Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Eastern Sand Darter (*Ammocrypta pellucida*) in Canada, Quebec populations

Eastern Sand Darter

2014

Canada

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For copies of the recovery strategy, or for additional information on species at risk, including COSEWIC Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk Public Registry (www.sararegistry.gc.ca).

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PREFACE

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the competent federal ministers are responsible for the preparation of recovery strategies for listed extirpated, endangered, and threatened species and are required to report on progress within five years.

The Minister of Fisheries and Oceans Canada is the competent minister for the recovery of the eastern sand darter (Quebec populations)[1] and has prepared this strategy, as per section 37 of SARA. It has been prepared in cooperation with The Équipe de rétablissement des cyprinidés et des petits percidés du Québec.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Fisheries and Oceans Canada or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the eastern sand darter, Quebec populations, and Canadian society as a whole.

This recovery strategy will be followed by an action plan that will provide information on recovery measures to be taken by Fisheries and Oceans Canada and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

[1] In both previous COSEWIC assessments in 1994 and 2000, only one designatable unit (distributed throughout Ontario and Quebec) was recognized for eastern sand darter populations in Canada. The species was listed as “threatened” under SARA in June 2003 and a proposed recovery strategy was posted on the Species at Risk Public Registry in July 2007 (Edwards et al., 2007). In COSEWIC's third assessment in 2009, Canadian eastern sand darter populations were separated into two designatable units, i.e., the Quebec populations (subject of this recovery strategy) and the Ontario populations (DFO, 2012). These two designatable units were added to the Species at Risk List under SARA on March 2013, and two separate recovery strategies have been produced.

ACKNOWLEDGMENTS

Fisheries and Oceans Canada would like to thank Jacinthe Beauchamp and Daniel Hardy, who drafted this recovery strategy in conjunction with the Équipe de rétablissement des cyprinidés et des petits percidés du Québec[2]:

- Geneviève Audet, Société de conservation et d'aménagement du bassin de la rivière Châteauguay (SCABRIC)
- Jacinthe Beauchamp, Fisheries and Oceans Canada (DFO)
- Julie Boucher, ministère des Ressources naturelles et de la Faune du Québec (MRNF)
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- Chantal Côté, ministère des Ressources naturelles et de la Faune du Québec
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- Henri Fournier, ministère des Ressources naturelles et de la Faune du Québec
- Steve Garceau, ministère des Ressources naturelles et de la Faune du Québec
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- Ghislain Thibodeau, ministère des Ressources naturelles et de la Faune du Québec

Fisheries and Oceans Canada thanks Gilles Fortin for producing all maps and department staff who reviewed the document during its drafting.

Finally, Fisheries and Oceans Canada thanks the stakeholders who commented on the draft or proposed version of this recovery strategy during the jurisdiction review, the First Nations consultation and the public consultation on Species at Risk Public Registry

[2] Members in 2010-11 who participated in drafting this recovery strategy.

EXECUTIVE SUMMARY

The eastern sand darter is a small, translucent freshwater fish of a yellowish or silvery shade with a series of 10-14 lateral dark spots. The global distribution of the eastern sand darter consists of two disjunct areas and is limited to North America. In Quebec, the eastern sand darter is found in the St. Lawrence River and its tributaries between Lac des Deux Montagnes and Leclercville, downstream from Lake St. Pierre.

The species was assessed as “threatened” by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2000 and was added to the Species at Risk List of the *Species at Risk Act* in 2003. In 2009, the COSEWIC divided the Canadian eastern sand darters populations into two separate units: Quebec populations (the unit subject to this recovery strategy) and Ontario populations (DFO, 2012). Both units was designated as "threatened" and added to the Species at Risk List.

The eastern sand darter appears to have limited adaptability and specific habitat requirements (e.g., sand substrate), a specialized diet, low fecundity, a short life span and limited dispersal capability. It is consequently highly sensitive to any factors likely to alter its habitat, such as increased sediment input and siltation, alteration of flow regimes and fluctuation in water level, presence of contaminants, nutrient loading or barriers to movement. In addition to these threats, the presence of exotic species and diseases, reduced availability of prey and incidental harvest of eastern sand darter individuals could affect the survival and recovery of the species.

The recovery of the eastern sand darter in Quebec is considered feasible. The short-term (i.e., within five years) objective of this recovery strategy is to maintain eastern sand darter populations throughout the species' distribution in Quebec and prevent their decline. The objective over the longer term (i.e., 20 years) is to promote the growth of existing populations to ensure their viability and, wherever possible, to restore historical populations that have disappeared. Viable populations should eventually cover the entire current and historical distribution if possible.

To achieve these recovery objectives, 14 management and research-related recovery measures have been developed in accordance with five strategies:

1. Survey and monitoring;
2. Knowledge acquisition;
3. Protection, restoration and stewardship;
4. Communication and outreach;
5. Partnership and coordination.

Based on the best available information[3], the critical habitat of the eastern sand darter, Quebec populations, has been identified in three areas: 1) L'Assomption and Ouareau rivers; 2) Richelieu River; and 3) aux Saumons River (near Dundee city). Further work is required to identify additional critical habitat necessary to support the population and distribution objectives for the species. An action plan will be established within five years of publication of the final version of this recovery strategy in the Species at Risk Public Registry.

[3] This recovery strategy includes data from surveys conducted up to and including the summer of 2010.

RECOVERY FEASIBILITY SUMMARY

The recovery of the eastern sand darter in Quebec is considered feasible insofar as it meets all four criteria for assessing the technical and biological feasibility of this recovery:

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance:

Yes. Although the spawn require specific habitat conditions, the ongoing presence of the species in certain watercourses in Quebec (e.g., L'Assomption and Richelieu rivers) and the discovery of new sites (e.g., aux Saumons, Trout and Ouareau rivers) indicate that mature individuals are present in the natural environment and capable of reproduction. However, the last COSEWIC status report on the species documents an inferred but continuous decline in the number of mature individuals (COSEWIC, 2009). Due to the species' low fecundity and limited dispersal capability, when isolated populations disappear, natural recolonization of habitats is unlikely to occur or could require a long period of time (COSEWIC, 2009). When a population is made up of interconnected groups (i.e., a structured metapopulation), in the event of a catastrophic event affecting some of these groups, recolonization may be possible by the surviving eastern sand darter individuals in unaffected groups. The eastern sand darter's early maturation, spawning frequency and rapid growth enable it to respond to favourable environmental changes and rapidly repopulate areas affected by catastrophic events (Finch et al., 2011).

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration:

Yes. As noted previously, recent surveys have supported confirmation of the continuous presence of the eastern sand darters in certain watercourses and the discovery of new sites inhabited by the species. Suitable habitats consequently still exist in multiple watercourses where the eastern sand darter can complete its entire life cycle. However, the presence of the required habitat (i.e., sand substrate) appears to be limited or disturbed by human activities (Équipe de rétablissement des cyprinidés et des petits percidés du Québec, 2008). Better watercourse management and the restoration of certain habitats could help to enhance and increase the number of suitable habitats.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated:

Yes. Although numerous threats may lead to habitat loss or degradation for the eastern sand darter, it is possible to mitigate some of these threats (Équipe de rétablissement des cyprinidés et des petits percidés du Québec, 2008). According to the last COSEWIC status report (COSEWIC, 2009), some threats are clearly reversible. For example, concrete actions could be taken to improve the water quality and reduce siltation in watercourses inhabited by the species. In some cases, these actions will have to be extended to the watershed level rather than implemented strictly within the watercourse in question in order to effect real improvement.

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable time frame:

Yes. More effective land and watercourse management practices as well as stewardship activities are available and can support improved water quality in the lakes and rivers inhabited by the eastern sand darter (Équipe de rétablissement des cyprinidés et des petits percidés du Québec, 2008). As noted, the eastern sand darter is capable of responding rapidly to favourable environmental changes and colonizing habitats made suitable (Finch et al., 2011), but these habitats must be located in the proximity of currently occupied habitats. It has been demonstrated that habitat improvements based on the restoration of riparian strips should help watercourse colonization (Daniels, 1993). Adoption of an integrated watershed management approach could prove particularly effective as it supports reconciliation of all water uses while also promoting the use of multiple techniques for restoring watercourses.

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LIST OF ACRONYMS

Bti	*Bacillus thuringiensis israelensis*
CARA	Corporation de l'Aménagement de la Rivière L'Assomption
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CFIA	Canadian Food Inspection Agency
COVABAR	Comité de concertation et de valorisation du bassin de la rivière Richelieu
DFO	Department of Fisheries and Oceans Canada
MAPV	Minimum Area for Population viability
MRNF	Ministère des Ressources naturelles et de la Faune du Québec
MVP	Minimum Viable Population
RCM	Regional County Municipality
SARA	*Species at Risk Act*
SCABRIC	Société de conservation et d'aménagement du bassin de la rivière Châteauguay
SEA	Strategic Environmental Assessment
SL	Standard Length
TL	Total Length
IUCN	International Union for Conservation of Nature
VHS	Viral Hemorrhagic Septicemia

1. COSEWIC SPECIES ASSESSMENT INFORMATION

Summary of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessment as published in the latest status report (COSEWIC, 2009)[4]:

Date of Assessment: November 2009

Common Name (population): Eastern sans darter (Quebec populations*)

Scientific Name: *Ammocrypta pellucida*

COSEWIC Status: Threatened

Reason for Designation: This species prefers sand bottom areas of lakes and streams in which it burrows. There is continuing decline in the already small and fragmented populations; three (of 18) have probably been extirpated, and the fate of five others is unknown due to lack of recent sampling. The extent of occurrence of this species in Quebec is approximately two-thirds of what it was in the 1970s, despite records at five new sites in two locations. There is continuing habitat loss and degradation from historic and ongoing urban and agricultural development, stream channelization and competition with invasive alien species.

Canadian Occurrence: Quebec

COSEWIC Status History: The species was considered a single unit and designated “threatened” in April 1994 and November 2000. When the species was split into separate units in November 2009, the "Quebec populations" unit was designated “threatened.”

* Multiple isolated populations exist in Quebec, hence the description of the designatable unit as "Quebec populations."

[4] Available at http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=1076

2. SPECIES STATUS INFORMATION

The eastern sand darter (*Ammocrypta pellucida*) has a global status of G4[5] or "apparently secure" (Table 1) based on the following grounds:

1) Disjunct and reduced distribution in the northeastern United States and Canada;
2) Extirpation of multiple populations due to siltation on sand banks, dyking or damming of watercourses and pollution;
3) Need for close monitoring due to small population size and the ongoing destruction of already limited habitats (NatureServe, 2010).

Table 1. Global, national and state/province conservation ranks for the eastern sand darter.

Scale	Conservation Rank
Global (G)	**G4**
National (N)	Canada (**N3**) United States (**N4**)
Subnational (S)	**Canada** Quebec (**S2**)*, Ontario (**S2**) **United States** Illinois (**S1**), Indiana (**S4**), Kentucky (**S4**), Michigan (**S1S2**), New York (**S2**), Ohio (**S3**), Pennsylvania (**S1**), Vermont (**S1**), West Virginia (**S2S3**)

Source: NatureServe (2010) http://www.natureserve.org.
* Subject to current recovery strategy

The species has also been designated as "vulnerable" by the International Union for Conservation of Nature (IUCN) (NatureServe, 2010).

In the United States, the species is ranked N4, "apparently secure," while its status by state ranges from S1, "critically imperiled," to S4, "apparently secure." The eastern sand darter's status, as designated by the American Fisheries Society is "threatened" (NatureServe, 2010), and the species is listed as "at risk" in 9 of the 11 North American jurisdictions in which it is found (COSEWIC, 2009).

In Canada, the eastern sand darter is ranked N3, "vulnerable," while the populations in Ontario and Quebec are both ranked S2, "imperiled," by NatureServe (2010). In June 2003, the eastern sand darter was listed under SARA as a "threatened" species. COSEWIC reassessed the species in 2009 and divided the eastern sand darter populations in Canada into two designatable units, one in Ontario and the other in Quebec (the designatable unit subject to this recovery strategy); both designatable units were listed under SARA on March 2013. In Ontario, the provincial government listed the species as "endangered" pursuant to the *Endangered Species Act, 2007*. In Quebec, the Ministère des Ressources naturelles et de la Faune (MRNF)

[5] The conservation status rank of a species or community is based on a one to five scale preceded by a letter to indicate the geographic scale of the assessment: global (G), national (N) or subnational (S). The numbers have the following meaning: 1 = critically imperiled; 2 = imperiled; 3 = vulnerable; 4 = apparently secure; and 5 = demonstrated to be widespread, abundant and secure (NatureServe, 2010).

designated the eastern sand darter as a "threatened" species in October 2009 pursuant to the *Act respecting threatened or vulnerable species*, and a provincial recovery plan was developed (Équipe de rétablissement des cyprinidés et des petits percidés du Québec, 2008).

3. SPECIES INFORMATION

3.1 Species description

The eastern sand darter is a translucent fish partially covered with scales (Figure 1). The average total length (TL)[6] of adults ranges from 46 to 71 mm (Scott and Crossman, 1974; Williams, 1975; Trautman, 1981) with a recorded maximum of 84 mm (DFO, 2011). The fish is of a yellowish or silvery shade with a series of 10 to14 dark lateral spots, usually located below the lateral line scale row. These spots are slightly smaller than the pupil and are frequently rounded anteriorly and oblong posteriorly. The median fins are not pigmented. The eastern sand darter is one of the most elongate species of *Ammocrypta*, with body height entering into standard length (SL) usually 8 to 9 times[7]. There are usually 10 to12 transverse scale rows on each side, 4 to 7 of these below the lateral line, and 9 to11 (usually 10) preopercular-mandibular canal pores (this canal is part of the lateral line on the head). The pelvic rays of adult males are darkly pigmented and have small tubercles (COSEWIC, 2009).

