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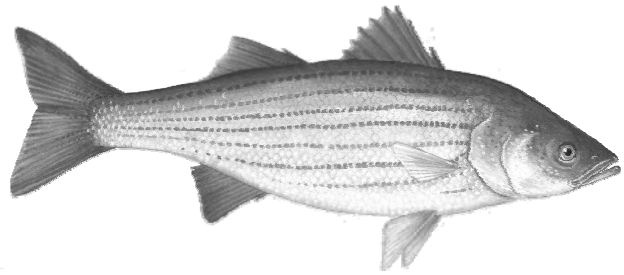
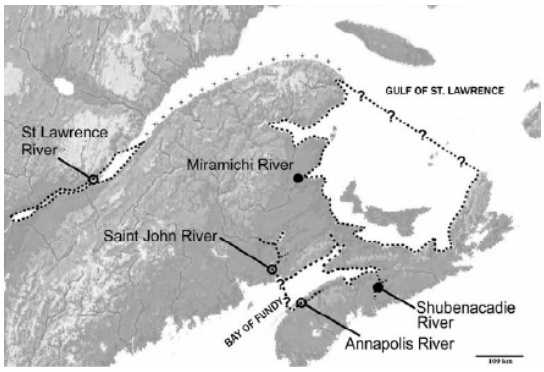
Gulf Region
Canadian Science Advisory Secretariat
Science Advisory Report 2006/053

RECOVERY POTENTIAL ASSESSMENT FOR THE ST. LAWRENCE ESTUARY, SOUTHERN GULF OF ST. LAWRENCE AND BAY OF FUNDY STRIPED BASS (*Morone saxatilis*) POPULATIONS





From: COSEWIC 2004.

Context

In 2004, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed three "designatable units" (DU) of striped bass as extirpated (XT) for the St. Lawrence Estuary, and threatened (TH) for the southern Gulf of St. Lawrence and the Bay of Fundy. If the Governor in Council accepts COSEWIC's recommendations, striped bass will be listed on, and afforded protection under, Canada's Species at Risk Act (SARA).

The last reported catch of striped bass in the Saint Lawrence Estuary occurred in 1969. Reasons for this population's extirpation have been linked to habitat degradation and overfishing.

Although southern Gulf striped bass spawn at a single location, meeting COSEWIC's endangered criteria for small distribution, it was designated as threatened "because of the high degree of resilience evident from recent spawner abundance estimates". COSEWIC identified threats to the southern Gulf population that included bycatch in commercial gaspereau and rainbow smelt fisheries, as well as, illegal harvests.

Bay of Fundy striped bass were assessed as threatened on the basis that repeated spawning failures had led to the disappearance of the Annapolis and Saint John River populations, which were two of the three populations known to occur in the Bay. These disappearances were thought to be due to changes in flow regime and/or poor water quality. Threats to the Shubenacadie River population, the third documented spawning group, were the presence of the introduced chain pickerel (Esox niger) in overwintering sites and bycatch from various commercial fisheries.

SUMMARY

St. Lawrence Estuary

- The St. Lawrence Estuary population disappeared in the late 1960's.
- A re-introduction program was initiated in 2002 with the objective of re-establishing the species in its historical area of occupancy.
- A recovery target was defined on the basis of re-establishing a population than can perpetuate itself with an area of occupancy and occurrence that existed in the past.
- Recovery is considered potentially feasible with the implementation of the re-introduction program.

Southern Gulf of St. Lawrence

- The Northwest Miramichi River is the only striped bass spawning area, known historically and currently, within the southern Gulf of St. Lawrence. Spawning has resulted in the production of new individuals every year since monitoring began in 1993.
- The extent of occurrence for this population of striped bass has remained unchanged and includes the coastal realm of the entire southern Gulf of St. Lawrence.
- A recovery target was defined on the basis of adult striped bass spawner abundance and a compliance rule of exceeding the target in 5 out of 6 years was proposed.
- Recovery was considered feasible but additional mortality beyond current levels will decrease this population's potential for recovery as described in this RPA.
- Under the present mortality conditions, there is a low probability of exceeding the recovery limit by 2015.
- Illegal harvests are believed to be the most important limiting factor for this population of striped bass.

Bay of Fundy

- The Shubenacadie River is the only one of three historical spawning locations in the Bay of Fundy DU where striped bass continue to be produced annually.
- The presence of migrant US fish in the Bay of Fundy DU confounds the perception of status.
- Harvest levels (directed, bycatch) for striped bass in the Bay of Fundy DU are not supported with assessment information on abundance or reference levels.
- A recovery target was defined on the basis of area of occupancy.
- Recovery was considered to be potentially feasible, however the severity of stated threats and specific mechanisms contributing to the reported loss of the Annapolis and Saint John populations are unknown.

