Atlantic Sturgeon

Acipenser oxyrinchus oxyrinchus

St John River, Canadian Maritimes

Extra-large Mesh Gillnet

June 2018

Ocean Wise Consulting Researcher

Seafood Watch Standard used in this assessment: Standard for Fisheries vF3.2

Table of Contents

About Ocean Wise Seafood 3

Recommendation Policy 4

Table of Conservation Concerns and Overall Recommendations 5

Summary 6

Introduction 7

Analysis 10

Criterion 1: Impact on the Species Under Assessment *10*
Factor 1.1 Abundance 11
Factor 1.2 Fishing mortality 13

Criterion 2: Impacts on Other Species *15*
Factor 2.1 Abundance 16
Factor 2.3 Modifying Factor: Discards and Bait Use 18

Criterion 3: Management Effectiveness *20*
Factor 3.1 Management Strategy and Implementation 21
Factor 3.2 Bycatch Strategy 22
Factor 3.3 Scientific Research and Monitoring 23
Factor 3.4 Enforcement of Management Regulations 23
Factor 3.5 Stakeholder Inclusion 24

Criterion 4: Impacts on the Habitat and Ecosystem *26*
Factor 4.1 Physical Impact of Fishing Gear on the Habitat/Substrate 27
Factor 4.2 Modifying factor: Mitigation of gear impacts 28
Factor 4.3 Ecosystem-based Fisheries Management 28

Acknowledgements 31

References 32

About Ocean Wise Seafood

The Ocean Wise® seafood program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the Canadian marketplace. Ocean Wise defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Ocean Wise makes its science-based recommendations available to the public in the form of reports that are available to view on our mobile app and download from www.ocean.org/seafood. Ocean Wise also works directly with restaurants, markets, and seafood suppliers to ensure they have the most up to date scientific information regarding sustainable seafood. The options are highlighted on their menus and display cases with the Ocean Wise symbol, making it easier for consumers to make informed seafood choices.

Sustainability recommendations are supported by assessments that synthesise and analyse the most current ecological, fisheries and ecosystem science on a species, then evaluate this information against the programs conservation ethic to arrive at a recommendation. In producing the assessments, Ocean Wise seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Ocean Wise Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Ocean Wise' sustainability recommendations and the underlying assessments will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Ocean Wise assessments in any way they find useful.

Recommendation Policy

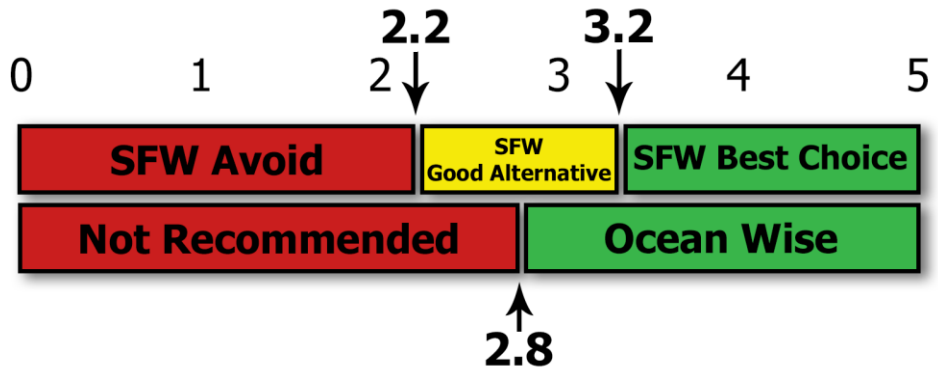
Ocean Wise recommendations are generated from assessments using the Monterey Bay Aquarium's Seafood Watch (SFW) program methodology. Following the Seafood Watch Standard for Fisheries, each assessment synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic and four criteria:

1. Impacts of the fishery on the stock in question
2. Impacts of the fishery on other species
3. Effectiveness of management
4. Impacts on habitat and ecosystem

Unlike the Seafood Watch three-tiered traffic light system of Red, Yellow, Green, Ocean Wise Seafood's classification system is based on two categories: sustainable (Ocean Wise Recommended) or unsustainable (Not Recommended).

Using the Seafood Watch Standard for wild capture fisheries, Ocean Wise requires that fisheries score ≥ to **2.8** (out of 5) and no more than 1 criterion scoring ≤2.2 to be recommended.

A comparison between the Seafood Watch and Ocean Wise scoring is depicted in the figure below:



Full Ocean Wise Recommendation Policy can be found here. http://seafood.ocean.org/seafood-guide/how-we-grade/

Ocean Wise recommendations are re-assessed every 4 years. For species that are COSEWIC listed, Ocean Wise will conduct an annual review of all new information relevant to the fishery and make adjustments to scoring if necessary. The Ocean Wise seafood program also reserves the right to amend recommendations at any time if new information becomes available.

1. "Fish" is used throughout this document to refer to finfish, shellfish and other invertebrates.

Table of Conservation Concerns and Overall Recommendations

Stock	Fishery	Impacts on the Stock Rating, Score	Impacts on other Species Lowest scoring species Rating, Score	Management Rating, Score	Habitat and Ecosystem Rating, Score	Overall Score	Ocean Wise Recommendation
Atlantic sturgeon	St John River	Red 1.73	Shortnose Sturgeon Green, 3.41	Yellow 3	Green 3.46	**2.8**	

Summary

This report provides recommendations for the Atlantic Sturgeon fisheries in the Canadian Maritimes regions. Atlantic Sturgeon are a large-bodied, slow-growing, late-maturing species that are particularly susceptible to overexploitation. Current fisheries are heavily restricted and use 33 or 38 cm bottom gillnets. The Atlantic Sturgeon fisheries in the Saint John River scored as Ocean Wise Recommended as they are highly regulated, have implemented restrictive total allowable catch quotas, are intensively monitored, and have minimum impact on the wider ecosystem.

Atlantic Sturgeon are a wide-ranging anadromous species found from Florida, USA to Labrador, Canada. In Canada, Atlantic Sturgeon spend the majority of their lives in the marine environment, migrating into rivers to spawn and leaving as juveniles or subadults. Mature females reach 2-3 m and 100-200 kg, mature males reach 1.5-2 m and 50-100 kg. The Maritimes Designatable Unit is commercially targeted solely in the Saint John River, but the species is located throughout estuaries in the Bay of Fundy.

The primary gear is fixed bottom gillnets, minimum 33 cm, in the Saint John River. Harvested sturgeon species are extremely susceptible to overexploitation and have been subject to severe regulations across the various fisheries as a consequence of intense overexploitation. The Atlantic Sturgeon is evaluated as Threatened by COSEWIC (2011) in the Maritimes Designatable Unit. The large gillnet size and restriction to riverine habitats greatly reduces the chance of bycatch and the only impacted species are exceptionally large individuals of Shortnose Sturgeon. There is good evidence that discarded individuals have very high survival rates.

Management measures include gear restrictions, seasonal closures, total allowable catch quotas, catch registration, size restrictions, and intense enforcement. The effectiveness of these regulations is working as fishery-independent monitoring have demonstrated increasing stock trends.

Landings are reviewed by fishery managers and the data informs management advice. The gear type used, extra-large mesh bottom gillnet, has no documented appreciable impact on the habitat. Habitat destruction is a primary threat but through habitat modification from dams, impoundments, dredging, and other non-fishery anthropogenic activity.

