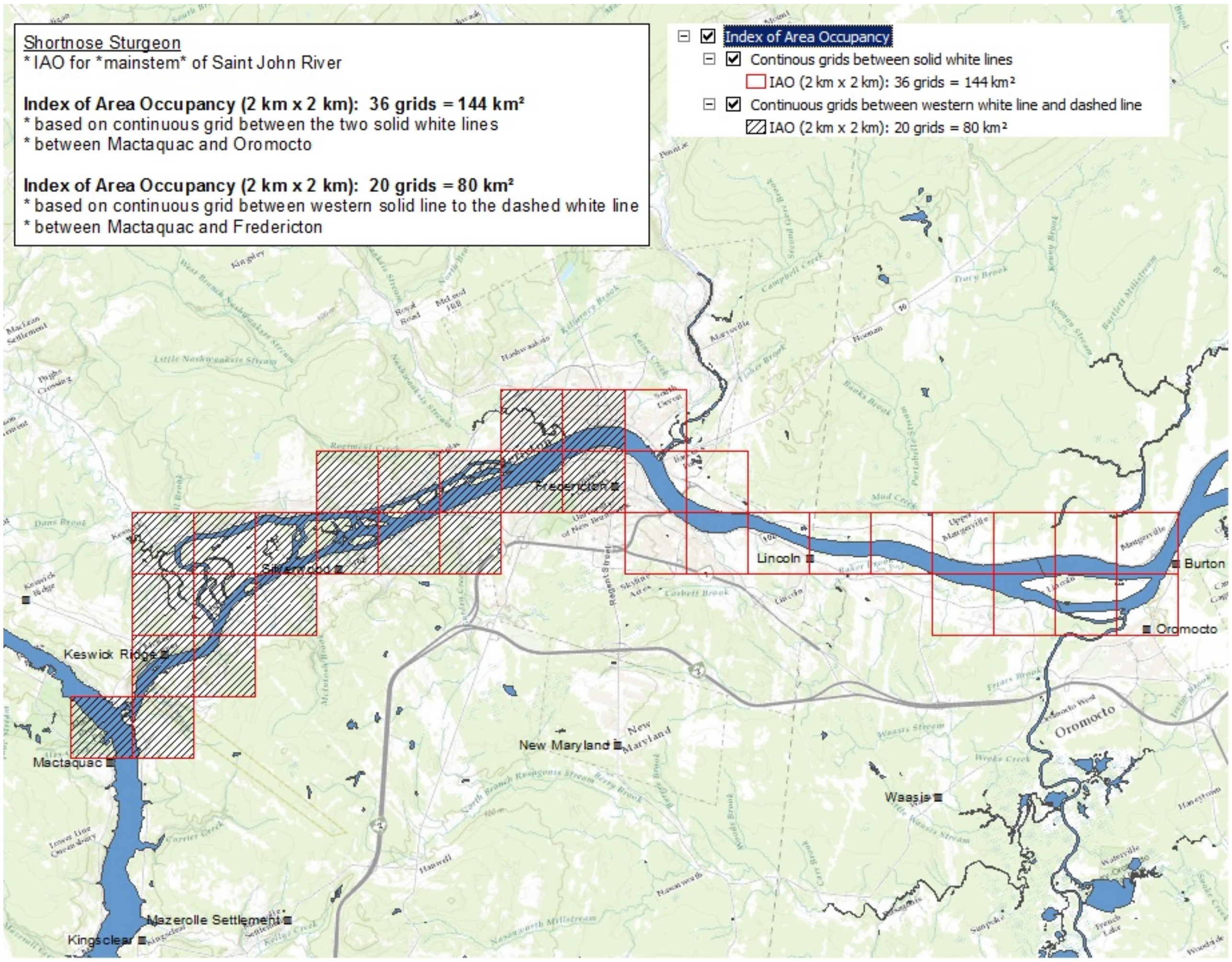
COLLECTIONS EXAMINED

None.