BACKGROUND

Rationale for Assessment

Listing under SARA carries automatic prohibitions against activities that threaten either the survival or recovery of species. However, Section 73(3) of the Act authorizes competent Ministers to permit otherwise prohibited activities affecting a listed wildlife species, any part of its critical habitat, or the residences of its individuals if the following conditions are met:

1) all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted
2) all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals, and
3) the activity will not jeopardize the survival or recovery of the species

Authorized activities must be for one or more of the following purposes:

(a) the activity is scientific research relating to the conservation of the species and conducted by qualified persons,
(b) the activity benefits the species or is required to enhance its chance of survival in the wild, or
(c) affecting the species is incidental to the carrying out of the activity.

Both authorization of incidental harm and recovery planning require information concerning the impact of human activities on both the survival and recovery of the species, alternatives and mitigation measures to these activities, and an assessment of the potential for recovery of the species. An evaluation framework consisting of three phases (species status, scope for human – induced harm and mitigation) has been established by DFO to allow determination of whether or not SARA incidental harm permits can be issued until a recovery plan has been developed and to determine if the activity could be authorized within the recovery plan. The analysis provided in this report will inform decisions relating to the listing of striped bass and its recovery planning.

In the context of this Science Advisory Report, “harm” refers to all prohibitions as defined in the SARA. The term “mortality” is used throughout the document to cover the full range of prohibited activities (i.e., harm, harass, capture, kill, take, damage or destroy a residence or critical habitat), and includes reduction in production or productivity, as well as death of individuals.

Species Biology

Striped bass is an anadromous percoid that spawns in many estuaries along the eastern seaboard of North America. The natural range of the striped bass extends along the western Atlantic Ocean from the St. Lawrence River in Québec, Canada, to the St. John’s River in Florida, U.S.A but, is only considered anadromous north of Cape Hatteras, North Carolina. Highest concentrations of striped bass occur in the middle of the species range; specifically in the Chesapeake Bay area of Maryland and the Hudson River of New York.

Historically, striped bass are considered to have spawned at 5 locations in eastern Canada: the St. Lawrence estuary (Quebec), the Miramichi estuary of the southern Gulf of St. Lawrence, and the Saint John, Annapolis and Shubenacadie estuaries of the Bay of Fundy. Genetic analyses and tagging studies indicate that striped bass in the southern Gulf are isolated from those in the

Bay of Fundy. Striped bass from populations in the USA undergo annual summer migrations to the Bay of Fundy.

Striped bass spawn in tidal freshwater near the upper limit of the salt wedge of estuaries. Spawning for Canadian striped bass occurs during May and June. Female striped bass are highly fecund, often producing 50,000 eggs per kilogram of their own weight. Age to sexual maturation generally occurs at ages 4 to 5 (45 – 55cm fork length) for females and earlier for males at ages 2 to 4 (35 – 50cm fork length). A river temperature of about 15^{o}C is associated with spawning. Milt and eggs are broadcast simultaneously into the water column, float freely, and hatch in 2-3 days depending on water temperatures and conditions. Larval striped bass exhaust their yolk reserves in 1-2 weeks at which time exogenous feeding begins on small zooplankton and benthic invertebrates. Mortality of striped bass eggs and larvae can be high when exposed to adverse environmental conditions. Growth can be rapid during the summer months with end of season fork length ranging between 8 and 20 cm.

Young-of-the-year (YOY) striped bass move to the nearshore habitats of estuaries shortly after the transition from larvae to juvenile is complete. Juveniles exhibit a downstream range extension into saline environments throughout the summer. By October, their range can extend from a few to hundreds of kilometres away from their river of origin. Both YOY and adult striped bass return to estuaries or freshwater habitats in the fall to spend the winter. Wintering and spawning sites are not necessarily synonymous.

As striped bass grow and become high order predators within estuarial and coastal ecosystems, their diet shifts to include small fishes and invertebrates such as Atlantic silversides, alosids, herring, American eels, and crabs. Canadian spawned striped bass can be long lived, reaching a maximum age of at least 20 years and a maximum length of over 1 m.

ASSESSMENT

Trend and Current Status

St. Lawrence Estuary: Fishing mortality for striped bass is reported to have increased during the mid 1950s and the last reported catch of striped bass in the St. Lawrence estuary occurred in the late 1960's. Dredging of navigation channels in traditional rearing areas may have displaced immature bass into southern parts of the estuary where commercial fisheries for American eel were abundant and efficient at catching them, which is believed to have removed many immature bass from the population.

Some of the factors that contributed to the disappearance of striped bass in the St. Lawrence estuary are still present today but, exist in a very different context and at lower risk levels than before.

Since 1975, dredging has been exclusively for maintenance purposes and the volume of sediment dredged has been much smaller than during the widening and deepening of the seaway done in the past. Moreover, the Canadian Coast Guard is currently studying ways of reducing the environmental impact of the maintenance dredging of the St. Lawrence Seaway and the deposits it generates.