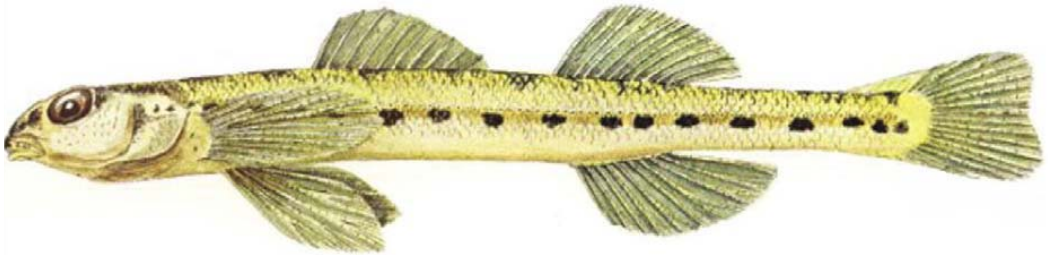

Figure 1. Eastern sand darter (*Ammocrypta pellucida*). Illustration by E. Edmonson and H. Chrisp (New York State Department of Environmental Conservation).

[6] Total length (TL): distance from the tip of the nose to the extremity of the tail.
[7] Standard length (SL): distance from the tip of the nose to the base of the tail.

3.2 Population and distribution

The global distribution of the eastern sand darter consists of two disjunct areas and is limited to North America, specifically Canada and the United States (Figure 2). The main range (southern range) is located in the east-central United States as far as the southernmost part of Ontario, while a smaller area (northern range) is mainly located in Quebec and includes a few tributaries in eastern Ontario and in Vermont and New York (COSEWIC, 2009).

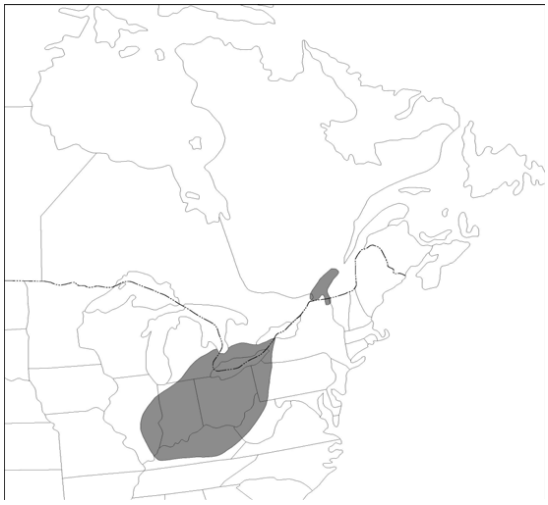

Figure 2. Global distribution of the eastern sand darter. Taken from Gaudreau (2005).

3.2.1 United States

The eastern sand darter inhabits the Ohio River basin (in Ohio, Indiana, Illinois, Kentucky, West Virginia and Pennsylvania). It is also found in part of the lower Great Lakes basin (drainage areas of lakes Huron, St. Clair and Erie in Michigan, Ohio, New York and Pennsylvania) and, to the east (in its northern range), in the basins of the St. Lawrence River and Lake Champlain (Vermont and New York). Immigration of individuals from the United States into Canada appears unlikely due, in part, to the scarceness of the American populations in the border area and the eastern sand darter's limited dispersal capability and special habitat requirements (COSEWIC, 2009).

3.2.2 Canada

All Canadian populations are found within the Great Lakes-Upper St. Lawrence Ecological Area in Ontario and Quebec. According to the last COSEWIC status report, the large range disjunction (approximately 500 km) eliminates the possibility of exchange between the two populations, which justifies the designation of two designatable units in Canada: 1) Quebec populations; and 2) Ontario populations. However, there are no known phenotypic or genotypic distinctions between the populations in these two units (COSEWIC, 2009). Populations have disappeared from a number of other watershed areas in Canada (COSEWIC, 2009).

Although no specific studies have been conducted to estimate the size of the eastern sand darter populations in Canada, there appears to be a continuous decline in the number of mature individuals, number of sites inhabited by the species and the habitat area, extent and quality. The current extent of occurrence of the eastern sand darter in Canada is approximately

20 764 km² (10 840 km² in Ontario and 9 924 km² in Quebec). Its historical extent of occurrence was 33 832 km² (19 534 km² in Ontario and 14 298 km² in Quebec). These data represent a 39% decrease in the Canadian extent of occurrence (45% decrease in Ontario and 32% in Quebec). The index of the area of occupancy is estimated at 797 km² based on a 1 km² grid (304 km² in Ontario and 493 km² in Quebec) (COSEWIC, 2009).

In Ontario, the eastern sand darter occurs in the southwestern part of the province in lakes Huron, Erie and St. Clair and in several of their tributary streams (seven watersheds). The eastern sand darter populations have probably disappeared from three of the seven drainage basins, and based on the available information, the populations have likely declined in lakes Erie and St. Clair and Big Creek (COSEWIC, 2009). In Quebec, eastern sand darter populations occur at approximately 10 sites in the St. Lawrence River and its tributaries from Lake des Deux Montagnes to Leclercville, downstream from Lake St. Pierre (Table 2, Figure 3) (Gaudreau, 2005; COSEWIC, 2009; Boucher and Garceau, 2010). Research documents drawn up to support a recovery potential assessment of the eastern sand darter in Canada (Boucher and Garceau, 2010; Bouvier and Mandrak, 2010) and the resulting scientific advisory report (DFO, 2011) provide a status assessment for eastern sand darter populations in Canada, each population having been evaluated taking into account its relative abundance index and trajectory.

3.2.3 Quebec

In the St. Lawrence River, some specimens were collected in Lake St. Pierre and its archipelago as well as in a reach between Montréal and Sorel as part of surveys conducted by the Réseau de suivi ichtyologique du Saint-Laurent (RSI) (D. Deschamps, MRNF, pers. comm., 2010). The species has also been collected from tributary streams in the hydrographic regions of Outaouais and Montréal (des Mille-Îles River [A. Boutin, Éco-Nature, pers. comm., 2010]), the northwestern St. Lawrence (L'Assomption and Ouareau rivers [Bourgeois, 2010; Blanchette, 2011]) and the southwestern St. Lawrence (e.g., Missisquoi Bay in Lake Champlain [Gaudreau, 2005], aux Saumons River in the Montérégie [D. Hatin, MRNF, pers. comm., 2010; Ginson, 2010] Richelieu River [Vachon, 2007; N. Vachon, MRNF, unpublished data used in COSEWIC, 2009; Ginson, 2010] and Trout River [Garceau et al., 2007; Gareau et al., 2011]).

In Quebec, according to COSEWIC (2009), there appears to have been a continuous decline in the number of mature individuals (still estimated at more than 10 000), number of sites inhabited by the species and the habitat area, extent and quality. Eastern sand darters have recently been collected from four historically occupied watercourses (L'Assomption, Richelieu and Trout rivers and two different sections of the St. Lawrence River), and since the previous COSEWIC status assessment in 2000, four new sites have been discovered in Quebec (Ouareau, des Mille-Îles and aux Saumons rivers in the Montérégie and Missisquoi Bay in Lake Champlain). However, it is likely that the species has disappeared from three rivers (Châteauguay, Yamaska and Saint-François), and no information is available to support assessment of trends in certain historically occupied rivers (Yamachiche, Bécancour, Gentilly, aux Orignaux and du Chêne).

Table 2. Observation sites for the eastern sand darter in Quebec, 1940–2010
√ = present; O = absent despite specific surveys; (xxxx) = collection year; [RSI] = data from Réseau de suivi ichtyologique du Saint-Laurent.

Waterway	Period			
	1940–1959	1960–1979	1980–1999	2000–2010
St. Lawrence River				
Montréal/Sorel		O 1973		√ 2001[RSI]
Lake St. Pierre Archipelago	√ 1944	√ 1974	O 1995[RSI]	√ 2002 √ 2003[RSI] O 2010[RSI]
Lake St. Pierre		O 1974	O 1995[RSI]	√ 2002[RSI] √ 2005 √ 2006 √ 2007[RSI]
Outaouais and Montréal Hydrographic Region				
Lake des Deux Montagnes	√ 1941 √ 1946	O between 1964–77	O 1990	
des Mille-Îles River				√ 2008
Northwest St. Lawrence Hydrographic Region				
L'Assomption River		√ 1969	√ 1983 O 1990	√ 2002 √ 2009 √ 2010
and its tributary Ouareau River			O 1990	√ 2002 √ 2003 √ 2009
Yamachiche River	√ 1944	√ 1972		
Southwest St. Lawrence Hydrographic Region				
Lake Champlain (Missiquoi Bay)				√ 2003
aux Saumons River (Montérégie)				√ 2008 √ 2010
Châteauguay River	√ between 1941–44	√ 1975 √ 1976	O 1993	O 2006
Richelieu River		√ 1970 √ 1974	√ 1993 O 1995 √ 1999	√ between 2001 and 2010
And its tributary Trout River		√ 1976	O 1993	√ 2006 √ 2010
Saint-François River	√ 1944	O between 1965–74	O 1991	O 2002 O 2003 O 2008 O 2009
Yamaska River		√ 1967	O 1995	O 2003 O 2010
Southeast St. Lawrence Hydrographic Region				
Bécancour River		√ 1975	√ 1981	
aux Orignaux River			√ 1982	
du Chêne River			√ 1982	
Gentilly River	√ 1941		√ 1982	

Data source: Based on data from Équipe de rétablissement des cyprinidés et des petits percidés du Québec (2008), updated with 2009 and 2010 data.

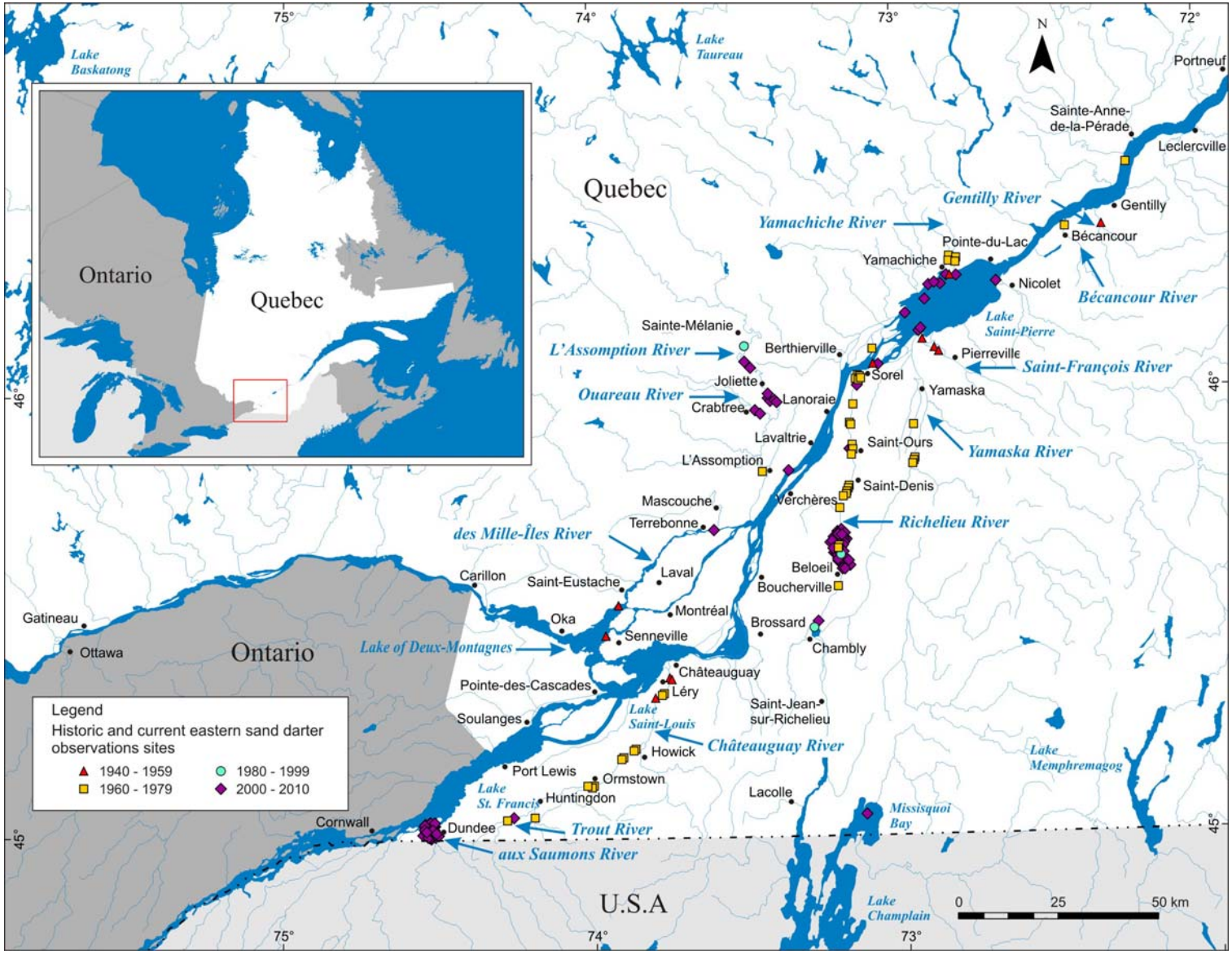

Figure 3. Distribution of the eastern sand darter in Quebec.