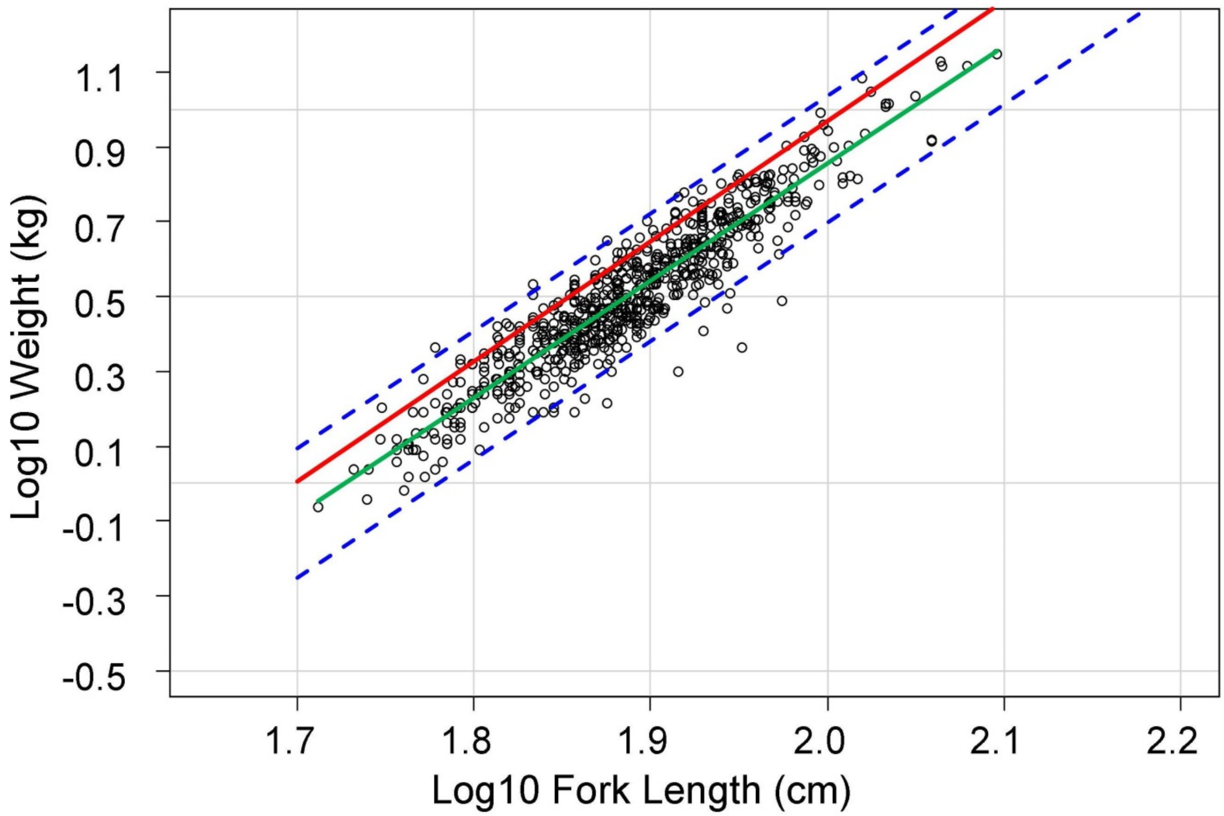
Appendix 1. Estimated extent of occurrence (EOO) of Shortnose Sturgeon in Canada. The hatched area is the EOO based on Saint John River and adjacent estuary only. The open polygon area is the additional amount of EOO that would encompass the single verified record of unknown origin from Minas Basin in Nova Scotia. Prepared by J. Wu, Environment Canada.



Appendix 2. Estimated index of area of occupancy of Shortnose Sturgeon in Canada based on spawning area suspected to extend from Mactaquac Dam to Frederiction (hatched squares) or perhaps downstream to Oromocto (open squares). Prepared by J. Wu, Environment Canada.