Striped bass fishing is prohibited in the St. Lawrence. As a result, all striped bass caught by commercial fishers or anglers must be put back in the water. However, although the eel fishing

effort has declined considerably since the early 1960s, when the population disappeared (the number of fishers dropped from about 200 to fewer than 50), bass are still dying in this gear. Yet, the mortality rate of bass accidentally caught during commercial eel fishing, estimated at 50%, could be considerably reduced with simple modifications to the fishing gear.

A recovery program is currently being carried out by the Ministère des Ressources naturelles et de la Faune du Québec in cooperation with the Fédération québécoise de la faune and Hydro-Québec. Young-of-the-year striped bass caught in the Miramichi River, in the southern Gulf, are raised in fish culture stations to produce juveniles that are then placed in the estuary. The goal is to seed 50 000 fry each year for 10 years, starting in 2008. Since 2002, some 3 500 young-of-the-year have been transferred from the Miramichi River to the St. Lawrence estuary, and by-catches are reported regularly, suggesting a good level of growth and survival of the individuals introduced.

Southern Gulf of St. Lawrence: Mark-recapture experiments conducted on spawning striped bass in the Northwest (NW) Miramichi River indicated an average of 22,000 fish over the last 5 years (2001-2005) and represented a modest increase from the record low of the 1998 to 2000 period (Fig. 1). Spawning runs of striped bass to the NW Miramichi continue to be represented by a limited number of year-classes. Male recruitment of the 2002 year-class, which became mature in 2005, was poor and suggests that the female component of this year-class may be weak in 2006 and beyond.

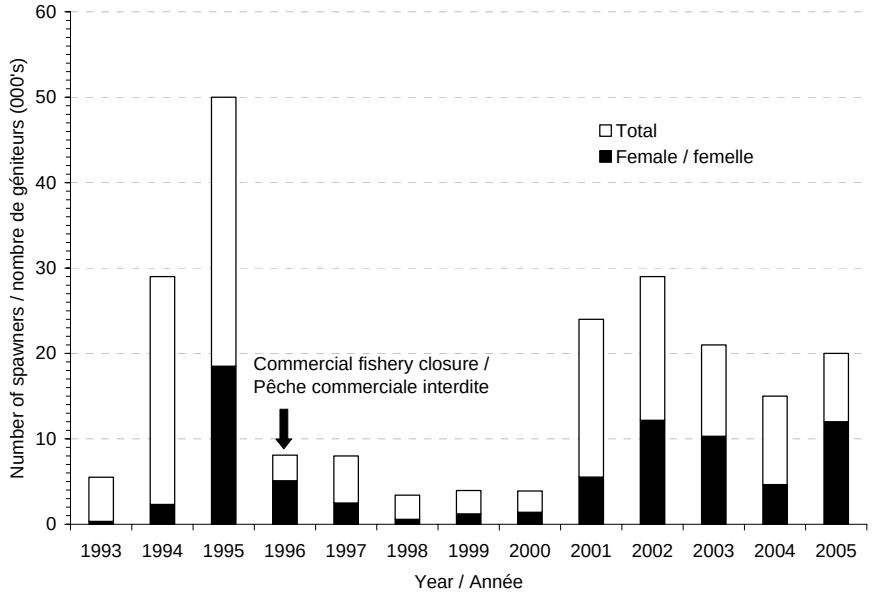


Figure 1. Spawner abundance estimates between 1993 and 2005 for southern Gulf striped bass.

Total annual mortality for striped bass aged 3-7 has averaged about 60% since commercial fishing for southern Gulf bass was closed in 1996. Since 1993, the length and age distributions for the spawning component are dominated by fish of 50cm and ages 5 to 6. This phenomenon is often indicative of a population with high mortality, as a combination of natural and fishing mortality. All directed fisheries for striped bass in the southern Gulf remain closed but illegal harvests occur.

Successful striped bass spawning is believed to be limited to the Northwest Miramichi River. Spawned eggs and larvae have not been observed in samples taken from neighbouring estuaries. Recaptured striped bass from conventional tagging studies have shown the species ranging between Percé, Quebec and Margaree, Cape Breton. Juvenile and adult striped bass continue to occupy the whole of the southern Gulf indicating that the extent of occurrence has remained unchanged.

Bay of Fundy: There is no new information to inform on the status of the Annapolis River population, considered extirpated.

Recent genetic studies confirm that the extent of occurrence of the Shubenacadie population extends at least to the Saint John River, New Brunswick. Bycatch data from the Shubenacadie alosid fisheries suggest that striped bass spawner abundance has likely increased since the 2003 assessment, consistent with expectations arising from recruitment of the 1999 year-class. Juveniles have been produced annually since 1999.

Genetic analysis of striped bass collected in the Saint John River since 2000 revealed the presence of Shubenacadie origin, USA origin, and a potential third group of fish which could not be assigned to any known population. These fish exhibit greater genetic similarity to the southern Gulf and Shubenacadie populations than to any of the U.S.A origin populations included in the analysis.