Very little information is available on population sizes and trends for the eastern sand darter in Quebec (Gaudreau, 2005; Équipe de rétablissement des cyprinidés et des petits percidés du Québec, 2008; COSEWIC, 2009; Boucher and Garceau, 2010); the limited surveys conducted in recent years have been inadequate in terms of covering the entire historical distribution. In addition, most of these surveys were conducted with the objective of confirming the presence of the species in the watercourses in question rather than estimating population density. During sampling activities, the work was stopped after identifying a single specimen so as to limit impact on the species and its habitat. According to Boucher and Garceau (2010), the status of most of the populations is either "unknown" or "poor" in most sections of the St. Lawrence River and other rivers where the eastern sand darter was collected; only the populations in the Richelieu, L'Assomption and Ouareau rivers had a status described as "fair," while the status of the population in aux Saumons River was classified as "good."

Assessment of the distribution of the eastern sand darter in Quebec has also proved problematic. New collection sites for the eastern sand darter are probably the result of adoption of a more effective sampling strategy for collecting the species rather than of expansion of the species' distribution (Boucher and Garceau, 2010).

3.3 Needs of the Eastern sand darter

Eastern sand darters are benthic (bottom-dwelling) insectivores with well-developed fossorial (burying) behaviour, that feed primarily on the larvae of midges (*Chironomidae*) and blackflies (*Simuliidae*) (Turner, 1922; Scott and Crossman, 1974; Smith, 1979; Cooper, 1983; D. Hatin, MRNF, pers. comm., 2010). Their preferred habitat is sand-bottomed areas in streams and rivers and sandy shoals in lakes (Scott and Crossman, 1974), although the species has also been collected from other types of substrates, including mud, silt, clay and gravel (Vladykov, 1942; Holm and Mandrak, 1996). In rivers, the eastern sand darter is usually found in sandy depositional areas downstream from bends (Daniels, 1993; Facey, 1998) where a moderate current helps maintain a sandy bottom with no silt (Trautman, 1981). The waters of their river or lake habitats are typically clear or tea-coloured, but samples have also been collected from highly turbid environments (COSEWIC, 2009). The habitat at most capture sites is characterized by no aquatic macrophytes and shallow depths (<1.5 m) (COSEWIC, 2009), although this could be the result of a sampling bias; specimens were recently found at greater depths in some watercourses (DFO, 2011). There are no published studies on the physiology or environmental tolerances of the eastern sand darter (COSEWIC, 2009), and there remain numerous sources of uncertainty related to biology, ecology, life history, and young-of-the-year and juvenile habitat requirements (DFO, 2011).

The only information available for the Quebec eastern sand darters populations relates to the general characterization of a number of collection sites summarized in Boucher and Garceau (2010), and several recent studies:

Missisquoi Bay: mainly sandy substrate, no aquatic plants, depth less than 1.5 m, current speed near nil
Richelieu River, Chambly Rapids section: substrate 80% sand, depth less than 20 cm, current speed less than 1 cm/s, some aquatic plants
Lake St. Pierre: mainly sand substrate, depth less than 1.5 m, no aquatic plants
L'Assomption River: sand and silt or gravel substrate, depth less than 1 m, sparse to no vegetation, current speed less than 27 cm/s, no sedimentation (Blanchette, 2011)

Ouareau River: sand and silt substrate, depth less than 1 m, low current speed (Bourgeois, 2010).

The movements of the eastern sand darter are virtually unknown, but the species likely has limited dispersal abilities. Larvae and recently transformed juveniles have been caught around adult habitats or in the same habitats as adults (COSEWIC, 2009). There is little information available on seasonal changes in habitat use, but a number of surveys appear to point toward the movement of some individuals within certain watercourses. In the Richelieu River, for example, surveys conducted in late May and early June 2007 enabled the collection (and return to the water) of more than 200 eastern sand darters in a given section; in September 2007, no individuals were captured in that section (N. Vachon, MRNF, unpublished data used in COSEWIC, 2009). It is to be noted that individuals were collected from this section of the river at depths of up to 5 metres on a substrate of hard clay (S. Garceau, MRNF, pers. comm., 2010).

Spawning takes place from late spring throughout the summer in water temperatures ranging between 14.4 and 25.5ºC (Williams, 1975; Spreitzer, 1979; Johnston, 1989; Facey, 1998; Faber, 2006; Simon and Wallus, 2006). Eastern sand darters of both sexes mature in the spring following their first growing season at age one, but some females may not spawn until their second year (Faber, 2006). Generation time is estimated at two years (COSEWIC, 2009), and the species is relatively short-lived, reaching an age of up to four years (Drake et al., 2008). Fecundity is low (for example, average clutch size is 56 eggs for the Little Muskingum River in Ohio [Faber, 2006] and 66 for the Thames River in Ontario [Finch et al., 2008]), but females may lay eggs several times during the spawning season (Johnston, 1989; Simon and Wallus, 2006). The slightly adhesive eggs are likely laid in sand and gravel substrates. A well-oxygenated substrate such as unsilted sand is likely required for high egg survivorship. Hatching peaks in four to five days at 20.5 to 23.0ºC (Simon et al., 1992). Larvae likely drift at first but become benthic soon after hatching. It is interesting to note that according to Finch et al. (2011), the eastern sand darter population growth rate appears most sensitive to the survival of juveniles and the fecundity of first-time spawners. The concept of residence as defined in SARA[8] does not apply to this species.

The eastern sand darter thus appears to have limited adaptability (COSEWIC, 2009). The eastern sand darter also appears to have specific habitat requirements (e.g., clean, sandy substrate), a specialized diet, low fecundity, a short life span and limited dispersal capability, all of which are limiting factors for the survival and recovery of the species. However, the early maturity, spawning frequency and rapid growth of the species enable it to respond to favourable environmental changes and colonize habitats made suitable in proximity to currently occupied habitats.

4. THREATS

The last COSEWIC status report (COSEWIC, 2009) lists multiple threats to the survival and recovery of the eastern sand darter in Canada, such as loss of habitat due to siltation, pollution associated with intensive agriculture and urban development, impoundments, channel alterations and changes in flow regimes including fluctuating water levels in the St. Lawrence River, potential predation and competition from the round goby (*Neogobius melanostomus*),

[8] Dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating (SARA, Section 2).

incidental harvest during bait fishing and the use of the organic insecticide *Bacillus thuringiensis israelensis* (Bti) in watercourses to control blackflies.

Based on this information (COSEWIC, 2009) and documents relating to the recovery potential assessment (Boucher and Garceau, 2010; DFO, 2011), eight threats to the survival and recovery of the eastern sand darter were identified by the recovery team. Insofar as one activity (e.g., agriculture) may have multiple types of impact on individuals and habitats (e.g., increased siltation, nutrient loading, presence of toxic substances), these threats have all been identified in terms of their impact on individuals or their habitats. Most eastern sand darter populations face more than one threat, and the cumulative impact of these threats could accelerate the decline of the species (DFO, 2011).

Finch et al. (2011) have established that a decrease in the survival rate (by 34% for juveniles or 32% for all lifestages combined) or in the fertility rate among mature individuals (by 40% for 1+ individuals or 34% for all mature individuals) could compromise the future viability of eastern sand darter populations. Human activities causing harm in excess of these thresholds could compromise the future viability of eastern sand darter populations (Finch et al., 2011; DFO, 2011[9]).

4.1 Threat assessment

Each threat has been assessed based on six parameters (Table 3). However, it is important to note that this threat assessment may vary locally depending on the watercourse and the level of the threat (see Boucher and Garceau, 2010, for additional information):

1. **Extent**: indicates whether the threat is widespread or localized within the distribution of the species.
2. **Occurrence**: indicates whether the threat is historic, current, imminent or anticipated.
3. **Frequency**: indicates whether the threat is unique, seasonal, continuous or recurrent (not annual or seasonal).
4. **Causal certainty**: indicates whether the best available information concerning the threat and its impact on population viability is high, moderate or low.
5. **Severity**: indicates whether the severity of the threat is high, moderate or low.
6. **Level of concern**: indicates whether the degree of attention that should be devoted to the threat is high, moderate or low. This may take into account the ability to mitigate or eliminate the threat.

[9] Refer to the scientific advisory report (DFO, 2011) for additional information on allowable harm in relation to populations status.

Table 3. Classification of threats to the recovery of the eastern sand darter, Quebec populations.

Threats	Extent	Occurrence	Frequency	Causal Certainty	Severity	Level of Concern
Habitat Loss or Degradation and Pollution						
Increased Sediment Input and Siltation*	Widespread	Current	Continuous	High	High	**High**
Alteration of Flow Regimes and Fluctuation in Water Levels	Widespread	Current	Continuous	High	High	**High**
Presence of Contaminants	Widespread	Current	Continuous	Moderate	High	**High**
Nutrient Loading	Widespread	Current	Continuous	Moderate	High	**High**
Barriers to Movement	Localized	Current	Continuous	Moderate	Moderate	**Moderate**
Exotic Species, Invasive or Introduced						
Exotic Species and Diseases	Localized	Current	Continuous	High	Moderate	**Moderate**
Change in the Ecological Dynamics						
Reduced Prey Availability	Localized	Anticipated	Seasonal	Low	Unknown	**Low**
Incidental Mortality						
Incidental Harvest	Localized	Current	Seasonal	Low	Low	**Low**

* Combines the threats "shoreline modifications," "turbidity and excessive siltation" and "wave action from passing boats" set out in Boucher and Garceau, 2010, and DFO, 2011, since the threats in this recovery strategy are identified in terms of their impact on individuals or their habitats.

4.2 Description of threats

The eastern sand darter has very specific habitat requirements and is highly vulnerable to any factors likely to affect its habitat (Gaudreau, 2005; COSEWIC, 2009). In Quebec, the survival and recovery of the eastern sand darter are threatened primarily by the disruption and deterioration of aquatic habitats caused by intensive agricultural activities (Équipe de rétablissement des cyprinidés et des petits percidés du Québec, 2008). Other human activities such as commercial or recreational navigation, dam operation, control of biting insects, forestry activities, vacationing, stream channelization, fishing and industrial activities can negatively impact the eastern sand darter or its habitat. The descriptions of the following threats are taken from the research document produced by Boucher and Garceau (2010).

4.2.1 Increased sediment input and siltation

Siltation appears to be the leading cause of significant habitat loss for the eastern sand darter in Canada (Holm and Mandrak, 1996). Most watersheds supporting the species have been largely cleared of their forest cover, are subject to intensive agriculture and tile drainage. Many rivers also have large urban developments on their banks and within their catchments. All of these factors contribute to increased sediment input in streams and associated siltation (COSEWIC,

2009). Shoreline hardening and other changes to shorelines and riparian strips may accelerate sedimentation and substrate siltation. The presence of adequate riparian strips[10] helps to maintain water quality in watercourses inhabited by the eastern sand darter. Plant roots help to control soil erosion while also filtering surface runoff that may contain fertilizers, pesticides and sediment (FAPAQ, 2002; Vachon, 2003).

Of the human activities that increase sediment loading in watercourses, agriculture is by far the greatest contributor (Vachon, 2003), especially where riparian strips are inexistent or inadequate. A number of poor agricultural practices are particularly associated with this problem, including ploughing and harvesting up to shorelines, spreading liquid or solid manure near watercourses and trampling of stream banks and bottoms by livestock (Vachon, 2003). Other activities, such as marine shipping, recreational boating[11] and dredging, are also problematic in that they contribute to bank erosion and siltation affecting larger watercourse and lake beds (Gaudreau, 2005; COSEWIC, 2009). Dam construction and the subsequent formation of reservoirs promotes sedimentation due to the slowing of the current (from a lotic to a lentic environment) and limiting of the spring freshet (Gaudreau, 2005).

The siltation of sandy bottoms lowers the oxygen concentration in the substrate and consequently affects fossorial behaviour (which could have negative impact on fish survival by increasing the amount of energy required for the fish to maintain its position in the habitat) and species reproduction. Siltation can also reduce the number of available spawning sites and egg survival as well as trigger significant changes in the structure of the aquatic invertebrate communities serving as food sources for the eastern sand darter (Gaudreau, 2005; COSEWIC, 2009).

4.2.2 Alteration of flow regimes and fluctuation in water levels

The straightening of watercourses, creation of channels and ditches, drainage, filling, watercourse maintenance and the building of bridges or installation of culverts, dams or other sources of local modification of the natural hydrographic features (e.g., water level, temperature or flow) of eastern sand darter habitats could prove extremely harmful to the species. In Quebec, 9 000 to 10 000 km of watercourses have been created for drainage purposes and another 30 000 km of watercourses modified (BAPE, 2003) to support or increase agricultural production. This type of activity can lead to uniformization of watercourses in addition to altering their water regime and the natural processes resulting in the formation and maintenance of sandbanks free of fine sediment (Paine and Watt, 1994; Gaudreau, 2005; Helfman, 2007). The presence of structures used to control water flow, such as hydroelectric dams, can also cause major changes to habitats both up and downstream (e.g., by flooding ledges upstream and reducing flow downstream), which can also have negative impact on the eastern sand darter. Dam operation may also cause significant water level variations, thereby drying out spawning grounds or making them inaccessible or causing mortality among the eggs or larvae present at a given time (Gaudreau, 2005).

In the St. Lawrence River, dredging of the shipping channel and shoals modifies water levels by concentrating the flow in the main channel and reducing current speeds in shallower parts

[10] Width 10 to 15 m depending on the slope gradient and the presence or absence of a bank as recommended under Quebec's policy on shorelines, littoral zones and floodplains protection.
[11] The wave action against watercourse shores, caused by passing boats ranging from jet skis to major commercial carriers, can lead to bank erosion. This erosion increases sediment, leading to increased turbidity and siltation of stream beds (Gaudreau 2005; Boucher and Garceau, 2010).