Appendix 3. Weight length relationship for Shortnose Sturgeon caught in the lower Saint John River 1998-2002 with 95% confidence limits (blue dashed lines). Red line represents overlay of Dadswell's (1979) relationship for 1973-1977 and the green line represents data collected by Litvak (1998-2001, unpubl. data).



Appendix 4. International Union for Conservation of Nature Threats Assessment Calculator

THREATS ASSESSMENT WORKSHEET		
Species or Ecosystem Scientific Name	Shortnose Sturgeon	
Element ID		Elcode
Date (Ctrl + ";" for today's date):	17/06/2014	
Assessor(s):	K. Ovaska, D. Fraser, M. Sabine, R. Bradford, M. Ridgway, T. Hatfield, E. Taylor	
References:	COSEWIC status report, 2014 draft	

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts: high range	low range
A	Very High	0	0
B	High	0	0
C	Medium	2	0
D	Low	1	2
Calculated Overall Threat Impact:		Medium	Low

Assigned Overall Threat Impact:	**D = Low**
Impact Adjustment Reasons:	see below
Overall Threat Comments	**The overall assigned threat impact was rated as "low" owing to the considerable uncertainty of the actual effects of most potential threats on Shortnose Sturgeon, particularly given the time frame of 3 generations (60 years).**