The availability of Atlantic Sturgeon to the North American market is limited to Canada as it is listed in the United States as an Endangered Species and, thus, imports are prohibited.

Introduction

Scope of the analysis and ensuing recommendation

This analysis covers the Saint John River Estuary fishery in New Brunswick for Atlantic Sturgeon (*Acipenser oxyrinchus*). The gear type covered in this analysis is bottom gillnet (a minimum of 33 cm stretched mesh size). This fishery is responsible for 15-20% of all sturgeon landings in Canada.

Overview of the species and management bodies

Atlantic Sturgeon is an anadromous species, feeding on benthic invertebrates and maturing in estuaries and the coastal shelf but migrating into rivers to spawn in late May (COSEWIC 2011, Stewart et al. 2015). This species is long-lived, maturing around 16-24 years for males and 27-28 years for females at lengths greater than 1.5 m (COSEWIC 2011, DFO 2013a). Mature individuals typically grow to 2-3 m, weighing 80-200 kg, but can exceed 4 m. (COSEWIC 2011, Stewart et al. 2015). Atlantic Sturgeon are benthic broadcast spawners and females can carry over a million eggs with typically 25,000 eggs per kg of ovaries, which can be 12-25% of body weight at maturity (DFO 2013a). Atlantic Sturgeon are extant from the St. John's River in Florida, USA to Labrador, CAN.

Sturgeon fisheries in Canada were traditionally comprised of a diverse set of species on both Atlantic and Pacific coasts. High catchability and intense fishing effort resulted in unsustainable catch rates and, with long generational times, many species had become rare throughout their ranges by the turn of the 20thcentury (Dadswell 2006, COSEWIC 2011, Verreault and Trencia 2011). Many species were fished to the extent of local extirpation or below profitability and have not subsequently recovered to join the two current sturgeon fisheries in Canada, for Atlantic and Lake Sturgeon.

Atlantic Sturgeon in the Maritimes were harvested commercially beginning in 1880; a total of 700 tonnes were removed from 1880-1886 and overfishing was so intense that the fishery closed for 10 years in 1886. It reopened in 1897 and catches have not exceeded 41 tonnes annually since, with severe fishery restrictions (including closures, gear restrictions, small quotas, intense monitoring) going into place in 2011 (COSEWIC 2011, DFO 2013a).

Recent management

Atlantic Sturgeon fisheries in the Canadian Maritimes region are managed by Fisheries and Oceans Canada (DFO) under the Fisheries Act. DFO enforces management through direct monitoring, 5-6 times monthly, and oversight of commercial logbooks of the Saint John River Estuary fishery. The current commercial fishing quota is 350 fish but the fishery is closed as soon as either 175 males or 175 females are removed (DFO 2013a). Removals have been primarily used for meat and caviar production but 5-19 individuals have been used for spawning in aquaculture and returned to the wild (DFO 2013a). An additional 50 individuals,

above the 350 commercial quota, are allotted for recreational and Aboriginal fisheries and incidental mortality. There are two Aboriginal licenses that authorize harvest, but these licenses have reported minimal landings (<5 in total) between 2008 and 2012 (Bradford et al. 2016).

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is an independent advisory panel to the Minister of Environment that assesses the extinction risk of species in Canada. Assessments are species based on the best available information, including Indigenous traditional knowledge, scientific data, and local ecological information. Once COSEWIC has assigned a status to a species, DFO is required to make a recommendation whether or not to add the species to the List of Wildlife Species at Risk under the Species at Risk Act (SARA). In order to inform the recommendation, DFO may undertake a Recovery Potential Assessment, a socio-economic analysis, and public consultations. A decision about whether or not the species will be listed under SARA will be made based on the available scientific information, the outcomes of consultations, and an analysis of the socioeconomic impacts.

If the species is listed under SARA as threatened, endangered or extirpated, automatic prohibitions would immediately come into effect making it illegal to kill, harm, harass, capture, possess, buy, sell, or trade the listed species. Additional management and mitigation measures for activities affecting the species may also be implemented. A recovery strategy, and subsequent action plan(s) would be developed to identify measures to address threats. Critical habitat would also be identified, to the extent possible, in a recovery strategy. If the species is not listed under SARA, the species would continue to be managed under existing legislation (e.g. the Fisheries Act) and additional management and mitigation measures may be implemented in order to promote the conservation and protection of the species.

Atlantic sturgeon were evaluated in two separate designatable units (Maritimes and St. Lawrence) as 'Threatened' by COSEWIC (COSEWIC 2011, DFO 2013b). Stocks of Atlantic Sturgeon in the United States are unfished at present and listed as 'Endangered' in the United States under the Endangered Species Act following a similar historic exploitation pattern as Canadian stocks.

Production statistics

Currently, fisheries for the Atlantic Sturgeon only occur in Canada, primarily in the St .Lawrence River and the St. John River (COSEWIC 2011). Landings have declined following intensive regulations of both fisheries in the late 1990s, now commercial removals are around 3,700-6,000 fish in the St. Lawrence River and capped at 350 fish as well as a 50:50 sex ratio in the Saint John River (Figure 1) (COSEWIC 2011, Verreault and Trencia 2011, DFO 2013c).

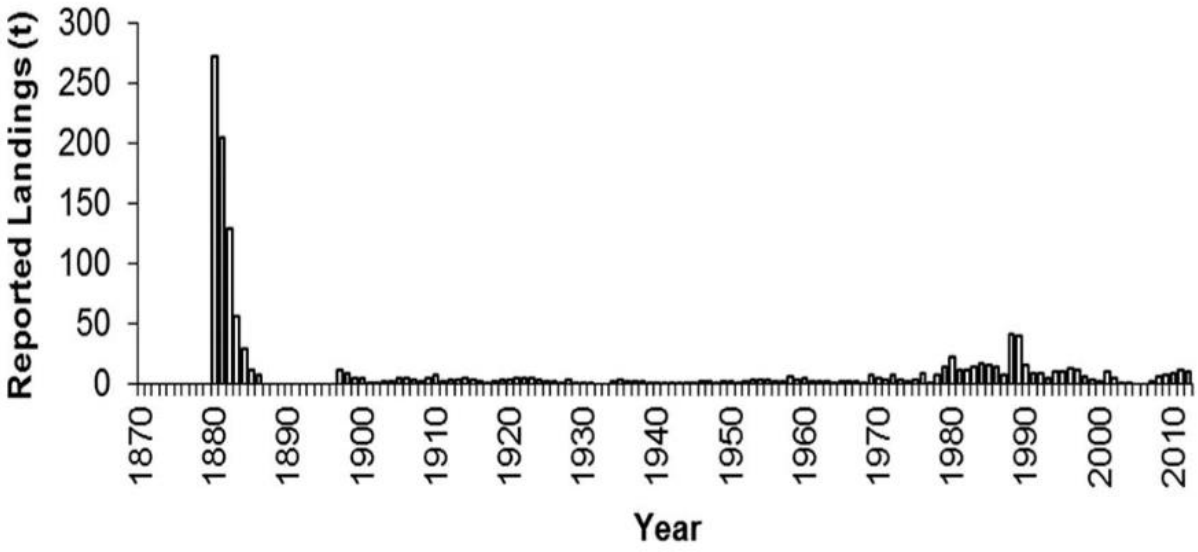


Figure 1 from DFO (2013) of the reported landings for the Saint John River Estuary fishery by year.