(COSEWIC, 2009). Moreover, water level fluctuations result not only from the combined action of multiple natural factors (e.g., climate variations) but also from human activity, since the river flow is influenced by the control structures used primarily to limit spring flooding, to facilitate commercial navigation and for producing hydroelectric power. Species inhabiting shallower areas, such as the eastern sand darter, could be particularly affected by problems associated with low water levels in the St. Lawrence River, all the more so against a backdrop of climate warming. A reduction in the habitat area of this species is to be expected subsequent to the exposure of sand banks (Gaudreau, 2005). Based on the outcomes of a modelling exercise, eastern sand darter populations in the St. Lawrence River are sensitive to alterations in water levels and flows (Giguère et al., 2005).

4.2.3 Presence of contaminants

Contaminants associated with industrial activity and urban and agricultural runoff could degrade water quality and have negative impact on the various stages of the fish's life cycle. This is a pervasive threat for most eastern sand darter populations in Canada (COSEWIC, 2009). Pesticides and agricultural fertilizers found in some watercourses generate multiple harmful effects for aquatic life with repercussions for the entire ecosystem (FAPAQ, 2002; Giroux, 2007). Municipal, industrial (e.g., textiles, pulp and paper) and mining wastewater discharged into watercourses contains a range of substances, including heavy metals (e.g., lead, mercury), chlorinated hydrocarbons (e.g., dichlorodiphenyltrichloroethane [DDT], Polychlorinated Biphenyls [PCBs]), polycyclic aromatic hydrocarbons (e.g., benzopyrene), detergents, hormones and pharmaceutical compounds. Depending on their nature and concentration, chemicals can have a lethal effect or disrupt the endocrine or immune systems, embryonic development or behaviour of exposed fish, resulting in reproduction and development disorders (de Lafontaine et al., 2002; Jobling and Tyler, 2003; Aravindakshan et al., 2004).

The eastern sand darter is a species classified as “pollution intolerant” (Barbour et al., 1999) and could consequently be greatly affected by industrial, urban or agricultural contaminants. Insofar as the eastern sand darter is a species that burrows and feeds into the substrate, the consequences of the accumulation of toxic substances in sediment could be more dramatic than for other fish species (Grandmaison et al., 2004). According to Scott and Crossman (1974), it is also unlikely that the eastern sand darter would be able to survive any length of time against assaults to the environment in highly industrialized areas such as the Montréal region. The water quality in certain rivers inhabited by the eastern sand darter (e.g., Richelieu, Yamaska, L’Assomption, Châteauguay) is a concern for aquatic species (Côté et al., 2006; Giroux, 2007) and could constitute a threat in terms of contamination from toxic substances.

4.2.4 Nutrient loading

Nutrient loading into watercourses is caused mainly by intensive livestock farming, excessive soil fertilization and domestic wastewater. In Quebec, the eastern sand darter is found mainly in a region where expanding pork production poses one of the greatest threats to aquatic animals and their habitats due to the excessive soil fertilization associated with that industry (Boucher and Garceau, 2010). With regard to domestic wastewater, most municipalities in Quebec now have water purification systems supporting the pre-treatment of waste (e.g., to reduce suspended solids and phosphorous). However, water rejected by sewer overflow systems (e.g., in heavy rain) directly into watercourses can represent a non-negligible, albeit occasional, pollution source (i.e., for contaminants and nutrients), particularly where sewer systems

combine storm water with sewage. Climate change could increase the frequency of extreme weather events, thereby also potentially increasing the frequency of sewer overflow incidents.

Excess fertilizers (e.g., nitrogen, phosphorous) can cause watercourse anoxia and eutrophication. They also promote the overdevelopment of algae and aquatic plants or periphyton, which can harm the development of fish eggs. Nocturnal plant respiration and plant decomposition by bacteria reduce oxygen levels in the water, which can be a limiting factor for fish survival (FAPAQ, 2002; Vachon, 2003). This decrease in the amount of dissolved oxygen in the water could constitute a significant threat to benthic species such as the eastern sand darter (FAPAQ, 2002).

4.2.5 Barriers to movement

Barriers to the free movement of fish can 1) split the habitat used annually by the eastern sand darter; and 2) isolate populations from one another. In Quebec, the harnessing of certain rivers, notably Ouareau and Richelieu, could be problematic for the eastern sand darter populations in those watercourses (Gaudreau, 2005; COSEWIC, 2009). Other types of barriers can also hinder the free passage of the eastern sand darter, for example, the presence of improperly installed culverts, the narrowing of a watercourse as a result of filling or a poorly constructed bridge, affecting the flow rate and making the obstacle impassable.

Although the eastern sand darter is a species with low dispersion and limited migration, free passage between its various types of habitats is important nonetheless. The occurrence of obstacles to free passage could compromise the survival of individuals or reproduction. Moreover, the presence of obstacles may restrict the movement of fish between populations, movements that may last several generations. After a catastrophic event involving mass fish mortalities, small, isolated groups of eastern sand darters may survive and disperse to suitable habitats left vacant (Finch et al., 2011). Habitat fragmentation could also be detrimental for maintaining genetic diversity and natural recolonization of eastern sand darter populations in case of local extinction.

4.2.6 Exotic species and diseases

Dextrase and Mandrak (2006) have suggested that although habitat loss and deterioration may pose the main threat to the survival of freshwater species at risk, exotic species constitute the second-greatest threat, affecting 26 of the 41 species in Canada classified as “at risk” by COSEWIC and used for the study at hand, including the eastern sand darter. There are at least 185 exotic species living in the Great Lakes and 88 in the St. Lawrence River (Y. de Lafontaine, Environment Canada, pers. comm., 2009). Climate warming could also promote the establishment of exotic species in greater numbers. Some of these species are bound to have an impact on the eastern sand darter. Exotic species could affect the eastern sand darter in different ways, such as through direct competition for space, habitats and food, by modifying the aquatic food chain or indirectly by altering the ecosystem.

For example, the round goby has become widespread within the last few years in the St. Lawrence River from the Great Lakes to Québec City. This exotic species represents a potential threat to most of the eastern sand darter populations in Canada (COSEWIC, 2009) in that it can dominate native fish by eating their eggs and young, by occupying the better habitats and by spawning several times during the summer. It is a benthic species that could have a direct impact on darter species once it is established. The progress of this species into the eastern

sand darter's distribution consequently represents a significant threat. Presumably, tributary streams to the St. Lawrence River with eastern sand darter populations are vulnerable to invasion by the round goby, and the impact of this exotic species on the eastern sand darter is bound to be negative (COSEWIC, 2009). Other species (e.g., the tench [*Tinca tinca*], present in the Richelieu) may also pose a potential threat to the eastern sand darter and the ecosystems in which it occurs.

Introduced pathogens can also pose a threat to various fish species. For example, viral hemorrhagic septicemia (VHS) is a contagious disease caused by a virus that affects, to varying degrees, more than 65 species of fish. Identified for the first time in the Great Lakes in 2005 and 2006, this potentially fatal disease is associated with mass mortalities in many species of fish in this region. To date, no cases of VHS have been detected in Quebec (C. Brisson-Bonenfant, MRNF, pers. comm., 2009). The Canadian Food Inspection Agency (CFIA) has implemented a biennial plan for monitoring the presence of the VHS virus in wild fish in Canada (CFIA, 2010). Given the precarious status of the eastern sand darter in Quebec, mass mortalities associated with this disease could significantly affect the survival and recovery of the species.

4.2.7 Reduced prey availability

Some toxic substances or contaminants may have an indirect impact on the eastern sand darter by affecting the quality, abundance or availability of the fish's prey, among other factors. For example, municipalities have been applying the biological insecticide *Bacillus thuringiensis israelensis* (Bti) for a number of years in Quebec in certain lotic environments inhabited by the eastern sand darter to control adult blackfly populations (order Diptera, family Simuliidae). Bti-based products are released into watercourses where blackfly larvae develop. Bti is a "stomach poison" to organisms with highly alkaline alimentary canals and thus acts on certain species of insects while remaining harmless to fish (Boisvert and Lacoursière, 2004). Nevertheless, some studies have demonstrated that in addition to the larvae targeted (i.e., blackflies), Bti affects the larvae of Diptera not targeted by the insecticides, such as those in the Chironomidae (midge) family (review by Boisvert and Lacoursière, 2004).

The impact on the eastern sand darter could be significant since this species feeds primarily on midge and blackfly larvae (Turner, 1922; Scott and Crossman, 1974; Smith, 1979; Cooper, 1983). Consequently, using Bti insecticides to control adult blackfly populations could indirectly affect the eastern sand darter by reducing the abundance of this prey in aquatic environments. The actual impact on the eastern sand darter is not yet known, but this threat remains a source of concern (COSEWIC, 2009).

4.2.8 Incidental harvest

In Quebec, the target of a commercial fishery is small fish caught using fishing gear such as seine nets, bait traps, square nets and dip nets. These small fish are subsequently used as bait in sport fishing, including ice fishing (Boucher et al., 2006). Other sport fishermen catch their own bait fish. Bait fishermen do not specifically target the eastern sand darter, the capture of which is prohibited under SARA. However, specimens could be harvested accidentally since the habitats used by the eastern sand darter overlap those used by the species targeted by bait fishermen.

A study evaluating the commercial bait fishery concerning five fish species with a precarious status was conducted in the fall of 2005 (Boucher et al. 2006) and summer of 2007 (Garceau et

al., in press). The eastern sand darter was absent from fishermen's catches in both sampling campaigns. Despite the fact that the fishing sites, particularly in the Richelieu River, overlap the species' known range, fishermen have apparently not caught them in their summer and fall catches. The unique morphological features of this fish species make it easily identifiable by fishermen. As a preventive measure, a number of sectors have been closed to commercial bait fishing (e.g., fishing area 8 covering part of the Richelieu River (S. Garceau, MRNF, pers. comm., 2010). This threat does not consequently appear to be a limiting factor for the survival and recovery of the species in Quebec.

5. POPULATION AND DISTRIBUTION OBJECTIVES

The short-term (i.e., within five years) objective of this recovery strategy is to maintain eastern sand darter populations throughout the species' distribution in Quebec and prevent their decline. The objective over the longer term (i.e., 20 years) is to promote the growth of existing populations to ensure their viability and, wherever possible, to restore historical populations that have disappeared. Viable populations should eventually cover the entire current and historical distribution if possible.

Based on the outcomes of a modelling exercise carried out by Finch et al. (2011) to support the recovery potential assessment for the eastern sand darter in Canada (DFO, 2011), a total of 13 viable populations are necessary[12] to ensure the persistence of the species for each designatable unit. The minimum viable population (MVP)[13] is predicted to be 52 282 adults taking into account a catastrophic event percentage per generation (drastic reduction of 50% of the population abundance) of 10% as the appropriate risk level[14]. The minimum area required for population viability (i.e., Minimum area for population viability [MAPV]) in this regard is estimated at 3.7 ha of suitable habitat in rivers and 21.4 ha in lakes (Finch et al., 2011; DFO, 2011).

Further work is required with respect to life cycle and the incidence of catastrophic events in order to fine-tune these estimates (Finch et al., 2011) and use them as a quantitative objective. The recovery team approves their use as an indicator (minimum area combined with number ofindividuals assessment) in assessing population viability.

Due to a lack of information on the species' abundance and current and historical distribution, it is impossible to determine where exactly the Quebec eastern sand darters populations stand in relation to these objectives. According to the last COSEWIC assessment (COSEWIC, 2009) and the occurrence data set out in this recovery strategy, the eastern sand darter should be present in three sections of the St. Lawrence River and seven other watercourses (sites confirmed via surveys within the last decade). Research will need to be undertaken to assess the viability of each population and verify the possibility that a single watercourse might be home to multiple distinct populations. Under current conditions and in the absence of both human threats and recovery efforts, a population that is 10% of its MVP value is expected to take 45 years (29 generations) to reach the recovery target. According to this model, the

[12] According to the modelling data, the extinction risk over 100 years is 5% with 8 viable populations, 2.5% with 10 viable populations, 1% with 13 viable populations and 0.01% with 24 viable populations (Finch et al., 2011; DFO, 2011).
[13] For 95% probability of persistence over 100 years (i.e., extinction risk of 5% over 100 years).
[14] In the absence of catastrophic events, the minimum viable population (MVP) size is predicted to be 323 adults, while inclusion of a 5% and 15% probability of catastrophic decline per generation produced MVP values of 4224 for 0.3 ha and 595 000 for 41.7 ha respectively.

implementation of recovery measures targeting higher juvenile survival and year-old adult fecundity could shorten the time frame for recovery to less than 20 years (13 generations) (Finch et al., 2011).

Judging from distribution data, the eastern sand darter may never have been a widespread or common species in Canada. It will consequently be challenging to achieve abundance and distribution objectives with a view to improving the precarious status of the species to the point of removing it from the Species at Risk List in Canada. Recovery of the species will be complete when its abundance and distribution are sufficient to ensure its persistence in Canada.