The evidence for existence of a previously unidentified population occurring within the Bay of Fundy, while introducing uncertainty in the stock structure of striped bass in the Bay of Fundy, is not considered sufficient to entertain the possibility of a status review (presence of populations, extent of occurrence, and area of occupancy) of the Bay of Fundy striped bass DU at this time.

Feeding migrations of U.S.A origin striped bass mix with native striped bass within the Bay of Fundy.

Residence and Critical Habitat

SARA prohibits damaging or destroying the residence of a listed threatened, endangered, or extirpated species. A residence is defined by SARA as a dwelling place that is similar in either form or function to a den or nest.

There was insufficient information to determine if the concepts of residence and critical habitat as defined by SARA would apply to any of the three striped bass DU's. Scoping of the issues did nonetheless reveal that pre-spawning staging areas, spawning sites, and wintering areas represent habitat which is essential for completing the life cycle and which are potentially definable in time and space. For the southern Gulf of St. Lawrence and Bay of Fundy DU's, the locations of these sites are identifiable in general terms and could be protected under the *Fisheries Act*. Similar sites could also be protected for the St. Lawrence Estuary DU.

Recovery Targets and Potential

Recovery of striped bass is associated with the status of two attributes: area of occupancy and abundance. Area of occupancy refers to the spatial extent of spawning locations whereas abundance refers to the number of mature spawning age individuals in a DU and preferably for each spawning component in the case of several discrete spawning locations within a DU. Area

of occupancy and abundance are evaluated on a relative scale. In most cases, recovery potential is assessed in the context of present threats and their potential reduction in the future. The objective to recover the area of occupancy takes precedence over the abundance attribute when evaluating recovery potential.

Area of Occupancy (Table 1): Area of occupancy is based on the existence of spawning habitat and the use of that habitat by reproductive individuals. The recovery potential was assessed relative to the following recovery targets specific to each DU:

1) Evidence of successful spawning at one historical location within the DU where spawning once occurred (St. Lawrence estuary),
2) Evidence of successful spawning annually at all historical locations within the DU (southern Gulf),
3) Evidence of successful spawning at one of the two historical locations within the DU where spawning has not occurred in the last ten years (Bay of Fundy).

Table 1. Area of occupancy attribute based on spawning locations (NA not applicable).

Designatable Unit *COSEWIC Proposed designation*	**St. Lawrence Estuary** *Extirpated*	**Southern Gulf of St. Lawrence** *Threatened*	**Bay of Fundy** *Threatened*
Recovery Target			
Objective defined	YES Reestablish annual spawning in the DU (St. Lawrence estuary)	YES Achieved annual spawning at all historical locations within the DU (NW Miramichi)	YES Reestablish annual spawning in a portion of the historical locations lost within the DU (Annapolis and Saint John)
Recovery Potential			
I – Reestablish annual spawning in the DU	Potentially feasible Actions started to achieve the objective of annual stocking of 50,000 YOY over ten years beginning in 2008	YES Annual spawning at all historical locations within the DU (NW Miramichi)	YES Annual spawning at one historical location within the DU (Shubenacadie)
Time frame	Unknown, > ten years	NA	NA
II – Reestablish annual spawning in a portion of the historical locations lost within the DU	Potentially feasible (see above)	YES Annual spawning at all historical locations within the DU (NW Miramichi)	Potentially feasible Work to determine the status of Saint John River striped bass is underway but no actions have been initiated for Annapolis River striped bass
Time frame	Unknown, > ten years	NA	Unknown, > ten years
III – Reestablish annual spawning at all historical locations within the DU	Potentially feasible (see above)	Achieved Annual spawning at all historical locations within the DU (NW Miramichi)	Potentially feasible (see above)
Time frame	Unknown, > ten years	NA	Unknown, > ten years

Abundance of individuals of reproductive age (Table 2): A recovery limit reference point could be interpreted as the boundary between the endangered/threatened and special concern ranking. As a limit, it is the abundance of the population which should be exceeded with a high probability in 5 out of 6 years (compliance rule). Recovery potential to 2015 was qualitatively assessed using present knowledge of the species biology and actual threats.

For the St. Lawrence estuary and Bay of Fundy DUs, the recovery objective for area of occupancy has not been attained and an abundance recovery objective has yet to be defined. An interim recovery limit for abundance of spawners was provided for the southern Gulf of St. Lawrence DU. Reported historical landings of striped bass combined with a range of exploitation rates and mean weights of spawners from the Miramichi suggest historical maximum abundances in the order of a few 100 thousand animals. Young-of-the-year production into the first fall is likely in the order of a few million individuals. A discrete life history model conditioned on these abundance levels, combined with mortality rates borrowed from other populations and observed on the southern Gulf population, and assumed values to balance age group abundance and characteristics, were used to define an interim recovery limit of 21,600 bass on the spawning grounds for this population. A compliance rule based on the objective of meeting or exceeding the limit in at least 5 of 6 consecutive years was proposed to define when recovery in the context of a limit objective was achieved. The interim value would be revised if warranted as new and updated information on mortality rates, indices of life stage abundances, and biological characteristics are obtained.