Importance to the US/North American market

The availability of Atlantic Sturgeon to the North American market is limited to Canada as it is listed in the United States as an Endangered Species. Production statistics of Atlantic Sturgeon products are not available from the Saint John River Estuary fishery but Atlantic Sturgeon fisheries in Québec produce 42 t of product in Canada with a mean value of $238,000 (DFO 2015). Bradford et al. (2016) estimated a filled quota in the Saint John River would produce a dressed weight of 10,485 kg and a caviar yield of 528 kg. A maximum of 400 kg per annum of caviar is produced from the Saint John River fishery (Bradford et al. 2016).

Common and market names

Atlantic Sturgeon are marketed generically as sturgeon, along with other species, in Canada.

Primary product forms

Atlantic Sturgeon are marketed in Canada in two forms, smoked flesh and caviar. The Maritimes Atlantic Sturgeon fishery produces both smoked flesh and caviar (DFO 2013c). Infrequently and not recently, isinglass is marketed but production from Canada has not been documented in many years.

Analysis

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Standard for Fisheries, available at www.seafoodwatch.org. The specific standard used in referenced on the total page of all Seafood Watch assessments.

Criterion 1: Impact on the Species Under Assessment

This criterion evaluates the impact of fishing mortality on the species, given its current abundance. When abundance is unknown, abundance is scored based on the species' inherent vulnerability, which is calculated using a Productivity-Susceptibility Analysis. The final Criterion 1 score is determined by taking the geometric mean of the abundance and fishing mortality scores. The Criterion 1 rating is determined as follows:

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and <=3.2=Yellow or Moderate Concern*
- *Score <=2.2=Red or High Concern*

Guiding principles

- *Ensure all affected stocks are healthy and abundant.*
- *Fish all affected stocks at sustainable level.*

Criterion 1 Summary

Stock	**Fishery**	**Abundance** Category (Score)	**Fishing Mortality** Category (Score)	**Criterion 1** Rating Score
Atlantic sturgeon	St John River	High (1)	Moderate (3)	Red 1.73

Criterion 1 Assessment

Atlantic Sturgeon, St John River (Canadian Maritimes Region), Extra-large Mesh Gill Net

Factor 1.1 Abundance

Goal: Stock abundance and size structure of native species is maintained at a level that does not impair recruitment or productivity

Scoring Guidelines:

- *5 (Very Low Concern) — Strong evidence exists that the population is above an appropriate target abundance level (given the species' ecological role), or near virgin biomass.*
- *3.67 (Low Concern) — Population may be below target abundance level, but is at least 75% of the target level, OR data-limited assessments suggest population is healthy and species is not highly vulnerable.*
- *2.33 (Moderate Concern) — Population is not overfished but may be below 75% of the target abundance level, OR abundance is unknown and the species is not highly vulnerable.*
- *1 (High Concern) — Population is considered overfished/depleted, a species of concern, threatened or endangered, OR abundance is unknown and species is highly vulnerable.*

Key relevant information:
A quantitative stock assessment with reference points has not been completed, but two separate assessments of population size have occurred since COSEWIC evaluated the stock as "Threatened" in 2011. However, there is a high degree of discrepancy between these assessments, with DFO (2013) models indicating a relatively stable, but small, population of adult spawners, and Dadswell et al. (2017) estimates indicating significant recovery and an adult population close to virgin biomass.

As the St John River population is designated 'Threatened' by COSEWIC, this criterion scores a 'high concern'. Although the Dadswell et al (2017) study indicated significant stock increases since the COSEWIC designation, a lack of reference points and consensus over the data mean there is not adequate evidence to improve the score.

Detailed rationale:
Two population estimates have been conducted since the COSEWIC designation. In 2013, the Recovery Potential Assessment (DFO 2013a) used a Gazey and Staley Bayes estimator to calculate within season numbers of adult spawners for 2009 – 2012. Estimates were consistently between 1,000 and 3,000 annual adult spawners with a decreasing median trend from 3,050 to 950 from 2009 to 2012 (Table 1). The assessment considered that estimating

virgin biomass was not possible due to uncertainty over annual levels of fishing effort. However, cumulative reported removals from 1880 to 1886 of approximately 700 t indicate a minimum of 7,000 to 14,000 adults historically (DFO 2013a). Dadswell et al. (2017) used multi-year mark-recapture estimates to generate yearly population estimates with a mean adult abundance of 18,179 (Schnabel) and 20,798 (Jolly-Seber). It should also be noted that confidence intervals suggest a wide margin for sampling error, especially using the Jolly-Seber method. Dadswell et al (2017) also estimated virgin adult abundance between 14,240-23,733 adults based on 50-30 kg average adult weight (Table 2). COSEWIC estimated the number of mature adults to be 11,000 prior to exploitation (COSEWIC 2011). Dadswell et al. (2017) estimates of adult Saint John River abundance are within the range of their study's estimate of virgin adult abundance (COSEWIC 2011, DFO 2013a).

Discrepancies between the Recovery Potential Assessment estimates and the latest population estimate by Dadswell et al. (2017) stem from the analytical techniques used to estimate adult abundance, the length of the data series, and assumptions about the population. The DFO (2013a) estimate used single-year mark-recapture estimates within a season over a four-year period assuming a closed population (2009 to 2012). Dadswell et al. (2017) used multi-year mark-recapture analytical methods to estimate population estimates over a six-year period (2011-2016).

Table 1 Population estimate of annual spawners derived using mark-recapture experiments for 2009 to 2012 (DFO 2013a).

	2009		2010		2011		2012	
Variable	May	Season	May	Season	May	Season	May	Season
Marks	-	193	110	236	-	171	44	93
Catch	-	702	357	502	-	485	338	329
Recaptures	-	45	17	48	-	46	8	33
Abundance								
Mode	-	3,010	2,300	2,470	-	1,800	1,800	930
Median	-	3,050	2,450	2,505	-	1,825	2,125	950
LowCI-95%	-	2,330	1,550	1,910	-	1,400	1,020	690
UppCI-95%	-	4,170	4,150	3,345	-	2,475	4,855	1,350

Table 2 Schnabel and Jolly-Seber population estimates and 95% confidence intervals for the St. John River Atlantic Sturgeon population for 2011-2016 (Dadswell 2017)

Year	Schnabel estimate	95% CI	Jolly–Seber estimate	95% CI
2011	27,354	16,944–57,917	27,791	21,428–118,667
2012	24,463	16,655–35,723	16,926	14,825–56,690
2013	20,340	15,493–26,623	24,914	20,496–91,735
2014	16,891	13,852–21,075	12,591	10,560–44,864
2015	17,307	14,407–20,785	24,888	11,558–218,544
2016	17,299	14,735–20,307		
Mean for 2013–2015	18,179		20,798	

Factor 1.2 Fishing mortality

Goal: Fishing mortality is appropriate for current state of the stock.

Scoring Guidelines:

- *5 (Low Concern) — Probable (>50%) that fishing mortality from all sources is at or below a sustainable level, given the species ecological role, OR fishery does not target species and fishing mortality is low enough to not adversely affect its population.*
- *3 (Moderate Concern) — Fishing mortality is fluctuating around sustainable levels, OR fishing mortality relative to a sustainable level is uncertain.*
- *1 (High Concern) — Probable that fishing mortality from all source is above a sustainable level.*

Key relevant information:
Dadswell et al (2017) estimated F to be 0.02 for the St John River fishery, a value that is within the range Boreman (1997) calculated as a sustainable rate for Atlantic Sturgeon. However, Boreman's (1997) calculation used data from the Hudson River population and no F_{msy} has been calculated for the St John River population.