6. BROAD STRATEGIES AND GENERAL APPROACHES TO MEET OBJECTIVES

To achieve these recovery objectives, five general strategies must be implemented concurrently:

1. **Survey and monitoring:** Conduct surveys in watercourses where occurrences have historically been reported and in other watercourses where suitable habitats are present as well as monitoring of known populations. Monitor areas inhabited by the species.
2. **Knowledge acquisition:** Perform knowledge acquisition activities to learn more about the ecology and biology of the species, determine the habitat attributes associated with its presence through the various life stages and build knowledge about threats to the species' survival and recovery.
3. **Protection, restoration and stewardship:** Implement concrete actions to protect the species and the inhabited sections of watercourses and restore degraded habitats through stewardship activities or other improvement efforts.
4. **Communication and outreach:** Perform communication and outreach activities to increase awareness among the public and interest groups about the eastern sand darter's status under SARA and educate them about how they can contribute to the recovery of the species.
5. **Partnership and coordination:** Establish partnerships (e.g., Government of Quebec, watershed organizations, environmental groups, municipalities, universities, associations and agricultural cooperatives) to improve the coordination and effectiveness of recovery activities targeting the species.

6.1 Actions already completed or currently underway

A number of measures have been implemented in this regard in recent years, setting the direction for recovery measures to be undertaken in the years to come.

6.1.1 Survey and monitoring

Some surveys conducted in recent years have resulted in the successful collection of many eastern sand darters and the discovery of new watercourses inhabited by the species:

- L'Assomption and Ouareau rivers: fish surveys including the eastern sand darter conducted by the Corporation de l'Aménagement de la Rivière L'Assomption in 2002 (CARA, 2002), 2009 (Bourgeois, 2010) and 2010 (Blanchette, 2011) resulted in the collection of a few individuals (9 in 2002, 2 in 2009 and 32 in 2010). It is to be noted that

sampling at each station was stopped after collecting any species at risk targeted under the project.

- aux Saumons River in the Montérégie: in 2008, a survey of small fish was conducted in the Lake St. François National Wildlife Area, including a 6 km section of aux Saumons River, in which 359 eastern sand darters were collected at 38% of the stations sampled (D. Hatin, MRNF, pers. comm., 2010). Another 22 eastern sand darters were captured at one station in September 2010 as part of a survey conducted by a University of Windsor graduate student in conjunction with the Great Lakes Laboratory for Fisheries and Aquatic Sciences of DFO and the MRNF (Ginson, 2010).
- Richelieu River: eastern sand darters were collected in the Saint-Marc-sur-Richelieu area near the islands of aux Cerfs and Jeannotte and near the mouth of Petit ruisseau Leboeuf during monitoring activities for the copper redhorse (*Moxostoma hubbsi*) (Vachon, 2007). In 2007, for example, more than 235 individuals were captured in late May and early June (N. Vachon, MRNF, unpublished data used in COSEWIC [2009]). In addition, individuals were collected at depths of up to 5 metres on a substrate of hard clay in 2010 (S. Garceau, MRNF, pers. comm., 2010).

The eastern sand darter has also recently been confirmed extant in Rivière des Mille-Îles (A. Boutin, Éco-Nature, pers. comm., 2010), Missisquoi Bay in Lake Champlain (Gaudreau, 2005), and Trout River (Garceau et al., 2007; Gareau et al. 2011), although only a few individuals were collected. Starting in 1995, the Réseau de suivi ichtyologique du fleuve Saint-Laurent (RSI) has also been sampling quantitative data in a standardized and reproducible manner on fish communities and the population dynamics of a number of exploited populations with the objective of assessing the health of the Quebec portion of the freshwater in six sectors of the St. Lawrence River: Lake St.François, Lake St. Louis, from Montréal to Sorel, Lake St. Pierre and its archipelago, from Bécancour to Batiscan and from Grondines to Donnaconna. Since launching these monitoring efforts, a dozen eastern sand darters have been collected in two of these sectors: Montréal to Sorel and Lake St. Pierre and its archipelago.

In 2009, MRNF created, with the collaboration of DFO a central database for recording all collection instances for five freshwater fish species at risk (including the eastern sand darter). This database is updated regularly.

6.1.2 Knowledge acquisition

Surveys conducted by the MRNF and watershed organizations have enabled the acquisition of data on the attributes of the habitats used by the eastern sand darter. More specifically, studies carried out on the aux Saumons and Richelieu rivers have supported the acquisition of biological and ecological data (e.g., feeding, fecundity) on the species were analyzed in 2011 and 2012. In addition, a project has been implemented in conjunction with the University of Windsor, DFO's Great Lakes Laboratory for Fisheries and Aquatic Sciences and the MRNF with the objective of analyzing the genetic structure of several eastern sand darter populations in Quebec (aux Saumons and Richelieu rivers) and Ontario (Grand, Thames and Sydenham rivers) based on sampling of a small portion of pelvic fin in support of subsequent genetic analysis in the laboratory (Ginson, 2010).

With regard to threats, two studies have been conducted to confirm the vulnerability of the eastern sand darter to bait fishing, in the fall of 2005 (Boucher et al., 2006) and the summer of 2006 (Garceau et al., in press). No eastern sand darter specimens were found in the tanks of the fishermen and retailers visited (Boucher et al., 2006; Garceau et al., in press).

6.1.3 Protection, restoration and stewardship

The eastern sand darter was designated as threatened by COSEWIC and listed as a species at risk under SARA in June 2003. The proposed version of a recovery strategy was published in the Species at Risk Public Registry in July 2007 (Edwards et al., 2007). At the time of the COSEWIC reassessment in 2009, the species was divided into two designatable units representing the populations in Quebec (subject to the current recovery strategy) and Ontario; both designatable units were listed under SARA on March 2013. In Quebec, the eastern sand darter was designated as a threatened species in October 2009 pursuant to the *Act respecting threatened or vulnerable species*, and a provincial recovery plan was published in 2008 (Équipe de rétablissement des cyprinidés et des petits percidés du Québec, 2008).

In addition to SARA, the *Fisheries Act* and the regulations made thereunder apply directly or indirectly to the protection of the eastern sand darter. Under the *Canadian Environmental Assessment Act*, the effects of project on species at risk should be part of an environmental assessment when it is required by this Act.

In Quebec, two provincial acts provide for the general protection of fish habitats: the *Act respecting the conservation and development of wildlife* and the *Environmental Quality Act*. Under this legislation, any activity (e.g., dredging, filling, dam building, and direct discharge of contaminants) in the aquatic environment likely to disrupt a fish habitat is prohibited except where authorized by the responsible minister. A regulatory framework for protecting riparian environments is also in place through Quebec's Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains, the *Cities and Towns Act* and the *Land Use Planning and Development Act*. In addition, the *Regulation respecting agricultural operations* of the *Environmental Quality Act* exists to protect the environment, particularly the water and soil, against pollution caused by certain agricultural activities. Pursuant to this regulation, with the exception of fording, it is prohibited (as of April 1, 2005) to allow animals free access to watercourses and shorelines. This regulation also contains provisions governing the storage of animal dung and the spreading of fertilizing substances.

The eastern sand darter is extant in the Pierre-Étienne Fortin wildlife refuge, a protected area established in 2002 in the Chambly Rapids in the Richelieu River to protect a multispecific spawning ground. Another similar protected area, recently acquired by the Nature Conservancy of Canada, has been proposed downstream around the islands of Jeannotte and aux Cerfs near Saint-Marc-sur-Richelieu (COSEWIC, 2009). A number of areas have also been closed to commercial bait fishing (e.g., fishing area 8 covering part of the Richelieu River) to prevent the incidental harvest of species at risk and avoid disrupting their habitats (S. Garceau, MRNF, pers. comm., 2010).

The federal government has been funding the Habitat Stewardship Program (HSP) for species at risk since 2000. The objective of the HSP is to protect and conserve the habitats of species at risk to foster their recovery. A number of projects relating to the eastern sand darter have been financed in Quebec in recent years, including the following:

- Long-term protection of the habitat of the eastern sand darter in the southern part of the L'Assomption River watershed by the Corporation de l’aménagement de la rivière L’Assomption (CARA): confirming the occurrence of the eastern sand darter in meandering rivers in the southern L'Assomption River watershed with a view to monitoring population status and habitat quality, educating riparian landowners,

potentially restoring habitats and protecting these habitats through stewardship agreements (e.g., for the protection of riparian strips).
- Caretaking project for habitat conservation in the Pierre-Étienne Fortin wildlife refuge by the Comité de concertation et de valorisation du bassin de la rivière Richelieu (COVABAR): the presence of outreach officers helps to ensure compliance with regulations in the wildlife refuge and supports the development of user awareness activities with a view to protecting species at risk and their habitats in the refuge.
- Habitat protection and restoration in the watersheds of the des Anglais and Trout rivers by Ambioterra: habitat survey and characterization, stewardship activities (e.g., conservation agreements, easements), habitat restoration, outreach and ecosystemic management of natural resources through the development of conservation plans and landowner guides with the objective of identifying habitats used by the eastern sand darter and promoting the improvement of water and habitat quality.
- Protection of species at risk in aquatic and island environments in Lake Champlain and the Richelieu and St. Lawrence rivers by the Nature Conservancy: outreach, stewardship and habitat improvement, monitoring of invasive species, habitat development and restoration and habitat protection.

6.1.4 Communication and outreach

In 2011, DFO developed awareness fact sheets on the eastern sand darter and the channel darter (*Percina copelandi*) for bait fishermen and riparian landowners. The purpose of these fact sheets was to provide information on how to recognize these species by their characteristics, threats, efforts to support the species' recovery and how to take part in recovery efforts (http://www.qc.dfo-mpo.qc.ca/publications/index-eng.asp). Environmental organizations such as CARA and Ambioterra have also developed awareness pamphlets and signage.

6.1.5 Partnership and coordination

The 2007–2012 provincial recovery plan for the eastern sand darter, which was also drafted in conjunction with the Équipe de rétablissement des cyprinidés et des petits percidés du Québec, is currently in place in Quebec (Équipe de rétablissement des cyprinidés et des petits percidés du Québec, 2008). The goals, recovery objectives, general strategies and recovery measures set out in this recovery strategy are consistent with the provincial plan. In addition, the Équipe de rétablissement des cyprinidés et des petits percidés du Québec prioritizes proposed activities and fosters partnerships with organizations, such as watershed organizations, on an annual basis. This recovery team is made up of representatives from DFO, the MRNF, non-profit environmental organizations and Hydro-Québec.

6.2 Strategic direction for recovery

To achieve the designated recovery objectives, 14 management and research-related recovery measures have been developed in accordance with the five previously mentioned strategies (see Tables 4 – 8).

These measures have been put in order of priority as follows:

- Critical: essential for recovery
- Necessary: very important for recovery
- Beneficial: useful for recovery

Table 4. Recovery planning table for survey and monitoring recovery measures.

Priority	Recovery Measure	Remarks
Critical	Monitoring known eastern sand darters populations, estimating their abundance, characterizing habitats in use and assessing suitable habitat area.	• Assessing population viability: habitat area and number of individuals. • Assessing population trends, primarily when the population status is unknown or certainty is low; necessary to enable monitoring of the recovery measures to be implemented (DFO, 2011).
Critical	Conducting surveys, first in historically occupied areas and then in potential habitat areas.	• New surveys need to be conducted with a focus on sites associated with a historical presence (DFO, 2011). • The recent discovery of new watercourses inhabited by the species illustrates the necessity of building knowledge about distribution (DFO, 2011). • Clearer definition of the extent of occurrence and index of the area of occupancy (limiting COSEWIC assessment criterion for the eastern sand darter in Quebec).

Table 5. Recovery planning table for knowledge acquisition recovery measures.

Priority	Recovery Measure	Remarks
Critical	Building biological and ecological knowledge (e.g., life cycle, habitat used) about the eastern sand darter in Quebec.	• There remain numerous sources of uncertainty related to biology, ecology, life history, young-of-the-year and juvenile habitat requirements, population abundance estimates, population structure and the distribution of the eastern sand darter that need to be addressed (DFO, 2011). • As noted by Finch et al. (2011), the acquisition of biological and ecological knowledge about the species is necessary in terms of defining the parameters used for modelling. Once they are more accurate, the indicators used for gauging population viability (i.e., number of adults and area) can be used as quantitative recovery objectives. • This knowledge will also be very useful in gaining a better understanding of threats to the species and identifying more effective actions for promoting the recovery of the species, including habitat protection (DFO, 2011).
Necessary	Building knowledge about threats to population survival and recovery.	• A better understanding of threats responsible for the decline of eastern sand darter populations is required. This knowledge will also be very useful in targeting more effective actions for promoting the recovery of the species (DFO, 2011).
Beneficial	Assessing genetic variations among populations in Canada.	• More effective assessment of population structure (DFO, 2011).

Table 6. Recovery planning table for protection, restoration and stewardship recovery measures.

Priority	Recovery Measure	Remarks
Critical	Protecting eastern sand darter habitats.	• Protecting a sufficient number of habitats to ensure the survival and recovery of eastern sand darter populations in Quebec.
Necessary	Restoring degraded habitats supporting known and historical populations where natural recolonization is possible, including in agricultural setting (primary threat).	• Improving the quality of habitats available to the eastern sand darter with a view to increasing population abundance and expanding the current distribution. • To accelerate population recovery, DFO (2011) recommends implementing recovery strategies targeting a 20% improvement in the survival rate for individuals age 0+ and the fecundity of individuals age 1+.
Necessary	Ensuring that all involved stakeholders, including RCM land use planners and coordinators responsible for watercourses and fish habitat protection analysts, take the eastern sand darter and its habitat requirements into account before authorizing work on shorelines or in watercourses inhabited by the species. Proposing mitigation measures where applicable.	• Maintaining suitable habitat attributes to promote the use of watercourses by the eastern sand darter. • Refer to the mitigation measures developed specifically for species at risk in Ontario for examples (Coker et al., 2010).
Necessary	Undertaking habitat stewardship activities in riparian environments where the eastern sand darter is extant, including in agricultural settings (primary threat).	• Improving the quality of habitats available to the eastern sand darter with a view to increasing population abundance and expanding the current distribution.
Necessary	Taking the eastern sand darter's requirements into account in water flow management at dams and in sea lanes, particularly during spawning.	• Maintaining suitable habitat attributes to promote the use of watercourses by the eastern sand darter.
Beneficial	Protecting the eastern sand darter from use as a bait fish and reducing incidental harvest as needed in at-risk areas through concrete actions.	• Adding the eastern sand darter to the list of species prohibited as bait fish in the *Quebec Fishery Regulations*. • Implementing alternative solutions for reducing incidental harvest if necessary (e.g., closing fishing areas, buying back licenses, type of fishing gear) (DFO, 2011).