Table 2. Abundance of mature animals attribute (NA not applicable).

Designatable Unit *COSEWIC Proposed designation*	**St. Lawrence Estuary** *Extirpated*	**Southern Gulf of St. Lawrence** *Threatened*	**Bay of Fundy** *Threatened*
Recovery Reference Points			
Objective defined Recovery limit and compliance rule	NO Pending recovery of area of occupancy	YES Interim value of 21,600 spawners in at least 5 of 6 years	NO Pending recovery of area of occupancy
Expectation of recovery within ten years (by 2015)			
Under present conditions	NA No natural spawning occurring without the re-introduction program	LOW (<25%)	NA
If fisheries related mortalities are reduced	NA Higher abundance expected with the re-introduction program	MODERATE (25-75%) Higher abundance expected	NA Higher abundance expected
AND If other human-induced mortality factors are reduced	NA Higher abundance expected with the re-introduction program	MODERATE (25-75%) Non-fisheries related factors of low impact	NA Higher abundance expected

Allowable Harm/Provisions of Recovery Plan

Potential sources of mortality and aggregate harm and their relative rank effect by activity were considered separately for each DU (Tables 3 – 5). The relative rank of mortality sources were derived from information presented in this assessment and review. Relative ranks ranged from "high" in cases where significant numbers of striped bass are known to die annually, to "low", where the effects of an activity were perceived to have less of an impact. The rank of "NI" signifies "no indication" and represents sources of mortality which were not relevant because there has never been any indication of striped bass mortality from these activities.

Recovery of the Bay of Fundy DU was defined as reclamation of the area of occupancy, while the objective for the southern Gulf DU was to increase population abundance. The situation is different for the St. Lawrence Estuary DU since the population has completely disappeared. Therefore, the objective is to establish a new population that would perpetuate itself with an area of occupancy equivalent to what existed in the past. Striped bass mortality arising from human activities is considered relative to the recovery target defined for each DU. Mortality factors associated with a given striped bass DU are identical regardless of the recovery attribute to be achieved.

Table 3. St. Lawrence estuary DU - effects on the re-introduction. The following information is based on past experience and knowledge of the extirpated population, and with present knowledge of the environment (NI; no indication).

Potential sources of mortality/ harm	Source	Relative rank	Cause	Effect	Alternatives or mitigation
Directed Fishing	Illegal (poaching)	Low	- Targeted capture	- Direct mortality	- Education - Increased enforcement
Bycatch in Fisheries	Commercial fishery American Eel	Moderate	- Incidental captures	- Direct mortality - Handling related mortality	- Gear modifications - Better management practices. - Changes in fishing seasons or fishing areas.
	Commercial fisheries Yellow Perch, Bullhead, American Shad, Herring, Sturgeon	Low	- Incidental captures	- Direct mortality - Handling related mortality	- Gear modifications - Changes in fishing seasons or fishing areas.
	Recreational	Low	- Incidental captures	- Direct mortality - Hook and release mortality	- Gear modifications - Education - Changes in fishing seasons or fishing areas.
	Aboriginal (food, social, ceremonial)	Uncertain	- Incidental captures,	- Direct mortality - Handling related mortality	- Changes in fishing seasons or fishing areas. - Gear modifications
Unintentional Mortality Under Permit	NI				
Habitat Alterations Under Permit	Municipal waste water treatment facilities, Pulp & paper mills, Power generating facilities, Agriculture, Manufacturing sector	Uncertain	- Discharge of effluents, (waste water, heat)	- Mortality of all life stages	

Potential sources of mortality/ harm	Source	Relative rank	Cause	Effect	Alternatives or mitigation
	Municipal, provincial, and federal dredging activities	Moderate	- Dredging of navigation channels, wharf construction, and deposition of sediments	- Mortality of benthos and habitat destruction	- Best management of these activities within the present legal framework and considering striped bass requirements.
Ecotourism and Recreation	Private companies and public at large	Uncertain	- Boat and recreational vessel use	- Mortality of eggs and larvae on the spawning grounds - Disturbance of fish aggregations - Introduction of petroleum products and by-products	
Shipping, Transport and Noise	Municipal, provincial, federal, and private transport activities (land and water based)	Low	- Transport of hazardous materials - Boat use, toxic substance spills	- Mortality of all life stages - Introduction of petroleum products and bi-products	- Best management practices
Fisheries on Food Supplies	Commercial, recreational, and Aboriginal fisheries for: gaspereau, American shad, American eel, rainbow smelt, Atlantic tomcod, etc.	Low	- Mortality of striped bass prey species	- Mortality associated with starvation, reduced growth and/or reproductive effort	- Management plans in place for directed fisheries
Aquaculture	NI				
Scientific Research	Government, university, community groups First Nations	Low	- Installation of fixed gear, use of mobile gear - Manipulation and collection of striped bass - Boat use	- Handling related mortality, increased stress, and disease transfer - Obstruction of natural migrations and behavior - Introduction of petroleum products and by-products	- Permitted activities under section 52 of *Fisheries Act* - Proper handling techniques - Education
Military Activities	NI				

Table 4. Southern Gulf of St. Lawrence DU - effects on abundance.