The Fishing Mortality criterion scores as a "moderate concern" because, although fishing mortality rate is extremely low, there are no estimates of F_{msy} for the St John River stock. As there are no reference points for the stock, the relationship of F/F_{msy} is considered unknown.

Detailed rationale:
Fishing mortality, F, is estimated to be 0.017-0.019 and less than the natural mortality, M, of the stock 0.075 (Dadswell et al. 2017). Other sources of mortality (outside of fishing and natural mortality) are the remainder of the total instantaneous mortality estimate and estimated to be 0.016-0.018. This mortality plus fishing mortality sums to 0.035.

Estimates of total instantaneous rate of mortality (fishing and natural mortality) is 0.11 by Dadswell et al. (2017) based on the frequency distribution of adults, 0.08 by Dadswell et al. (2017) based on von Bertalanffy growth parameters estimated by Stewart et al. (2015), and 0.11-0.115 by Dadswell et al. (2016) based on the Minas Basin summer feeding aggregation.

This total instantaneous non-natural mortality (fishing + other undesignated sources) of 0.035 is below the F_{50} for the Atlantic Sturgeon (Boreman 1997, Dadswell et al. 2017) of 0.05 for the current quota of 350 individuals. The exploitation rate of 0.035 is also below the rate calculated that would achieve 50% of the lifetime maximum number of eggs per recruit of Atlantic Sturgeon (F=0.05) (Boreman 1997). In this model, 20% of the lifetime number of eggs is considered a minimum for sustaining a stock (calculated at F=0.14) and 50% necessary for

rebuilding (Boreman 1997), and an F of ~0.02 is close to 75% of the lifetime maximum number of eggs per recruit (Dadswell et al. 2017).

Recreational tournaments occur on the river, although the release rate is 98% and survival is expected to be high (DFO 2013a). Other sources of mortality include bycatch in other fisheries and death in turbines. Retention of bycatch is illegal; however, some fisheries, such as the set gillnet gaspereau and shad fisheries, carry a relatively high risk of mortality for incidental catch. The annual mortality from such fisheries is unknown (Bradford et al 2016). An estimated 5 Atlantic sturgeon are killed annually in turbines at the Annapolis Tidal Generating station, though it is unclear whether they are from the St. John River population (DFO 2013a). The RPA assumes 50 fish are removed annually from recreational, aboriginal, and incidental sources (DFO 2013a).

Criterion 2: Impacts on Other Species

All main retained and bycatch species in the fishery are evaluated under Criterion 2. Seafood Watch defines bycatch as all fisheries-related mortality or injury to species other than the retained catch. Examples include discards, endangered or threatened species catch, and ghost fishing. Species are evaluated using the same guidelines as in Criterion 1. When information on other species caught in the fishery is unavailable, the fishery's potential impacts on other species is scored according to the Unknown Bycatch Matrices, which are based on a synthesis of peer-reviewed literature and expert opinion on the bycatch impacts of each gear type. The fishery is also scored for the amount of non-retained catch (discards) and bait use relative to the retained catch. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard/bait score. The Criterion 2 rating is determined as follows:

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and <=3.2=Yellow or Moderate Concern*
- *Score <=2.2=Red or High Concern*

Guiding principles

- *Minimize bycatch. Ocean Wise defines bycatch as all fisheries-related mortality or injury other than the retained catch. Examples include discards, endangered or threatened species catch, bait species, pre-catch mortality and ghost fishing. All discards, including those released alive, are considered bycatch unless there is valid scientific evidence of high post-release survival and there is no documented evidence of negative impacts at the population level.*
- *The fishery optimizes the utilization of marine resources by minimizing post-harvest loss and by efficiently using marine resources as bait.*
- *Have no more than a negligible impact on any threatened, endangered or protected species. The fishery avoids catch of any threatened, endangered or protected (ETP) species. If any ETP species are inadvertently caught, the fishery ensures and can demonstrate that it has no more than a negligible impact on these populations*

Criterion 2 Summary

The Atlantic Sturgeon fishery in the Saint John River Estuary has little bycatch due to the extra-large mesh size, small spatial footprint, and realized short season (occurring only during Atlantic Sturgeon spawning runs) that reduce the fishery's impact on non-sturgeon species. While gillnet mesh sizes are selective for target sized Atlantic Sturgeon, undersized as well as oversized Atlantic Sturgeon are caught but not retained in these fisheries. However, based on

observations from the recreational Atlantic Sturgeon fishery in the Bay of Fundy, the fish are released with a high percent survival (Bradford et al. 2016).

Shortnose Sturgeon (*Acipenser brevirostrum*) are caught incidentally in the Saint John River Estuary fishery but often released unharmed (COSEWIC 2015). They are listed as a species of Special Concern in Canada under both SARA and COSEWIC (COSEWIC 2015) and listed as Endangered in the United States. Therefore, they are considered a main species under the SFW Standard and are assessed here.

Stock	**Abundance** Category (Score)	**Fishing Mortality** Category (Score)	**Subscore**	**Score** (subscore* discard modifier)	**Rating**
Atlantic sturgeon	High (1)	Moderate (3)	1.73	1.73	Red
Shortnose Sturgeon	Moderate (2.33)	Low (5)	3.41	3.41	Green

Criterion 2 Assessment

Shortnose Sturgeon, St John River (Canadian Maritimes Region), Extra-large Mesh Gill Net

Factor 2.1 Abundance

Scoring Guidelines (same as Factor 1.1 above)

Key relevant information:
No quantitative stock assessment with reference points has been conducted, although population estimates indicate that the shortnose sturgeon population status has not changed significantly since the 1970s (DFO 2014a)

As there is no stock assessment, a Productivity-Susceptibility Assessment was conducted according to the SFW standard (see below), resulting in a score of 3.16 (medium vulnerability). Therefore, as stock abundance is unknown, but the species is not highly vulnerable, this criterion scores a “moderate concern”.

Detailed rationale:
Shortnose Sturgeon have few recent abundance estimates (COSEWIC 2015). The only comprehensive census of the St. John River population was performed in the 1970s and estimated there to be approximately 18,000±30% adult Shortnose sturgeon in the Saint John River between 1973 and 1977 (Dadswell 1979, DFO 2014a, DFO 2016). A mark-recapture study in the Kennebecasis River (a St. John River tributary) between 1998 and 2004 concluded that there CPUE and growth similarities suggest the status of shortnose Sturgeon in the Saint John

River has not changed significantly since Dadswell's (1979) population estimate (DFO 2014a, DFO 2016).

Stokesbury et al. (2014) compared the Saint John River shortnose sturgeon population to other rivers throughout their range and found that on average the Saint John River had a high population estimate (but less than the highest of 57,000 adults in the Hudson River) and did not warranted being listed as threatened. Li et al. (2007) and Usvyatsov et al. (2012) found that a subgroup of the Saint John River population overwintering at the confluence of the Kennebecasis and Hammond rivers (tributaries of the Saint John River) had not change in composition or abundance from 2005 to 2011.