Table 7. Recovery planning table for communication and outreach recovery measures.

Priority	Recovery Measure	Remarks
Necessary	Developing and distributing awareness tools specific to the eastern sand darter to educate people about the eastern sand darter's status as "threatened" under SARA and this recovery strategy, among other concerns.	• Promoting protection of the eastern sand darter and its habitat among riparian landowners, agricultural producers and municipal decision makers with the objective of supporting its recovery. • Outreach to bait fishermen to encourage them to voluntarily avoid inhabited zones and immediately release any eastern sand darter caught accidentally (DFO, 2011).

Table 8. Recovery planning table for partnership and coordination recovery measures.

Priority	Recovery Measure	Remarks
Necessary	Planning, both annually and over the longer term, recovery activities relating to the eastern sand darter and involving the relevant stakeholders in the process.	• Planning, both annually and over the longer term, activities relating to the eastern sand darter by the coordinating committee for the Cooperation agreement for the protection and recovery of species at risk in Quebec in conjunction with the Équipe de rétablissement des cyprinidés et des petits percidés du Québec.
Necessary	Fostering effective cooperation from watershed organizations and other environmental groups active in areas where the eastern sand darter is extant.	• Incorporating their activities into the annual and long-term planning of activities relating to the eastern sand darter. • Two-way knowledge transfer.

6.3 Narrative to support the recovery planning table

It is important to note that the eastern sand darter has never been subject to comprehensive study in Quebec. Gaps in the knowledge about this species may be attributed to its scarceness, small size, benthic lifestyle, fossorial behaviour and translucent appearance, which makes it difficult to observe or collect. The only accessible information on the species is in the form of documented captures and, in some cases, descriptions of the habitats at capture sites (Gaudreau 2005). Knowledge acquisition concerning the species' life cycle, behaviour, adaptability, habitat requirements and threats is important for implementation of recovery measures in Quebec. Additional data concerning the species' abundance and locations are also necessary for monitoring population trends and distribution and for gauging the success of recovery measures (Boucher and Garceau, 2010; DFO, 2011).

The priority in terms of management should be the high-quality habitat zones currently occupied by eastern sand darter populations. Once the species disappears from a watercourse, restoring its presence there is challenging (Équipe de rétablissement des cyprinidés et des petits percidés du Québec, 2008). The recovery potential assessment sets out a number of more specific mitigation measures and alternatives that could be implemented to reduce the impact of certain threats, such as the presence of exotic species and diseases or the incidental harvest of

individuals (DFO, 2011). These mitigation measures and alternatives complement the recovery planning tables and will be addressed more specifically during the action plan phase.

7. CRITICAL HABITAT

7.1 Identification of the species' critical habitat

Critical habitat is defined under subsection 2(1) of SARA as: "…*the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species.*" [subsection 2(1)]

SARA defines habitat for aquatic species at risk as: *"… spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced."* [subsection 2(1)]

For the eastern sand darter, Quebec populations, critical habitat is identified to the extent possible, using the best available information[15], in three areas: 1) L'Assomption and Ouareau rivers; 2) Richelieu River; and 3) aux Saumons River (near Dundee city). The critical habitat identified in this recovery strategy is described in terms of the geospatial areas (i.e., watercourse sections) containing the habitat necessary for the survival or recovery of the species. The currently identified areas are insufficient to achieve the population and distribution objectives for the species. The schedule of studies outlines the activities required to identify additional critical habitat and describe it more accurately (in terms of functions, features and biophysical attributes as well as spatial distribution) with a view to ensuring its protection.

7.1.1 Information and methods used to identify critical habitat

The critical habitat of the eastern sand darter, Quebec populations, was identified using the best available information with a "bounding box" approach. This approach is used when the habitat attributes associated with a species' presence are known but the habitats used or exhibiting the characteristics suitable for their use are not clearly mapped within the bounding box. This bounding box corresponds to the watercourse section where the critical habitat is located. The bounding box is based on occurrence data for the species, that is, the stations furthest upstream and downstream where the species has been surveyed. Within this watercourse section, only the habitats exhibiting certain biophysical attributes (see section 7.1.3, Identification of Critical Habitat: Functions, Features and Biophysical Attributes) are identified as critical habitat.

Knowledge about the eastern sand darter's requirements, habitat and range is highly limited in Quebec. Occurrence data and limited habitat data have been compiled in the MRNF database form. Over the last two decades, significant numbers of eastern sand darters have been collected in only three areas of the province:1) L'Assomption and Ouareau rivers (CARA, 2002; Bourgeois, 2010; Blanchette, 2011); 2) Richelieu River (Vachon 2007; N. Vachon, MRNF, unpublished data used in COSEWIC, 2009; Ginson, 2010; S. Garceau, MRNF, pers. comm., 2010); and 3) aux Saumons River (D. Hatin, MRNF, pers. comm., 2010; Ginson, 2010). A summary description of the habitat used in these watercourses is also available. In light of the small quantity of eastern sand darters captured in other watercourses and the limited

[15] This recovery strategy includes data from surveys conducted up to and including the summer of 2010.

information available on habitat attributes, it was decided to limit the identification of the critical habitat of the eastern sand darter, Quebec populations, to these three areas. Further work (see section 7.2, Schedule of Studies for Identifying Critical Habitat) is required to better describe and explain the specific habitat attributes associated with the presence of the eastern sand darter, including the watercourse sections containing the critical habitats identified by this recovery strategy.

The length and area of the watercourse sections containing critical habitats for the eastern sand darter were assessed using a mapping method and compared to the minimum area required for population viability (MAPV). As noted at section 5, the minimum viable population (MVP) is predicted to be 52 282 adults taking into account a catastrophic event percentage per generation of 10% for an MAPV of 3.7 ha of suitable habitat in rivers (Finch et al., 2011; DFO, 2011). It is important to note that the areas assessed are the total surface areas of the watercourse sections rather than of the critical habitat area within each section. The actual critical habitat area values are likely smaller than the surface areas assessed; for the time being, however, this is the only methodology available for comparing the area of each section to the MAPV modelled.

7.1.2 Identifying critical habitat: geospatial data

The critical habitat of the eastern sand darter, Quebec populations, has been identified within three different sectors in two hydrographic regions. Within the bounding box (i.e., designated watercourse sections), only the habitats exhibiting certain biophysical attributes (see section 7.1.3, Identification of Critical Habitat: Functions, Features and Biophysical Attributes) have been designated as critical habitat.

Northwestern St. Lawrence Hydrographic Region

L'Assomption River and one of its tributaries, Ouareau River: The habitat used by the eastern sand darter in the L'Assomption River watershed was studied by the Corporation d'Aménagement de la Rivière L'Assomption (CARA, 2002; Bourgeois, 2010; Blanchette, 2011) (Figure 4). The sections containing the identified critical habitat include a section of L'Assomption River (upstream from the town of L'Assomption [from a line between geographic coordinates 46°06'35" N 73°29'19" W and 46°06'35" N 73°29'18" W to a line between the coordinates 45°49'28" N 73°26'16" W and 45°49'29" N 73°26'13" W]) and one of its tributaries, Ouareau River (downstream from Crabtree [from a line between the coordinates 45°57'30" N 73°27'19" W and 45°57'32" N 73°27'16" W] up to its outlet into L'Assomption River). These sections are respectively 74 km and 6 km in length corresponding to a total area of 350 ha. Knowledge acquisition should make it possible to determine whether these two sections support distinct populations.

Eastern sand darters were captured in zones characterized by a low to medium current, little to no aquatic vegetation, mainly sand substrate with silt in some places, relatively clear water and at depths of less than 1 m (CARA, 2002; Bourgeois, 2010; Blanchette, 2011).

Southwestern St. Lawrence Hydrographic Region

Richelieu River: The section of the Richelieu River containing the critical habitat of the eastern sand darter (Figure 5) extends from a point downstream of the Chambly reservoir (from a line between the coordinates 45°28'09" N 73°17'00" W and 45°28'08" N 73°16'03" W) to a point near

the river outlet into the St. Lawrence River (line between the coordinates 46°02'18" N 73°07'02" W and 46°07'18" N 73°06'55" W). This section is 71 km in length for a total area of 1880 ha.

In the area of Chambly rapids, eastern sand darters were generally captured in habitats where the substrate was 80% sand with a current speed of less than 1 cm/s at a depth of less than 20 cm (Boucher and Garceau, 2010). Further downstream, near the municipalities of Saint-Marc-sur-Richelieu and Saint-Ours, preliminary analysis of data collected since 2008 showed that eastern sand darters were captured on sand substrates at depths of up to 2.9 m (D. Hatin, MRNF, pers. comm 2012). In addition, individuals were also collected at depths of up to 5 m on a substrate of hard clay (S. Garceau, MRNF, pers. comm., 2010).

Aux Saumons River: The section of aux Saumons River containing the critical habitat of the eastern sand darter (Figure 6) extends from the Quebec-United States border (line between the coordinates 45°00'00" N 74°30'54" W and 45°00'00" N 74°30'52" W) to a point approximately 2 km from the river outlet into Lake St. Louis (line between coordinates 45°01'28" N 74°31'15" W and 45°01'25" N 74°31'11" W) for a total length of 3.8 km and a total area of 28 ha.

According to a preliminary analysis of data, eastern sand darter seem associated with lotic habitat in depths ranging from 1 and 1.5 m, on mainly sand substrate with absent or sparse vegetation and low turbidity (D. Hatin, MRNF, comm. perso. 2012).

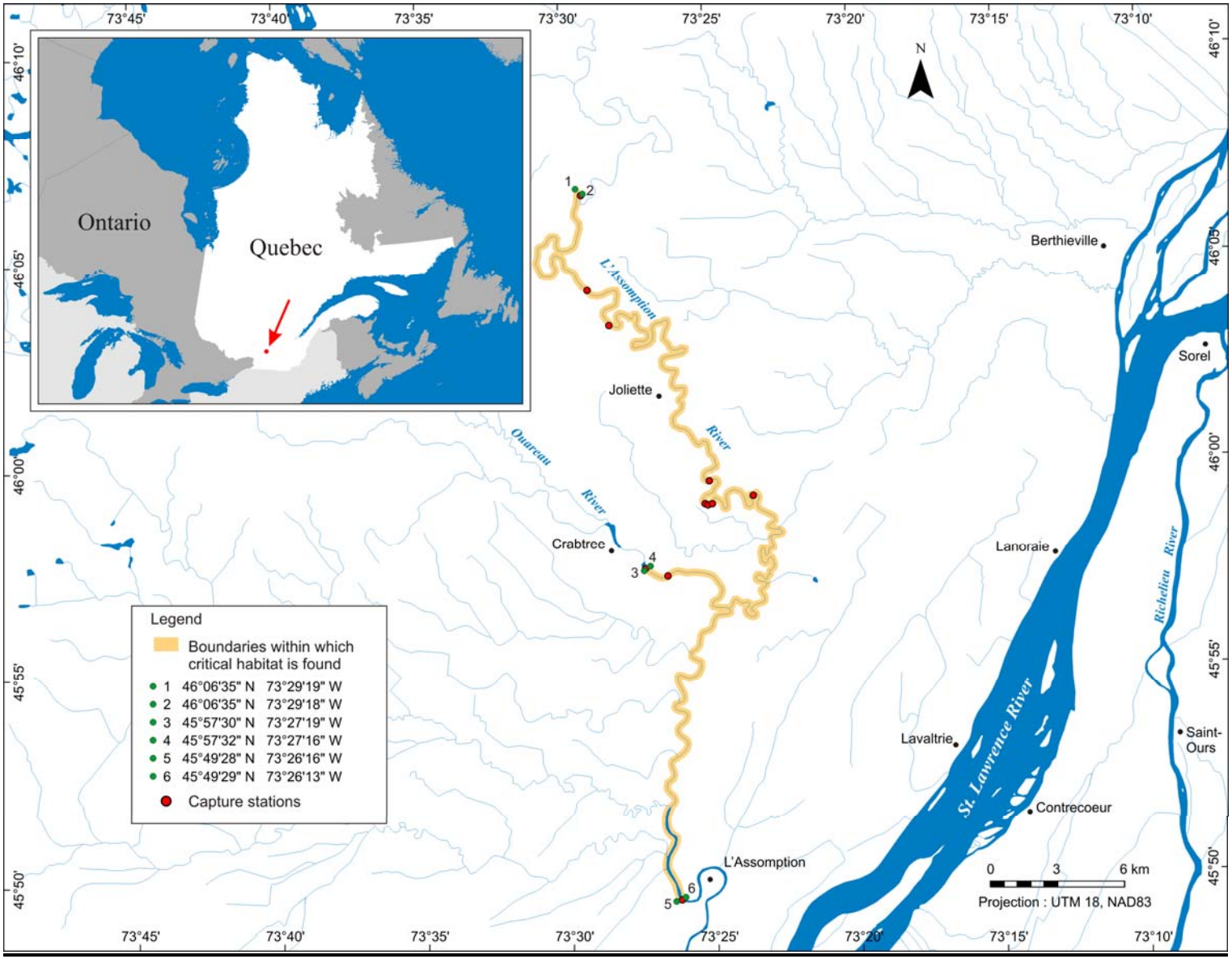

Figure 4. Boundaries of the area within which critical habitat of the eastern sand darter is found in the L'Assomption River and the Ouareau River.