Potential sources of mortality/ harm	Source	Relative rank	Cause	Effect	Alternatives or mitigation
Directed Fishing	Illegal (poaching)	High	- Targeted captures	- Direct mortality	- Education - Increased enforcement
Bycatch in Fisheries	Commercial Gaspereau	Moderate	- Incidental captures	- Direct mortality - Handling related mortality	- Season / area closures - Gear modifications - Best management practice in effect
	Commercial Rainbow smelt	High	- Incidental captures - Inefficient culling	- Direct mortality, - Handling related mortality	- Season / area closures - Gear modifications
	Commercial American Eel	Moderate	- Incidental captures - Inefficient culling	- Direct mortality, - Handling related mortality	- Season / area closures - Gear modifications
	Commercial Herring	Uncertain	- Incidental captures in gillnets - Inefficient culling	- Direct mortality - Handling related mortality	- Season / area closures - Best management practices
	Recreational	Uncertain	- Incidental captures	- Direct mortality - Hook and release mortality	- Season / area closures - Gear modifications
	Aboriginal (food, social, ceremonial)	High	- Incidental captures, - Inefficient culling	- Direct mortality - Handling related mortality	- Season / area closures - Gear modifications - Best management practices
Fisheries Impacts on Habitat	Illegal (poaching)	Low	- Installation of fixed gear - Boat use	- Obstruction of natural migrations and behavior - Introduction of petroleum products and by-products	- Education - Enforcement
	Commercial	Low	- Installation of fixed gear - Boat use	- Obstruction of natural migrations and behavior - Introduction of petroleum products and by-products	- Season / area closures - Gear modifications
	Recreational	NI	- Boat use	- Introduction of petroleum products and by-products	- Season / area closures - Gear modifications

Potential sources of mortality/ harm	Source	Relative rank	Cause	Effect	Alternatives or mitigation
	Aboriginal (food, social, ceremonial)	Low	- Installation of fixed gear - Boat use	- Obstruction of natural migrations and behavior - Introduction of petroleum products and by-products	- Season / area closures - Gear modifications
Unintentional Mortality Under Permit	NI				
Habitat Alterations Under Permit	Municipal waste water treatment facilities Pulp & paper mills, Power generating facilities	Uncertain	- Discharge of effluents, (waste water, heat)	- Mortality of all life stages	
	Municipal, provincial, and federal dredging activities	Low	- Dredging of navigation channels, wharf construction, and deposition of sediments	- Mortality of benthos and habitat destruction	- Select deposition sites which do not impact striped bass habitat - Forbid activities near essential habitats
Ecotourism and Recreation	Private companies and public at large	Uncertain	- Boat and recreational vessel use	- Mortality of eggs and larvae on the spawning grounds - Disturbance of fish aggregations - Introduction of petroleum products and by-products	
Shipping, Transport and Noise	Municipal, provincial, federal, and private transport activities (land and water based)	Low	- Transport of hazardous materials - Boat use, toxic substance spills	- Mortality of all life stages - Introduction of petroleum products and biy-products	- Best management practices
Fisheries on Food Supplies	Commercial, recreational, and Aboriginal fisheries for: gaspereau, American shad, American eel, rainbow smelt, Atlantic tomcod, Atlantic silverside, mackerel, herring, Crab spp. etc.	Low	- Mortality of striped bass prey species	- Mortality associated with starvation, reduced growth and/or reproductive effort	- Management plans in place for directed fisheries

Potential sources of mortality/ harm	Source	Relative rank	Cause	Effect	Alternatives or mitigation
Aquaculture	Private shellfish culture companies	Uncertain	- Introduction of excessive fecal matter - Boat use	- Mortality of benthos and habitat destruction - Introduction of petroleum products and by-products	
Scientific Research	Government, university, community groups, First Nations	Low	- Installation of fixed gear, use of mobile gear - Manipulation and collection of striped bass - Boat use	- Handling related mortality, increased stress, and disease transfer - Obstruction of natural migrations and behavior - Introduction of petroleum products and by-products	- Permitted activities under section 52 of *Fisheries Act* - Proper handling techniques - Education
Military Activities	NI				

Table 5. Bay of Fundy DU - effects on area of occupancy.