Productivity-Susceptibility Analysis:

Scoring Guidelines:

1) Productivity score (P) = average of the productivity attribute scores (p1, p2, p3, p4 (finfish only), p5 (finfish only), p6, p7, and p8 (invertebrates only))
2) Susceptibility score (S) = product of the susceptibility attribute scores (s1, s2, s3, s4), rescaled as follows: $S = [(s1 * s2 * s3 * s4) - 1/40] + 1$.
3) Vulnerability score (V) = the Euclidean distance of P and S using the following formula: $V = \sqrt{(P^2 + S)^2}$

Shortnose Sturgeon (*Acipenser brevirostrum*)

Productivity Attribute	**Relevant Information**	**Score (1 = low risk, 2 = medium risk, 3 = high risk)**
Average age at maturity	14-17 (Jones et al. 1978)	3
Average maximum age	67 years (DFO 2016)	3
Fecundity	27,000 – 208,000 eggs/year (Dadswell 1979)	1
Average maximum size	143 cm (Scott and Scott 1988	2
Average size at maturity	45-55cm (Dadswell et al. 1984)	2
Reproductive strategy	Demersal egg layers, external fertilisation (DFO 2016)	2
Trophic level	3.25 (Froese and Pauly 2017)	2
Productivity score:	**2.14**	

Susceptibility Attribute	Relevant Information	Score (1 = low risk, 2 = medium risk, 3 = high risk)
Areal overlap (Considers all fisheries)	Not targeted by directed fisheries, but vulnerable as bycatch in several set gillnet fisheries. Extent of geographic range this occurs in is unknown. Default score applied.	3
Vertical overlap (Considers all fisheries)	Unknown. Default score applied	3
Selectivity of fishery (Specific to fishery under assessment)	Species is caught incidentally. Mesh size is large (33cm), so many juveniles will escape, but there is still potential for adults to be caught as size of maturity is 45-55cm. High risk conditions do not apply.	2
Post-capture mortality (Specific to fishery under assessment)	All captured are released and the species exhibits characteristics likely to make tolerant to capture and have a better chance of survival when released (DFO 2016), however, this has not been recently studied in the St John River.	3
Susceptibility Score	**2.33**	

Overall Score – 3.16 (Medium vulnerability).

Factor 2.3 Modifying Factor: Discards and Bait Use

Goal: Fishery optimizes the utilization of marine and freshwater resources by minimizing post-harvest loss. For fisheries that use bait, bait is used efficiently.

Scoring Guidelines: The discard rate is the sum of all dead discards (i.e. non-retained catch) plus bait use divided by the total retained catch.

Ratio of bait + discards/landings	Factor 2.4 score
<100%	1
≥100	0.75

St John River, Extra-large Gillnet

Key relevant information:

As the Saint John River Atlantic Sturgeon fishery uses extra-large mesh gillnets to intercept adults before and after their spawning migration, there is no bait use and little capture of subadult fish or bycatch. Bycatch of shortnose sturgeon and capture of subadult Atlantic sturgeon are almost always released with a high probability of survival post-capture (COSEWIC 2015, Bradford et al. 2016). Therefore, as the ratio of bait and discards/landings is less than 100%, no modification was applied to the score.

Criterion 3: Management Effectiveness

Five factors are evaluated in Criterion 3: Management Strategy and Implementation, Bycatch Strategy, Scientific Research/Monitoring, Enforcement of Regulations, and Inclusion of Stakeholders. Each is scored as either 'highly effective', 'moderately effective', 'ineffective,' or 'critical'. The final Criterion 3 score is determined as follows:

- *5 (Very Low Concern) — Meets the standards of 'highly effective' for all five factors considered.*
- *4 (Low Concern) — Meets the standards of 'highly effective' for 'management strategy and implementation' and at least 'moderately effective' for all other factors.*
- *3 (Moderate Concern) — Meets the standards for at least 'moderately effective' for all five factors.*
- *2 (High Concern) — At a minimum, meets standards for 'moderately effective' for Management Strategy and Implementation and Bycatch Strategy, but at least one other factor is rated 'ineffective.'*
- *1 (Very High Concern) — Management Strategy and Implementation and/or Bycatch Management are 'ineffective.'*
- *0 (Critical) — Management Strategy and Implementation is 'critical'.*

The Criterion 3 rating is determined as follows:

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and <=3.2=Yellow or Moderate Concern*
- *Score <=2.2 = Red or High Concern*

Rating is Critical if Management Strategy and Implementation is Critical.

Guiding principle

The fishery is managed to sustain the long-term productivity of all impacted species.

Criterion 3 Summary

Fishery	3.1 Mgmt strategy and implement.	3.2 Bycatch Strategy	3.3 Scientific research and monitoring	3.4 Enforcement	3.5 Stakeholder Inclusion	**Management Effectiveness Category (Score)**	**C3 Rating**
St John River	Moderately Effective	Highly Effective	Moderately Effective	Highly Effective	Moderately Effective	Moderate (3)	Yellow

Criterion 3 Assessment

Factor 3.1 Management Strategy and Implementation

Considerations: What type of management measures are in place? Are there appropriate management goals, and is there evidence that management goals are being met? Do manages follow scientific advice? To achieve a highly effective rating, there must be appropriately defined management goals, precautionary policies that are based on scientific advice, and evidence that the measures in place have been successful at maintaining/rebuilding species.

St John River (Canadian Maritimes Region), Extra-large Mesh Gill Net

Key relevant information:
There is no full stock assessment of the fishery with reference points; however, fishery-independent population estimates have been conducted and an estimation of F was calculated (Dadswell et al. 2017). Management of the fishery is based on scientific advice, errs on risk adverse quotas, and imposes a number of regulations to control fishing mortality (see below for list of regulations). Science-based assessments occur frequently through governmental (COSEWIC 2011, DFO 2013c, 2013a, Bradford et al. 2016) and non-governmental (Stokesbury et al. 2014, Stewart et al. 2015, Dadswell et al. 2016, 2017) organizations to assess the current status of the stock. Management measures include limited licenses, temporal closures to protect spawning, gear limits, a minimum size limit and a conservative TAC (DFO 2009).

Although the stock is considered 'threatened' (COSEWIC 2011), no recovery strategy has yet been developed. However, the RPA indicates that the measures that have been put in place will ensure that stock remains stable (DFO 2013). Recent research suggests that measures have been in fact effective at initiating some recovery of the stock (Dadswell et al. 2017). Therefore, as only some of the criteria for 'highly effective' are met, this criterion scores 'moderately effective'.

Detailed rationale:

Regulations (from Bradford et al. 2016)*:*
Numerous regulations are imposed on the Saint John River Atlantic Sturgeon fishery. Participants are limited by non-transferable licenses (4 remaining licenses, 3 active in the Saint John River Estuary) and required to complete and submit logbooks. Harvest and fishing effort are limited by temporal closures for the month of June. As the fishery targets adults, it is effectively limited to May, July, and August as adults enter and exit the river before and after spawning upstream. Other harvest and fishing effort restrictions are spatial restriction to the tidal reaches of the Saint John River, a harvestable quota limit of 350 individuals for the commercial fishery, and total allowable catch (TAC) of 400 individuals allows for 50 individuals available to Aboriginal fisheries that typically take less than 5 fish per year. The commercial quota is also rarely fully filled but has approached the quota limit frequently in recent years as

there is a 50:50 sex ratio limit that closes the fishery once 175 of either sex are retained. Wild fish retained for aquaculture are counted against the quota but are required to be released in the following year (C. Ceapa pers. comm.).