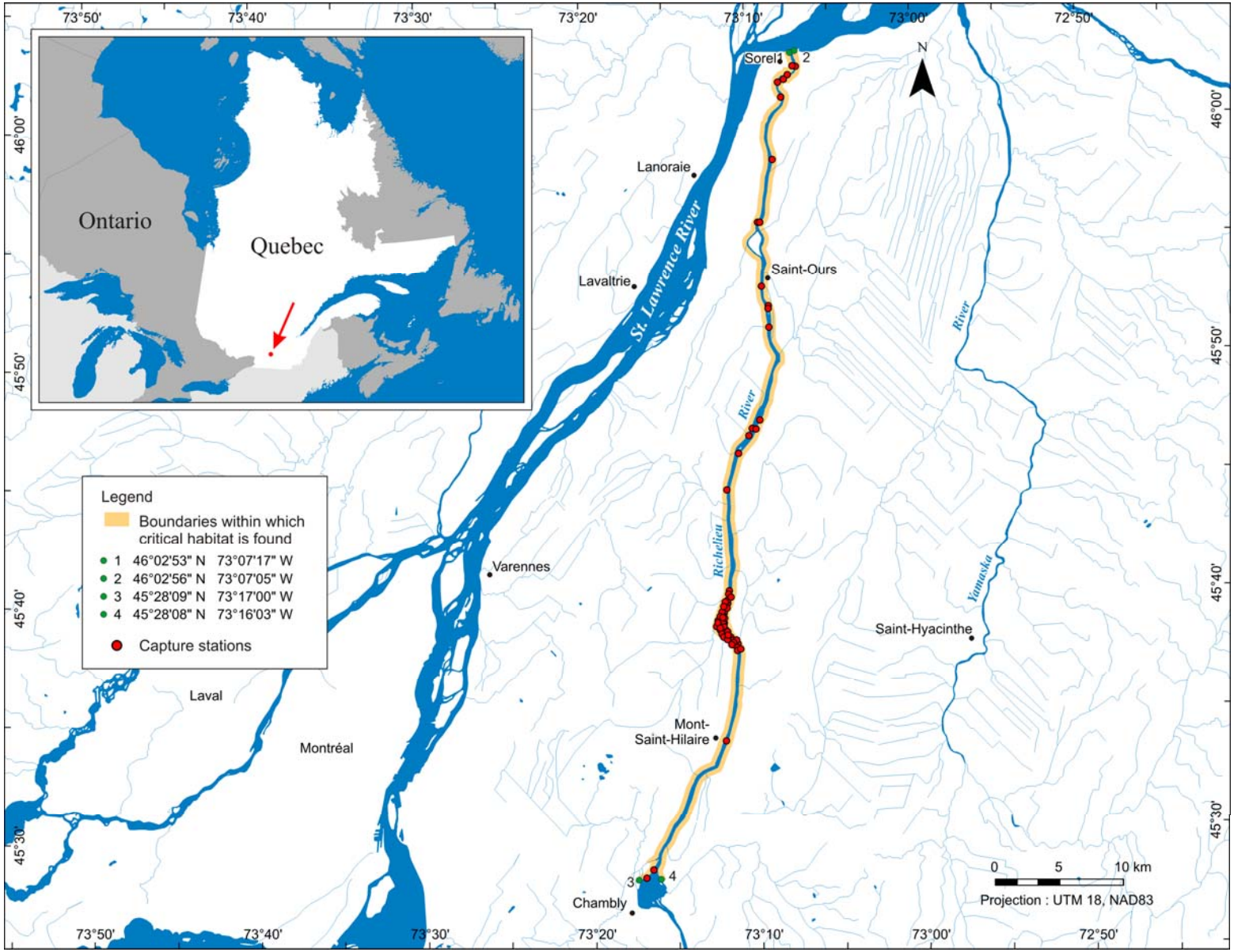

Figure 5. Boundaries of the area within which critical habitat of the eastern sand darter is found in the Richelieu River.

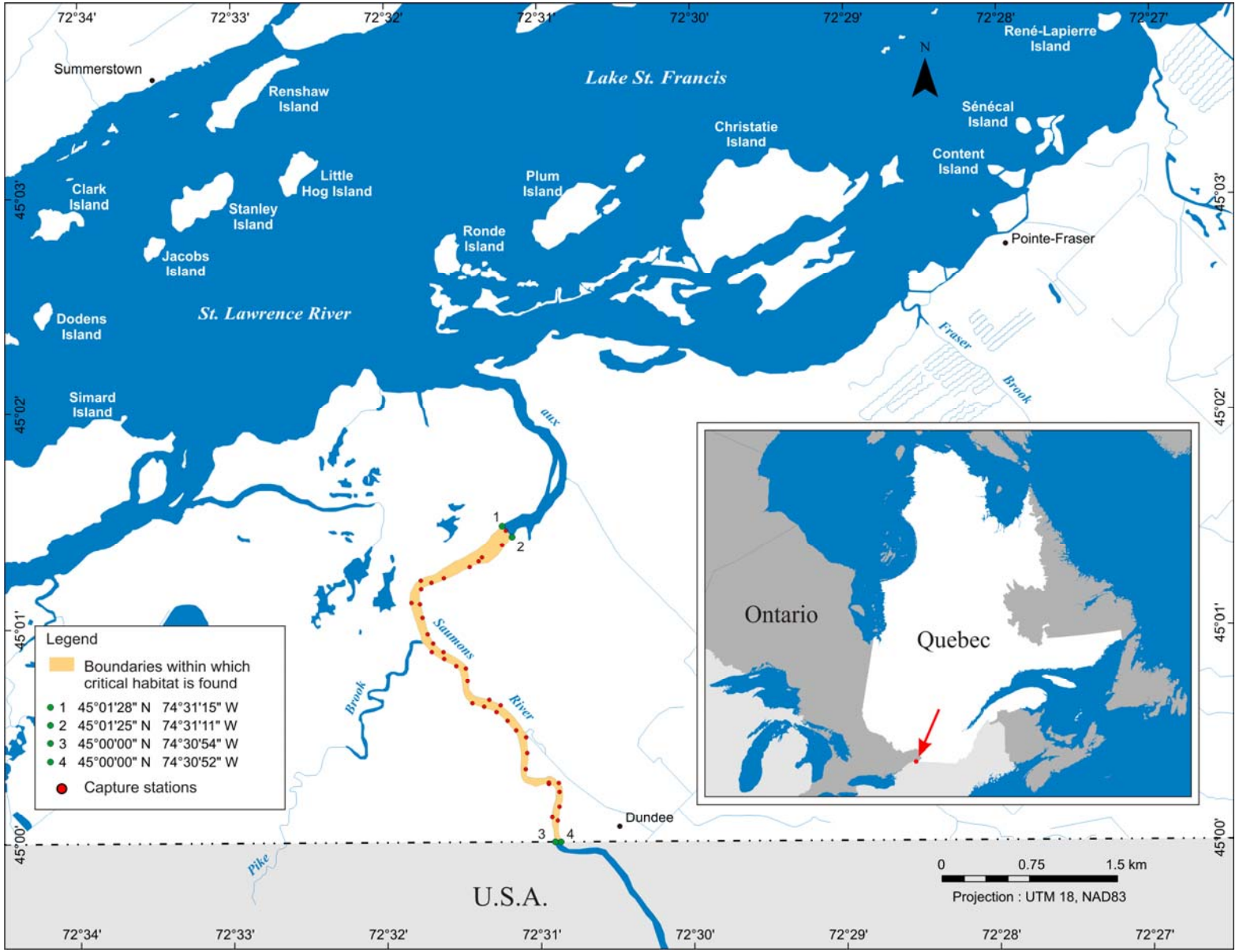

Figure 6. Boundaries of the area within which critical habitat of the eastern sand darter is found in the aux Saumons River.

Population Viability

For purposes of assessing the viability of the eastern sand darter populations in the three sectors containing identified critical habitats, the area of the bounding box (i.e., the section containing the identified critical habitat) was compared to the MAPV determined through modelling by Finch et al. (2011) (Table 9). The area of these sections in all three sectors was greater than the MAPV. However, the area of the bounding box was assessed for the entire watercourse section rather than specifically in terms of the habitat attributes used to define critical habitat as set out in the following section. It is consequently impossible to state that these watercourse sections contain enough identified critical habitat to achieve MAPV. Additional work is required to assess the quantity and quality of the critical habitats available in these sections. This information, combined with refinement of the MAPV model, will enable determining population viability with greater certainty. The results documented to date are consequently preliminary and to be interpreted with caution.

Table 9. Comparison of total area (ha) of watercourse sections containing identified critical habitats for each eastern sand darters population in Quebec to the predicted minimum area required for population viability (MAPV) of 3.7 ha

Populations	Area of Critical Habitat Identified (ha)	MAPV Achieved (Yes/No)
L'Assomption and Ouareau rivers	350	To be confirmed
Richelieu River	1862	To be confirmed
aux Saumons River	28	To be confirmed

7.1.3 Identifying critical habitat: functions, features and attributes

The critical habitat of the eastern sand darter in Quebec inside the delimitation zones is made up of sand banks in lotic environments with habitat attributes corresponding to those set out in Table 10 in terms of water velocity, water depth, substrate, aquatic vegetation cover, turbidity and prey availability. This table provides a summary of the habitat attributes documented during the recent surveys of the eastern sand darter in Quebec. It is to be noted that a habitat does not necessarily have to have every attribute to be considered a critical habitat for the eastern sand darter. Professional judgment must be used in determining whether a particular area should be classified as a critical habitat for the eastern sand darter. For example, a sand bank that is exposed during low-water periods may serve as a critical habitat for the eastern sand darter when water levels are higher. Moreover, the values are provided for reference purposes only and may vary locally or depending on the time of year (e.g., current speed and water depth during the spring freshet versus low-water periods in late summer).

Insofar as the eastern sand darter is a small fish with limited dispersal abilities that appears to develop entirely within a small area, the critical habitat attributes for the Quebec populations were determined for all stages of development combined. For additional information on the critical habitat requirements specific to each stage of development, refer to section 3.3 Needs of the eastern sand darter. Knowledge acquisition (see the next section, 7.2 Schedule of Studies to Identify Critical Habitat), should lead to greater understanding of the habitat attributes associated with the presence of the eastern sand darter and adjustments to this table in terms of both the habitat requirements specific to each life stage and the species' tolerance thresholds associated with biophysical attributes.

Table 10. Functions, features and biophysical attributes of critical habitat for all life stages combined for the eastern sand darter, Quebec populations.

Functions	Features	Biophysical Attributes
• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Lotic environment with a very low to moderate **water velocity**, although this may increase in freshet conditions. • Shoals or along the banks of watercourses where the **water depth** is less than 2 m. • Mainly sandy **substrate** with or without gravel. • No or, where present, little or scarce **aquatic vegetation cover** • Generally low **turbidity.** • **Prey availability** in sufficient quality and quantity.

7.2 Schedule of studies to identify critical habitat

This recovery strategy includes the identification of critical habitat to the extent possible, based on the best available information. Further work is required to identify additional critical habitat necessary to support the population and distribution objectives for the species (see Table 11). Knowledge acquisition concerning habitat requirements for the various life stages is necessary in order to better describe the biophysical attributes of critical habitat associated with each life stage and various functions in addition to defining the species' tolerance thresholds. Conducting surveys in the currently occupied, historical and potential area will assist in identifying critical habitat. Characterization of habitats where the species is extant, combined with density index values, will enable population viability assessment. Lastly, the population/habitat model can be refined, population and distribution objectives reviewed and an estimate of the critical habitat area requiring protection established with a view to achieving these objectives.

Table 11. Schedule of studies to complete critical habitat identification of eastern sand darter, Quebec populations.

Study Description	Time Frame
Conduct studies on habitat requirements for each life stage of the eastern sand darter and analyze data previously collected.	2013-2017
Conduct surveys to fill in gaps in the knowledge about distribution and assist in determining connectivity between populations. Focus first on historical and potential habitats, and where possible, estimate the density of eastern sand darter populations found there.	2013-2017
Survey and map habitat quantity and quality in the current and historical distribution as well as in sites adjacent to currently occupied habitats.	2013-2017
Validate the population/habitat model and, if possible, make a population/habitat model available for each life stage.	2013-2017
Review population and distribution objectives based on the information collected. Determine the quality and quantity of critical habitat necessary to achieve these objectives where adequate information exists.	2013-2017

7.3 Activities likely to result in the destruction of critical habitat

The activities likely to result in the destruction of critical habitat described in this table (Table 12) are neither exhaustive nor exclusive and have been guided by the threats described in this recovery strategy under Section 4.2 Description of Threats. The absence of a specific human activity does not preclude or fetter the Department's ability to regulate it pursuant to SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition since it is destruction of critical habitat that is prohibited. Since habitat use is often temporal in nature, every activity is assessed on a case-by-case basis and site-specific mitigation is applied where it is reliable and available. In every case, where information is available, habitat thresholds and limits are associated with biophysical attributes to better inform management and regulatory decision-making. However, in many cases the knowledge of a species and its critical habitat, and more specifically information associated with species' or habitat's thresholds of tolerance to disturbance from human activities, may be insufficient and must be acquired.