Potential sources of mortality /harm	Source	Relative rank by spawning location A- Shubenacadie B- Annapolis C- Saint John	Cause	Effect	Alternatives or mitigation
Directed Fishing	Recreational	A- High B- Uncertain C- Uncertain	- Targeted captures of bass >68cm TL - Catch and release of undersized bass	- Direct mortality - Hook and release mortality,	- Season / area closures - Gear modifications, - Alter bag / size limits
	Illegal (poaching)	A- Uncertain B- Low C- Low	- Targeted captures	- Direct mortality	- Education - Increased enforcement
	Aboriginal (food, social, ceremonial)	A- Moderate B- Uncertain C- Uncertain	- Targeted captures	- Direct mortality	- Assess allocation re: number / size of fish

Potential sources of mortality /harm	Source	Relative rank by spawning location A- Shubenacadie B- Annapolis C- Saint John	Cause	Effect	Alternatives or mitigation
Bycatch in Fisheries	Commercial Gaspereau, American shad	A- High B- Low C- Uncertain	A – Incidental captures (3 fish per day <3.5kg), C – Incidental captures (1 fish per day >68cm TL) A, C – Inefficient culling	- Direct mortality - Handling related mortality	- Season / area closures - Alter bycatch tolerance
	Commercial Inner Bay of Fundy weir fishery (herring, flounder)	A- Low B- Uncertain C- Low	- Incidental captures (fish >68cm TL) - Occasional stranding of striped bass (all age classes)	- Direct mortality - Handling related mortality	- Change bycatch tolerances - Gear modifications - Enforce requirement that weirs be checked every tide
	Commercial Groundfish handline fishery	A- Low B- Uncertain C- Low	- Incidental captures - Inefficient culling	- Direct mortality - Handling related mortality	- Season / area closures where bycatch is high - Gear modifications
	Recreational	A- Uncertain B- Uncertain C- Uncertain	- Incidental captures	- Direct mortality - Hook and release mortality	- Season / area closures - Gear modifications
	Aboriginal (food, social, ceremonial)	A- Uncertain B- Uncertain C- Uncertain	- Incidental captures - Inefficient culling	- Direct mortality - Handling related mortality	- Season / area closures - Gear modifications
Fisheries Impacts on Habitat	Commercial Gaspereau, shad	A- Low B- Uncertain C- Uncertain	Installation of fixed gear	- Obstruction of natural migrations and behaviour	- Season / area closures - Gear modifications
	Commercial Inner Bay of Fundy weir fishery (herring, flounder)	A- Moderate B- Uncertain C- Low	Installation of low head weirs in intertidal zone	- Obstruction of natural migrations and behaviour	- Gear modifications,
	Recreational	A- NI B- NI C- Uncertain	- Boat use	- Introduction of petroleum products and by-products	- Season / area closures - Gear modifications

Potential sources of mortality /harm	Source	Relative rank by spawning location A- Shubenacadie B- Annapolis C- Saint John	Cause	Effect	Alternatives or mitigation
Unintentional Mortality Under Permit	Tidal Power generating facilities	A- Uncertain B- Uncertain C- Uncertain	- Entrainment in flow through turbines	- Direct mortality or injury, cavitation	- Improve existing fish bypass facilities
Habitat Alterations Under Permit	Municipal waste water treatment facilities, pulp & paper mills	A- Uncertain B- Uncertain C- Uncertain	A, B, C - Discharge of effluents, (waste water, heat)	- Mortality of all life stages	
	Hydroelectric Power generating facilities	A- NI B- Uncertain C- Uncertain	B – *see Non-Domestic air pollutants* C - Barrier to habitat above Mactaquac Dam, potential loss of spawning habitat below Mactaquac Dam	B, C - Mortality of eggs/larvae C - Reduced growth, reproductive effort	B, C - Change water release schedules C - Benefit to creating upstream bypass for striped bass uncertain
	Tidal power generating station	A- NI B- High C- NI	B - Well-mixed estuary converted to a stratified headpond	- Mortality of eggs/larvae	- Remediate specific cause of egg/larval mortality
	Agriculture	A- Uncertain B- Uncertain C- Uncertain	- Run-off	- Eutrophication, siltation	- Best management practices
Ecotourism and Recreation	Private companies and public at large	A- Uncertain B- Uncertain C- Uncertain	A, B, C - Boat and recreational vessel use A - Tidal bore rafting	- Disturbance of fish aggregations - Introduction of petroleum products and bi-products	
Shipping, Transport and Noise	Municipal, provincial, federal, and private transport activities (land and water based)	A- Uncertain B- NI C- Uncertain	- Transport of hazardous materials - Boat use, toxic substance spills	- Mortality of all life stages - Introduction of petroleum products and by-products	- Best management practices