Monitoring by DFO oversees the fishery annually (Bradford et al. 2016). Some examples of other management measures are: (A) a temporal closure to protect migrating spawning adults in June; (B) the tracking size-structure of the intercepted population; (C) use of minimum size limit of 120 cm to protects subadults; (D) closure when 175 males or females are retained; (E) total allowable catch (TAC) is low (350 individuals) to reduce fishing mortality. The TAC was set after determining the stock had a healthy age structure and the historic catch of 400 individuals had occurred for 40 years (DFO 2009).

Gear is restricted to a minimum gill-net mesh size of 33 cm and retained individuals must be greater than a minimum size limit of >120 cm in total length. Retained individuals are individually tagged to track the filling of quota (dockside monitoring) and processing (smoked flesh or caviar production). Caviar production is limited to 400 kg per annum. An annual review of fishery logbooks is conducted by DFO Fishery Management and regular monitoring is conducted by fishery officers. Additionally, fishers are active stakeholders and choose fish to maximize value of the yield as well as allowing large post-spawn females to exit the fishery if caught. Also, if captured fish appear to be unable to be released alive, the individual is landed. (C. Ceapa pers. comm.). Fishers have also contributed actively to government status reports (Bradford et al. 2016) and non-governmental research (Stewart et al. 2015, Dadswell et al. 2016, 2017).

Factor 3.2 Bycatch Strategy

Considerations: What type of management strategy/measures are in place to reduce the impacts of the fishery on bycatch species and when applicable, to minimize ghost fishing? How successful are these management measures? To achieve a Highly Effective rating, the fishery must have no or low bycatch, or if there are bycatch or ghost fishing concerns, there must be effective measures in place to minimize impacts.

St John River (Canadian Maritimes Region), Extra-large Mesh Gill Net

Key relevant information:
Fishery is implemented in a narrow reach of the St. John's River (Dadswell et al. 2017) and utilizes extra-large gill nets (33 to 38 cm) allowing all species but the target species, Atlantic Sturgeon, and, very infrequently, captured shortnose sturgeon to escape. Individuals of the target species less than 130 cm in fork length are infrequently caught by the gear but are not retained (Dadswell et al. 2017).

Bycatch strategy scores as "highly effective" as there is limited, only incidental, bycatch of shortnose sturgeon. Shortnose sturgeon have post-capture survival and are typically too small to be captured by the extra-large mesh gillnets used in the Saint John River Atlantic Sturgeon

fishery (COSEWIC 2015, DFO 2016). These minimize bycatch to the greatest extent possible and results in the fishery not being a source of high mortality to shortnose sturgeon.

Factor 3.3 Scientific Research and Monitoring

Considerations: How much and what types of data are collected to evaluate the fishery's impact on the species? Is there adequate monitoring of bycatch? To achieve a Highly Effective rating, regular, robust population assessments must be conducted for target or retained species, and an adequate bycatch data collection program must be in place to ensure bycatch management goals are met.

St John River (Canadian Maritimes Region), Extra-large Mesh Gill Net

Key relevant information:
An independent robust stock assessment has not been completed due to a lack of relevant information, however DFO reviews stock status annually (Bradford et al. 2016). There are plans to conduct a stock assessment under the current research regime (C. Ceapa pers. comm.). A partnership of fishers/buyers (Acadian Sturgeon and Caviar Ltd.), government agencies (DFO), and universities (Acadia University and University of New Brunswick) gathers the following data: 1) Tissue samples and pelvic fin spines of all landed fish 2) Length, weight, sex, and fecundity (using a probe to measure gonadal maturation stage) on captured fish 3) Mark and recapture (PIT and t-bar tags) of all released fish, 4) Acoustic tagging and tracking of select individuals, 5) Ageing of landed fish and 6) Fishing effort is recorded and CPUE indices are in development (C. Ceapa pers. comm.)(DFO 2013a, 2013c).

Scientific research and monitoring scores as "moderately effective" because there is an annual review of the stock status and the stock is intensively monitored. Fisheries-independent data is collected through DFO Science Branch. Scientific mark-recapture occurred in 2016 through catch and release contracts with fishers during the season closure in June. Ultrasonic tracking of mature adults has also occurred in concert with the fishery to understand interactions between gillnets and sturgeon as well as to determine the spawning periodicity (C. Ceapa pers. comm.).

Factor 3.4 Enforcement of Management Regulations

Considerations: Do fishermen comply with regulations, and how is this monitored? To achieve a Highly Effective rating, there must be regular enforcement of regulations and verification of compliance.

St John River (Canadian Maritimes Region), Extra-large Mesh Gill Net

Key relevant information:
Enforcement scores as "highly effective" because DFO enforces regulations, collects commercial logbooks, and conducts dockside monitoring. The DFO Conservation and Protection officers inspect fishers at least 5-6 times per month during the effective fishing season (May, July, and August (C. Ceapa pers. comm.)). Retained individuals are individually tagged to track quota filling and processing (Bradford et al. 2016) and reported daily to from the first day nets are soaked (C. Ceapa pers. comm.). The license number, individual tag numbers, sex, total length, date, time, and location of landing, as well as the buyer are reported with the daily catch data (C. Ceapa pers. comm.). Processing market is limited to one buyer (Acadian Sturgeon and Caviar Ltd.) and adds a layer of additional monitoring, reducing illegal take (C. Ceapa pers. comm.)(DFO 2013a).

Bradford et al. (2016) note that “enforcement is considered to be effective at minimizing retention of bycatch and illegal harvest.” At the beginning of the season, fishers are provided harvest tags (less than the quota total) and contact DFO Fisheries Management to request more. As the quota is close to being reach, fishers and managers contact each other regularly to monitor quota filling. When the quota is reached, all gear is removed from the water and DFO closes the fishery. One month after the quota is reached, fishers send their logbooks to Atlantic Catch Data and the original boat logs to DFO Science Branch (C. Ceapa pers. comm.).

Factor 3.5 Stakeholder Inclusion

Considerations: Are stakeholders involved/included in the decision-making process? Stakeholders are individuals/groups/organizations that have an interest in the fishery or that may be affected by the management of the fishery (e.g., fishermen, conservation groups, etc.). A Highly Effective rating is given if the management process is transparent, if high participation by all stakeholders is encouraged, and if there a mechanism to effectively address user conflicts.

St John River (Canadian Maritimes Region), Extra-large Mesh Gill Net

Key relevant information:
Stakeholder inclusion scores as "moderately effective" because DFO has provisions in its management strategies for consultation (DFO 2004) but until a formal SARA listing decision is made those consultation are on hold. DFO consultation provisions are guidelines for transparency and stakeholders actively engage with managers to contribute to the implementation and design of management (C. Ceapa pers. comm.)(DFO 2004, 2013c). Fishers have contributed to the management of the stock by collaborating on government reports (Bradford et al. 2016) and non-governmental research (Stewart et al. 2015, Dadswell et al. 2016, 2017). Given the strict regulations on the Atlantic Sturgeon fishery, DFO handles fisheries management through writing or telephone (Greg Stevens, DFO, pers. comm.).

As a formal decision regarding the Atlantic Sturgeon's listing status under SARA has not been made, there is little ongoing consultation with stakeholders. If Atlantic Sturgeon are listed as "Threatened", it is likely that all commercial fisheries will cease. However, should they not be listed, an Atlantic Sturgeon management plan will be developed in consultation with a broad range of stakeholders (Greg Stevens, pers. comm.). In summary, all decisions about alternate or additional resource use require a formal SARA listing decision. Stakeholders, fishers and the sole commercial buyer, are included in the current management regime as well as indigenous users and aquaculturists. Other stakeholders will be consulted upon develop of an Atlantic Sturgeon management plan (Greg Stevens, pers. comm.)