Under SARA, critical habitat for aquatic species not found in an area described in subsection 58(2) of the Act must be legally protected within 180 days of the final recovery strategy or action plan in which it is identified being posted on the Species at Risk Public Registry. For the critical habitat of the eastern sand darter, it is anticipated that this will be accomplished through a SARA Critical Habitat Order made under subsections 58(4) and (5), which will trigger the prohibition in subsection 58(1) against the destruction of the identified critical habitat.

Table 12. Human activities likely to destroy critical habitat of the eastern sand darter including the pathway of effects for each activity and potential impact on the functions, features and biophysical attributes of critical habitat.

Activity	Pathway of Effects	Function Affected	Feature Affected	Attribute Affected
Degradation of riparian strips due to the clearing of riparian vegetation	• Promotes bank erosion leading to increased sediment input and turbidity as well as siltation of the substrate. • Alteration of the natural processes resulting in the formation and maintenance of sandbanks free of fine sediment.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Mainly sandy substrate with or without gravel. • Generally low turbidity. • Prey availability in sufficient quality and quantity.
Shoreline structures (e.g., retaining walls, riprap)	• Destruction due to encroachment into watercourse beds. • May cause bank erosion leading to increased sediment input and turbidity as well as siltation of the substrate. • Alteration of the natural processes resulting in the formation and maintenance of sandbanks free of fine sediment.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Lotic environment with a very low to moderate water velocity, although this may increase in freshet conditions. • Shoals or along the banks of watercourses where the water depth is less than 2 m. • Mainly sandy substrate with or without gravel. • No or, where present, little or scarce aquatic vegetation cover. • Generally low turbidity. • Prey availability in sufficient quality and quantity.
Ploughing and harvesting up to watercourses	• Promotes bank erosion leading to increased sediment input and turbidity as well as siltation of the substrate. • Alteration of the natural processes resulting in the formation and maintenance of sandbanks free of fine sediment.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Mainly sandy substrate with or without gravel. • Generally low turbidity. • Prey availability in sufficient quality and quantity.

Activity	Pathway of Effects	Function Affected	Feature Affected	Attribute Affected
Allowing livestock free access to watercourses	• Trampling of watercourse banks and beds by livestock leading to increased sediment input and turbidity, siltation of the substrate and destruction of the watercourse bed. • Nutrient loading leading to possible anoxia and eutrophication of watercourses. • Alteration of the natural processes resulting in the formation and maintenance of sandbanks free of fine sediment.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Shoals or along the banks of watercourses where the water depth is less than 2 m. • Lotic environment with a very low to moderate water velocity, although this may increase in freshet conditions. • Mainly sandy substrate with or without gravel. • No or, where present, little or scarce aquatic vegetation cover. • Generally low turbidity. • Prey availability in sufficient quality and quantity.
Spreading fertilizer (liquid/solid manure) near watercourses	• Anoxia and eutrophication of watercourses. • Increased sediment input and turbidity as well as siltation of the substrate.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Mainly sandy substrate with or without gravel. • No or, where present, little or scarce aquatic vegetation cover. • Generally low turbidity. • Prey availability in sufficient quality and quantity.
Discharge of untreated wastewater, including sewer overflow	• Anoxia and eutrophication of watercourses. • Increased sediment input and turbidity as well as siltation of the substrate.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Mainly sandy substrate with or without gravel. • No or, where present, little or scarce aquatic vegetation cover. • Generally low turbidity. • Prey availability in sufficient quality and quantity.

Activity	Pathway of Effects	Function Affected	Feature Affected	Attribute Affected
Straightening and channelization of watercourses	• Uniformization of watercourses in addition to altering their water regime and the natural processes resulting in the formation and maintenance of sandbanks free of fine sediment. • Deterioration of the watercourse bed. • Blocking of fish passage potentially resulting in habitat fragmentation and isolation of populations from one another.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Lotic environment with a very low to moderate water velocity, although this may increase in freshet conditions. • Shoals or along the banks of watercourses where the water depth is less than 2 m. • Mainly sandy substrate with or without gravel. • No or, where present, little or scarce aquatic vegetation cover. • Generally low turbidity. • Prey availability in sufficient quality and quantity.
Dam building and operation	• Alteration of natural hydrographic conditions (e.g., water level, temperature and flow) and the natural processes resulting in the formation and maintenance of sandbanks free of fine sediment. • Destruction due to encroachment into watercourse beds. • Drying out spawning grounds, potentially making them inaccessible or causing mortality among the eggs or larvae present at thattime. • Blocking of fish passage potentially resulting in habitat fragmentation and isolation of populations from one another. • Increased sedimentation through limiting of the spring freshet or reservoir formation.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Lotic environment with a very low to moderate water velocity, although this may increase in freshet conditions. • Shoals or along the banks of watercourses where the water depth is less than 2 m. • Mainly sandy substrate with or without gravel. • No or, where present, little or scarce aquatic vegetation cover. • Generally low turbidity. • Prey availability in sufficient quality and quantity.

Activity	Pathway of Effects	Function Affected	Feature Affected	Attribute Affected
Other structures on the shorelines of or in watercourses (e.g., docks, bridges, culverts)	• Destruction due to encroachment into watercourse beds. • Alteration of natural hydrographic conditions (e.g., water level, temperature and flow) and the natural processes resulting in the formation and maintenance of sandbanks free of fine sediment. • Blocking of fish passage potentially resulting in habitat fragmentation and isolation of populations from one another.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Lotic environment with a very low to moderate water velocity, although this may increase in freshet conditions. • Shoals or along the banks of watercourses where the water depth is less than 2 m. • Mainly sandy substrate with or without gravel. • No or, where present, little or scarce aquatic vegetation cover. • Generally low turbidity. • Prey availability in sufficient quality and quantity.
Filling	• Destruction due to encroachment into watercourse beds. • Alteration of natural hydrographic conditions (e.g., water level, temperature and flow) and the natural processes resulting in the formation and maintenance of sandbanks free of fine sediment. • Blocking of fish passage potentially resulting in habitat fragmentation and isolation of populations from one another.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Lotic environment with a very low to moderate water velocity, although this may increase in freshet conditions. • Shoals or along the banks of watercourses where the water depth is less than 2 m. • Mainly sandy substrate with or without gravel. • No or, where present, little or scarce aquatic vegetation cover. • Generally low turbidity. • Prey availability in sufficient quality and quantity.

Activity	Pathway of Effects	Function Affected	Feature Affected	Attribute Affected
Dredging and maintenance of watercourses	• Deterioration of the watercourse bed. • Alteration of natural hydrographic conditions (e.g., water level, temperature and flow) and the natural processes resulting in the formation and maintenance of sandbanks free of fine sediment. • Blocking of fish passage potentially resulting in habitat fragmentation and isolation of populations from one another.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Lotic environment with a very low to moderate water velocity, although this may increase in freshet conditions. • Shoals or along the banks of watercourses where the water depth is less than 2 m. • Mainly sandy substrate with or without gravel. • No or, where present, little or scarce aquatic vegetation cover. • Generally low turbidity. • Prey availability in sufficient quality and quantity.
Recreational nautical activities	• Wave action from passing boats causing bank erosion and leading to increased sediment input and turbidity as well as siltation of the substrate. • Alteration of the natural processes resulting in the formation and maintenance of sandbanks free of fine sediment.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Shoals or along the banks of watercourses where the water depth is less than 2 m. • Mainly sandy substrate with or without gravel. • Generally low turbidity. • Prey availability in sufficient quality and quantity.
Introduction of exotic species	• Sufficiently significant impact on biotic or abiotic components to affect one or more functions of critical habitat.	• Spawning • Rearing • Feeding and growth (juveniles) • Feeding and growth (adults) • Migration	• Sand bank in lotic environment	• Prey availability in sufficient quality and quantity. • Other habitat attributes if the introduction of an exotic species causes a modification of habitat attributes (e.g., substrate).

8. MEASURING PROGRESS

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives. Specific progress towards implementing the recovery strategy will be measured against indicators outlined in subsequent action plan.

- Identify three other viable populations (indicators: area and number of adult individuals) in the various watercourses by 2017, or nearly 50% of the target number of populations (13 viable populations) to achieve an extinction risk over 100 years of 1%, or a 99% probability of species persistence (Finch et al., 2011; DFO, 2011).
- Identification of critical habitat for each of these populations.

9. ACTIVITIES PERMITTED BY THE RECOVERY STRATEGY

The *Species at Risk Act* stipulates that "*No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species*" (subsection 32(1)). Under subsection 83(4) of the *Species at Risk Act*, "*Subsections 32(1) and (2), section 33 and subsections 36(1), 58(1), 60(1) and 61(1) do not apply to a person who is engaging in activities that are permitted by a recovery strategy, an action plan or a management plan and who is also authorized under an Act of Parliament to engage in that activity, including a regulation made under section 53, 59 or 71.*"

9.1 Commercial bait fishing

As noted previously, one sector of the commercial fishing industry in Quebec involves catching small fish for use as bait in sport fishing. Although commercial bait fishermen do not specifically target the eastern sand darter and the species is not listed as a permitted species in this regard, specimens could be harvested incidentally since the habitats used by the eastern sand darter overlap those targeted by bait fishermen.

Two studies have been carried out to assess the impact of commercial bait fishing on five fish species at risk, including the eastern sand darter (Boucher et al., 2006; Garceau et al., in press). Inspection of the fishing gear and holding tanks of commercial fishermen as well as the tanks of bait fish retailers did not reveal the presence of any eastern sand darter specimens. However, the studies concluded that a risk of capture exists nonetheless for small fish species with precarious status by commercial bait fishermen in certain areas with a concentration of habitats used by these species. As a preventive measure, a number of sectors have been closed to commercial bait fishing (e.g., the Richelieu River section of fishing area 8) (S. Garceau, MRNF, pers. comm., 2010). An awareness fact sheet was also developed by DFO in 2011 to educate people on recognizing eastern sand darters by their features and their obligation to return this fish to the water in the event it is caught accidentally.

Commercial bait fishing as it is currently practised is consequently very unlikely to have an impact on the overall survival and recovery of the population. In the event of incidental harvest, the unique morphological features of the eastern sand darter make it easily identifiable by fishermen (Équipe de rétablissement des cyprinidés et des petits percidés du Québec, 2008), who should then return to the water any specimens captured.

Pursuant to subsection 83(4) of SARA, the present recovery strategy authorizes commercial bait fishermen to carry out bait fishing activities subject to the following conditions:

- the fishing activity is carried out under the terms of a commercial fishing license issued under the provision of the *Quebec Fishery Regulations (1990)* SOR/90-214;
- any person who accidentally captures an eastern sand darter while fishing shall without delay return the fish to the water in which it was caught and, if the fish is alive, release it in a manner that causes the least harm to the fish.

Moreover, pursuant to subsection 83(4) of SARA, the present recovery strategy authorizes fishermen to carry out fishing activities under an Aboriginal communal license subject to the following conditions:

- the fishing activity is carried out under the terms of a communal license issued under the provision of the *Aboriginal Communal Fishing License Regulations (1993)* SOR/93-332;
- any person who accidentally captures an eastern sand darter while fishing shall without delay return the fish to the water in which it was caught and, if the fish is alive, release it in a manner that causes the least harm to the fish.

9.2 Sport bait fishing

In contrast to the conditions governing commercial fishing and Aboriginal communal fishing licenses, which prohibit keeping any species not permitted by the license, the sport fishing regulations (*Quebec Fishery Regulations*) do not currently prohibit using the eastern sand darter as bait fish. It is consequently not possible to permit sport bait fishing activities under the auspices of this recovery strategy. However, communication tools are being developed to educate sport fishermen and the general public about activities prohibited under SARA and the importance of protecting the eastern sand darter and its habitat. Quebec sport fishing regulations could be amended in the near future to prohibit using the eastern sand darter as bait fish, as is currently the case for the channel darter, another fish species listed under Schedule 1 of SARA with "threatened" status.

10. STATEMENT ON ACTION PLANS

An action plan will be established within five years of publication of the final version of this recovery strategy. At this stage, it appears unlikely that five years will be sufficient to allow for the acquisition of all knowledge required to enable comprehensive identification of the habitat necessary to the survival and recovery of the species.

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APPENDIX A: EFFECTS ON THE ENVIRONMENT AND OTHER SPECIES

A strategic environmental assessment (SEA) is conducted on all recovery planning documents according to SARA, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and programs to support environmentally sound decision-making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

The possibility of the inadvertent generation of negative impact on other species by the recovery strategy for the eastern sand darter, Quebec populations, has been considered. Based on the SEA, it has been concluded that this strategy will be clearly favorable for the environment and will not generate any significant negative impact.

APPENDIX B: RECORD OF COOPERATION AND CONSULTATION

This recovery strategy was developed in conjunction with the Équipe de rétablissement des cyprinidés et petits percidés du Québec, which was made up, during drafting, of representatives of Fisheries and Oceans Canada, Parks Canada Agency, the Ministère des Ressources naturelles et de la Faune du Québec, Hydro-Québec, Société de conservation et d'aménagement du bassin de la rivière Châteauguay (SCABRIC), Ambioterra and the Comité de concertation et de valorisation de la rivière Richelieu (COVABAR).

In addition, the draft version of this recovery strategy was submitted for review to relevant provincial and federal jurisdictions (i.e., ministère des Ressources naturelles et de la faune du Québec, Parks Canada Agency, Environment Canada). The draft version of this recovery strategy was also submitted to First Nations communities whose territory overlaps the eastern sand darter distribution to provide them with the opportunity to comment. A proposed version of this document was posted on the Species at Risk Public Registry for a public consultation. A letter concerning this consultation was sent to over 100 individuals and organizations likely to be interested by this recovery strategy.