Potential sources of mortality /harm	Source	Relative rank by spawning location A- Shubenacadie B- Annapolis C- Saint John	Cause	Effect	Alternatives or mitigation
Fisheries on Food Supplies	Commercial, recreational, Aboriginal fisheries for: Gaspereau, American shad, American eel, Rainbow smelt, Atlantic tomcod, Atlantic silverside, Mackerel, Herring, Crab sp. etc.	A- Low B- Low C- Low	- Mortality of striped bass prey species	Mortality associated with starvation, reduced growth and/or reproductive effort	- Incorporate ecosystem objectives into management plans for directed fisheries
Aquaculture	Private striped bass aquaculture	A- Low B- Low C- Low	- Farmed striped bass escape to the wild	- Introgression with wild striped bass	- Best management practices - Compliance with code of containment
Scientific Research	Government, university, community groups, First Nations	A- Low B- Low C- Low	- installation of fixed gear, use of mobile gear - Manipulation and collection of striped bass - Boat use	- Handling related mortality, increased stress, and disease transfer - Obstruction of natural migrations and behavior, - Introduction of petroleum products and bi-products	- Permitted activities under section 52 of *Fisheries Act* - Proper handling techniques - Education
Military Activities		A- NI B- NI C- NI			
Non-Domestic Air Pollutants	Acidic precipitation	A- NI B- Uncertain C- NI	B - Acidified water stored for hydroelectric generation released into spawning area	- Acid toxicity lethal to all life stages of bass	- Change water release schedules

Sources of Uncertainty

- The severity of stated threats and specific mechanisms contributing to the reported loss of the Annapolis and Saint John populations are unknown.
- The presence of migrant US fish in the Bay of Fundy DU confounds the perception of status.
- Harvest levels (directed, bycatch) for striped bass in the Bay of Fundy DU are not supported with assessment information on abundance or reference levels.
- The extent of occurrence for the three populations of striped bass in the Bay of Fundy DU overlap.
- The origin and status of fish recently genetically typed in the Saint John River with no known population affinity needs to be resolved.
- The population model used to determine reference levels for the southern Gulf of St. Lawrence population assumed or borrowed features from other populations.
- The lack of quantitative data to estimate mortality associated with human-induced factors for all striped bass populations necessitated the use of qualitative ranks.
- The magnitude of striped bass bycatch in numerous fisheries is unknown for all striped bass DU's.
- Not all human activities that could potentially impact striped bass were investigated.
- The physicochemical and biological parameters of the St. Lawrence River have undergone various changes since the disappearance of the DU from the St. Lawrence estuary in the late 1960s. It is not certain that a new population would behave in the same way as the extirpated population.

CONCLUSIONS AND ADVICE

St. Lawrence Estuary

With the striped bass recovery program put forward by the Ministère des Ressources naturelles et de la Faune du Québec, the Fédération québécoise de la Faune, Hydro-Québec, and other Quebec partners, recovery is considered possible.

However, in order to optimize the potential and speed of recovery, mitigation measures should be developed. They include modifications to eel fishing gear or dredging procedures and the depositing of sediment in the river. In addition, appropriate monitoring should be implemented to properly identify the critical habitats of the new population and the main factors limiting its recovery, if any.

Southern Gulf of St. Lawrence

Recovery is feasible. Southern Gulf striped bass persist even though the aggregate mortality from human-induced factors is substantial. Additional human-induced mortality beyond current levels will preclude this population's potential to achieve reference levels presented in this document.

Because there are no baseline mortality estimates for bycatch in any fishery, the effect of implementing any mitigation measures will be difficult to quantify. However, it was argued that implementation of any mitigation measure should only improve this population's potential to achieve reference levels.

Bay of Fundy

Recovery is potentially feasible. A definitive statement of recovery feasibility will require clarification of how the stated threats impede use of historical (and possibly currently occupied) spawning habitat (area of occupancy attribute) in the Saint John and Annapolis rivers and re-assessment of the population structure of striped bass within the Bay of Fundy. These are not possible with information presently available.

The Shubenacadie River population continues to produce new individuals annually. Mitigation of current human activities that are believed to negatively affect abundance are possible through a combination of changes to existing regulations, enforcement, and best management practices. It is not possible to estimate mortality for each of the potential threats listed above.

MANAGEMENT CONSIDERATIONS

- There continues to be directed fisheries for striped bass within the Bay of Fundy DU.
- Mixed stocks of striped bass, including fish from the U.S.A., are harvested in Bay of Fundy fisheries.
- Large quantities of striped bass, mostly juveniles, are intercepted in commercial, rainbow smelt, gaspereau and American eel fisheries of the southern Gulf.
- Prior to their extirpation, striped bass were intercepted in commercial American eel weirs of the St. Lawrence estuary. Recent recaptures of bass in this fishery from the preliminary stocking of a few thousand fish since 2002, indicate that fishing is still a potential source of high mortality. However, a mandatory release of striped bass caught, an important reduction in the number of American eel fishermen since the 1960's and a simple fishing gear modification favouring survival of striped bass caught should markedly reduce the impact of this type of fishery on the recovery potential of this population.
- Considering the status of the three striped bass populations and the close relationship of this species with the estuary and coastal habitats, any activities that could have an impact on the life cycle and habitat of this species should be carefully assessed using existing legal framework.

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