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development						
1.1	Housing & urban areas						not applicable
1.2	Commercial & industrial areas						not applicable
1.3	Tourism & recreation areas						not applicable
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						not applicable
2.2	Wood & pulp plantations						pulp mills producing pollution are accounted for in 9.0
2.3	Livestock farming & ranching						disease accounted under 9.0. cattle accounted for under pollution 9.0.
2.4	Marine & freshwater aquaculture						potential for disease transfer from land-based aquaculture is accounted for under Invasive species (8.1)
3	Energy production & mining		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate - Insignificant/Negligible	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.1	Oil & gas drilling		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate - Insignificant/Negligible	Natural gas drilling currently occurs in Kennebecasis River watershed in Sussex area, approx 50 km above the known overwintering site. There is potential for fracking to occur sometime in the future, at an unknown level of intensity, based on results of current exploratory work, and pending regulatory approval.
3.2	Mining & quarrying						Large tungsten and molybdenum open-pit mine planned in headwaters (currently under EIA review process); it would include a large (750 ha) tailings pond (waste products to be submerged) involving a dam/impoundment; discussed in pollution (breaching of dam a concern); change in hydrology.
3.3	Renewable energy						Hydroelectric dams accounted under system modifications (7.2).
4	Transportation & service corridors		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	
4.1	Roads & railroads						not applicable
4.2	Utility & service lines		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	West to east pipelines transport unrefined along length of St John's River (assessment process); will cross major tributaries; rupture once built of concern (to pollution); number of existing pipelines. NG probably not an issue; based on habitat loss
4.3	Shipping lanes						not applicable
4.4	Flight paths						not applicable
5	Biological resource use	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						not applicable
5.2	Gathering terrestrial plants						not applicable
5.3	Logging & wood harvesting						not applicable
5.4	Fishing & harvesting aquatic resources	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	By-catch in commercial and Aboriginal fisheries; recreational fishing (catch and release for the most part, but some hooking mortality is likely); aboriginal fishery; poaching? Management Plan: all ranked as unknown; highest level of concern was "medium" for by-catch, all others "low"; recreational fishing by-catch not showing up as population effect in at least one area; elevated fishing interest from recreational fishers on sturgeon; lots of uncertainty in severity;
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	
6.1	Recreational activities						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.2	War, civil unrest & military exercises						Large Military base located adjacent to the river; sedimentation from military exercises covered under see Pollution (9.2) No direct impact likely.
6.3	Work & other activities		Negligible	Negligible (<1%)	Negligible (<1%)	Insignificant/Negligible (Past or no direct effect)	Some disturbance caused by ongoing scientific research the benefits of which are likely in excess of any effects from distrubance
7	Natural system modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
7.1	Fire & fire suppression						not applicable
7.2	Dams & water management/use	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Scope: best available information on movements of fish support pervasive; severity: major dam coming to the end of its life-span & will have to be removed or replaced; to be decided within next 4 years & work started within next 15 years - will probably not happen within next 10 years. Sedimentation will likely be a major issue if dam is removed. Reproduction compromised but long-lived fish & may be resilient. Consider current regime. Hydroelectric dams alter river flows and optimal spawning temperature. Dams block fish passage but it is unknown if SNS were historically found above the dam site. Best available information supports prevasive. Larvae getting blown downstream. Mactaquac replacement plan has potential for profound impact. Dam needs replacement before 2030 but it may occur in the next 10yrs. unknown timing and impact of planned dam replacement. Dependent on how they replace it given the options.
7.3	Other ecosystem modifications						not applicable
8	Invasive & other problematic species & genes		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	
8.1	Invasive non-native/alien species		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Introduced diseases from aquaculture & farming. Irrido-virus is a concern for sturgeon. Aquaculture facility is land-based, potential for escapes is low, there is no intentional stocking. Muskellunge introduced to St. John River in the 1970s, currently expanding its range to lower parts of the river where the SN Sturgeon is. It is not known how well established the muskellunge is within SNS range. Potential for predation on juveniles; displacement from habitat. Smallmouth Bass and Chain Pickerel have been well established throughout SNS range for a hundred years.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species		Negligible	Large - Restricted (11-70%)	Negligible (<1%)	High (Continuing)	Brown Bullhead (Catfish) - appears to be a recent population explosion - potential predation on young of the year; competition for benthic prey?
8.3	Introduced genetic material						Not applicable. Aquaculture based on intermittent capture of wild caught St John R fish; land-based facilities, no stocking back into wild population.
9	Pollution	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
9.1	Household sewage & urban waste water		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Improving, especially in last 10 years; city of Saint John problematic, but all smaller communities have facilities. Was bad in 60's and 70's so damage is done. Some raw sewage in Saint John, but this has approval for treatment and remedying. Impact is possibly ongoing but negligible wrt other pollution threats.
9.2	Industrial & military effluents	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)	One of major tributaries flows through major military base - heavy sediment load; industrial effluents, pulpmills (major for SN Sturgeon), food processing plants upstream, but water quality improving below the dam; head ponds may contain pollutants & sediments to some degree; a big issue if dam is removed. Limit category largely to military base because...Major tributary on CFB is "Nerepis" River – there are major sedimentation issues on this tributary due to military activities, but this is not considered a SNS tributary. However, it likely contributes sediment to the lower SJR which is SNS habitat. Pulp upstream but water quality downstream good. Holding ponds contain contaminants in sediments. Dam removal may release these. Pulp Mill in Reversing Falls.
9.3	Agricultural & forestry effluents	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Lower Kennebecasis River, much agriculture Tributaries of the lower St.John are impacted through sedimentation such as the Kennebecasis and Hammond
9.4	Garbage & solid waste						not applicable
9.5	Air-borne pollutants						not applicable
9.6	Excess energy						not applicable
10	Geological events						
10.1	Volcanoes						not applicable
10.2	Earthquakes/tsunamis						not applicable
10.3	Avalanches/landslides						not applicable
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Habitat shifting & alteration		Not Calculated (outside assessment timeframe)	Pervasive (71-100%)	Unknown	Low (Possibly in the long term, >10 yrs)	Sea level rise: St. Johns R - tidal water 140 km upstream; effect all the way to the dam. Pronounced increase in tidal heights needed to see increase in salinity. sea level rise. Tidal water limit is 140km upstream. Key area for anandromous fish species. Salt water injection is moderate except for spring tides. Sea level rise would be potential for increased salinity. Possible in the next decade.
11.2	Droughts						not applicable
11.3	Temperature extremes						not applicable
11.4	Storms & flooding		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	Increased storms predicted; impact most, if result in high snow pack - local flooding in smaller tributaries. Pronounced effect on spawning time for other species but no info on SN Sturgeon. Hydro electric generation could be a factor. spawning occurs below the dam.