Criterion 4: Impacts on the Habitat and Ecosystem

This Criterion assesses the impact of the fishery on seafloor habitats, and increases that base score if there are measures in place to mitigate any impacts. The fishery's overall impact on the ecosystem and food web and the use of ecosystem-based fisheries management (EBFM) principles is also evaluated. Ecosystem Based Fisheries Management aims to consider the interconnections among species and all natural and human stressors on the environment.

The final score is the geometric mean of the impact of fishing gear on habitat score (factor 4.1 + factor 4.2) and the Ecosystem Based Fishery Management score. The Criterion 4 rating is determined as follows:

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and <=3.2=Yellow or Moderate Concern*
- *Score <=2.2=Red or High Concern*

Guiding principles

- *Avoid negative impacts on the structure, function or associated biota of marine habitats where fishing occurs.*
- *Maintain the trophic role of all aquatic life.*
- *Do not result in harmful ecological changes such as reduction of dependent predator populations, trophic cascades, or phase shifts.*
- *Ensure that any enhancement activities and fishing activities on enhanced stocks do not negatively affect the diversity, abundance, productivity, or genetic integrity of wild stocks.*
- *Follow the principles of ecosystem-based fisheries management.*

Criterion 4 Summary

Fishery	**4.1a Gear type and substrate** Score	**4.1b Mitigation of gear impacts** Score	**4.2 EBFM** Category (Score)	**Criterion 4** Rating Score
St John River	3	1	Moderate (3)	Green 3.46

Criterion 4 Assessment

Factor 4.1 Physical Impact of Fishing Gear on the Habitat/Substrate

Goal: The fishery does not adversely impact the physical structure of the ocean habitat, seafloor or associated biological communities.

Scoring Guidelines:

- *5 —Fishing gear does not contact the bottom*
- *4 —Vertical line gear*
- *3 —Gears that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Or bottom seine on resilient mud/sand habitats. Or midwater trawl that is known to contact bottom occasionally. Or purse seine known to commonly contact the bottom.*
- *2 —Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Or gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Or bottom seine except on mud/sand. Or there is known trampling of coral reef habitat.*
- *1 —Hydraulic clam dredge. Or dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 —Dredge or trawl fished on biogenic habitat, (e.g., deep-sea corals, eelgrass and maerl)*

Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive, plausible habitat type.

St John River (Canadian Maritimes Region), Extra-large Mesh Gill Net

Key relevant information:
The large mesh bottom gillnets used in this fishery are employed over sand, mud, and a mix of gravel (DFO 2013a, 2013c)(C. Ceapa pers. comm.). The default score for this gear over non-vulnerable benthic habitat is ‘3’.

Factor 4.2 Modifying factor: Mitigation of gear impacts

Goal: Damage to the seafloor is mitigated through protection of sensitive or vulnerable seafloor habitats, and limits on the spatial footprint of fishing on fishing effort.

Scoring Guidelines:

- *+1 —>50% of the habitat is protected from fishing with the gear type. Or fishing intensity is very low/limited and for trawled fisheries, expansion of fishery's footprint is prohibited. Or gear is specifically modified to reduce damage to seafloor and modifications have been shown to be effective at reducing damage. Or there is an effective combination of 'moderate' mitigation measures.*
- *+0.5 —At least 20% of all representative habitats are protected from fishing with the gear type and for trawl fisheries, expansion of the fishery's footprint is prohibited. Or gear modification measures or other measures are in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing that are expected to be effective.*
- *0 —No effective measures are in place to limit gear impacts on habitats or not applicable because gear used is benign and received a score of 5 in factor 4.1.*

St John River (Canadian Maritimes Region), Extra-large Mesh Gill Net

Key relevant information:
Fishing effort is restricted to the tidal reaches of the Saint John River (Bradford et al. 2016). This restricts the spatial footprint of the fishery to a narrow area in use only by adult Atlantic Sturgeon, the target of the fishery, during May-August. Fishing is prohibited during June, the height of the pre-spawning migration. Upstream spawning grounds are off limits as well as marine habitats occupied the remainder of the year. The majority of the stock's habitat is protected from commercial exploitation (Bradford et al. 2016). Therefore, a mitigation score of +1 is applied.

Factor 4.3 Ecosystem-based Fisheries Management

Goal: All stocks are maintained at levels that allow them to fulfill their ecological role and to maintain a functioning ecosystem and food web. Fishing activities should not seriously reduce ecosystem services provided by any retained species or result in harmful changes such as trophic cascades, phase shifts or reduction of genetic diversity. Even non-native species should be considered with respect to ecosystem impacts. If a fishery is managed in order to eradicate a non-native, the potential impacts of that strategy on native species in the ecosystem should be considered and rated below.

Scoring Guidelines:

- *5 (Very Low Concern)—Policies that have been shown to be effective are in place to protect species' ecological roles and ecosystem functioning (e.g. catch limits that ensure species' abundance is maintained at sufficient levels to provide food to predators) and effective spatial management is used to protect spawning and foraging areas, and prevent localized depletion. Or it has been scientifically demonstrated that fishing practices do not have negative ecological effects.*
- *4 (Low Concern)—Policies are in place to protect species' ecological roles and ecosystem functioning but have not proven to be effective and at least some spatial management is used.*
- *3 (Moderate Concern)— Policies are not in place to protect species' ecological roles and ecosystem functioning but detrimental food web impacts are not likely or policies in place may not be sufficient to protect species' ecological roles and ecosystem functioning.*
- *2 (High Concern)— Policies are not in place to protect species' ecological roles and ecosystem functioning and the likelihood of detrimental food impacts are likely (e.g. trophic cascades, alternate stable states, etc.), but conclusive scientific evidence is not available for this fishery.*
- *1 (Very High Concern)— Scientifically demonstrated trophic cascades, alternate stable states or other detrimental food web impact are resulting from this fishery.*

St John River (Canadian Maritimes Region), Extra-large Mesh Gill Net

Key relevant information:
Atlantic sturgeon has a mid-level trophic score and food-web impacts are unlikely. Spatial planning is in place, at a fishery level in terms of harvesting being restricted to tidal areas, and at a wider estuary and regional level, including Marine Protected Areas. However, no planning decisions have been made with specific respect to the species' ecological role. Therefore, this criterion scores a "moderate concern".

Detailed rationale:
Atlantic Sturgeon is not considered to be an "exceptional species"; this species occupies a mid-level trophic position within the food web (level of 3.4, consumers of benthic invertebrates (Froese and Pauly 2017) and does not represent a substantial link to upper trophic levels (low levels of natural mortality). Scientific assessment of ecosystem impacts are ongoing (COSEWIC 2011, DFO 2013a, 2013c). Specifically, the relative impacts of tidal power generation are underway (Wirgin et al. 2012).

Key habitats within the Bay of Fundy and Saint John River have been identified. In the Bay of Fundy, subadults and juveniles occur in the Minas Passage and Minas Basin during the summer

and the entirety of the lower Saint John River and its tributaries are important for adults particularly during spawning over the summer and possibly for overwintering (Bradford et al. 2016). Spatial management is used to limit the impact of the Saint John River Atlantic Sturgeon fishery. Other marine spatial management measures protect key Atlantic Sturgeon habitat such as the Musquash Estuary Marine Protected Area DFO 2017). A regional spatial management plan balances diverse resource use (shipping, oil and gas development, aquaculture, fishing, tourism, etc.) throughout the range of Atlantic Sturgeon in the Maritimes (DFO 2014b).

Acknowledgements

Ocean Wise would like to thank the external reviewers for their constructive comments.

References

Boreman, J. 1997. Sensitivity of North American sturgeons and paddlefish to fishing mortality. Environmental Biology of Fishes; Dordrecht 48:399–405.

Bradford, R. G., P. Bentzen, C. Ceapa, A. M. Cook, A. Curry, P. Leblanc, and M. J. W. Stokesbury. 2016. Status of Atlantic Sturgeon (Acipenser oxyrinchus oxyrinchus) in the Saint John River, New Brunswick. DFO Can. Sci. Advis. Sec. Res. 2016/072.

COSEWIC. 2011. COSEWIC assessment and status report on the Atlantic Sturgeon Acipenser oxyrinchus in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, CAN.

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, CAN.

Dadswell, M. J. 1979. Biology and population characteristics of the Shortnose sturgeon, Acipenser brevirostrum LeSueur 1818 (Osteichthyes: Acipenseridae), in the Saint John River estuary, New Brunswick, Canada. Canadian Journal of Zoology 57:2186–2210.

Dadswell, M. J. 2006. A review of the status of Atlantic sturgeon in Canada, with comparisons to populations in the united states and Europe. Fisheries 31:218–229.

Dadswell, M. J., C. Ceapa, A. D. Spares, N. D. Stewart, R. A. Curry, R. G. Bradford, and M. J. Stokesbury. 2017. Population characteristics of adult Atlantic Sturgeon captured by the commercial fishery in the Saint John River estuary, New Brunswick. Transactions of the American Fisheries Society 146:318–330.

Dadswell, M. J., S. A. Wehrell, A. D. Spares, M. F. Mclean, J. W. Beardsall, L. M. Logan-Chesney, G. S. Nau, C. Ceapa, A. M. Redden, and M. J. W. Stokesbury. 2016. The annual marine feeding aggregation of Atlantic sturgeon Acipenser oxyrinchus in the inner Bay of Fundy: population characteristics and movement. Journal of fish biology 89:2107–2132.

DFO. 2004. Consultation Framework. Department of Fisheries and Oceans, Ottawa, CAN.

DFO. 2009. Evaluation of Atlantic Sturgeon (Acipenser oxyrinchus) in the Maritimes Region with Respect to Making a CITES Non-detriment Finding. DFO Can. Sci. Advis. Sec. Res. 2009/009.

DFO. 2013a. Recovery Potential Assessment for Atlantic Sturgeon (Maritimes Designatable Unit). Can. Sci. Adv. Sect. Sci. Adv. Rep., Department of Fisheries and Oceans, Dartmouth, Nova Scotia, CAN.

DFO. 2013b. Recovery Potential Assessment for the Atlantic Sturgeon, St. Lawrence population. Department of Fisheries and Oceans, Mont-Joli, Quebec, CAN.

DFO. 2013c. Evaluation of Atlantic Sturgeon (Acipenser oxyrinchus) from the Bay of Fundy Population to Inform a CITES Non-detriment Finding. Department of Fisheries and Oceans, Ottawa, CAN.

DFO. 2014a. Distinctiveness and status of the Saint John River population of Shortnose Sturgeon (Acipenser brevirostrum). DFO Can. Sci. Advis. Sec. Res. 2014/043.

DFO. 2014b. Regional Oceans Plan: Scotian Shelf, Atlantic Coast, Bay of Fundy. Regional Oceans Plan DFO/2014-1927, Fisheries and Oceans Canada, Dartmouth, Nova Scotia, CAN.

DFO. 2015. Department of Fisheries and Oceans Commercial Freshwater Fisheries Production Statistics.

DFO. 2016. Management Plan for the Shortnose Sturgeon (Acipenser brevirostrum) in Canada. Species at Risk Act Management Plan Series, Fisheries and Oceans Canada, Ottawa, CAN.

DFO. 2017. Musquash Estuary: a management plan for the Marine Protected Area and Administered Intertidal Area. Management Plan, Dartmouth, Nova Scotia, CAN.

Froese, R., and D. Pauly. 2017. FishBase.

Jones, P.W., F.D. Martin and J.D. Hardy Jr. 1978. Development of fishes of the Mid-Atlantic Bight. An atlas of eggs, larval and juvenile stages. Vol. 1. Acipenseridae through Ictaluridae. U.S. Fish Wildl. Ser. Biol. Serv. Program FWS/OBS-78/12. 336 p.

Kahnle, A. W., K. A. Hattala, and K. A. McKown. 2007. Status of Atlantic sturgeon of the Hudson River Estuary, New York, USA. Pages 347–364 *in* J. Munroe, D. Hatin, J. E. Hightower, K. A. McKown, K. J. Sulak, A. W. Kahnle, and F. Caron, editors. Anadromous sturgeons: habitats, threats and management. American Fisheries Society.

Li, X., M. K. Litvak, and J. E. H. Clarke. 2007. Overwintering habitat use of Shortnose sturgeon (Acipenser brevirostrum): defining critical habitat using a novel underwater video survey and modeling approach. Canadian Journal of Fisheries and Aquatic Sciences 64:1248–1257.

Scott, W.B. and M.G. Scott. 1988. Atlantic fishes of Canada. Can. Bull. Fish. Aquat. Sci. 219

Stewart, N. D., M. J. Dadswell, P. Leblanc, R. G. Bradford, C. Ceapa, and M. J. Stokesbury. 2015. Age and growth of Atlantic sturgeon from the Saint John River, New Brunswick, Canada. North American Journal of Fisheries Management 35:364–371.

Stokesbury, K. D., M. J. Stokesbury, M. T. Balazik, and M. J. Dadswell. 2014. Use of the SAFE Index to evaluate the status of a summer aggregation of Atlantic sturgeon in Minas Basin, Canada, and the implication of the index for the USA endangered species designation of Atlantic and shortnose sturgeons. Reviews in Fisheries Science & Aquaculture 22:193–206.

Usvyatsov, S., J. Watmough, and M. K. Litvak. 2012. Age and population size estimates of overwintering shortnose sturgeon in the Saint John River, New Brunswick, Canada. Transactions of the American Fisheries Society 141:1126–1136.

Verreault, G., and G. Trencia. 2011. Atlantic Sturgeon (Acipenser oxyrinchus oxyrinchus) fishery management in the St. Lawrence Estuary, Québec, Canada. Page Chapter 40 Biology and Conservation of the European Sturgeon Acipenser sturio L. 1758. Springer-Verlag, Berlin Heidelberg.

Wirgin, I. 2016. Genetic assignment of adult Atlantic Sturgeon from the Saint John River. Department of Environmental Medicine, NYU School of Medicine, Tuxedo, New York.

Wirgin, I., L. Maceda, J. R. Waldman, S. Wehrell, M. Dadswell, and T. King. 2012. Stock origin of migratory Atlantic Sturgeon in Minas Basin, inner bay of Fundy, Canada, determined by microsatellite and mitochondrial DNA analyses. Transactions of the American Fisheries Society 141:1389–1398.