PROPOSED

Species at Risk Act
Recovery Strategy Series

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

Eastern Sand Darter

July 2007

Fisheries and Oceans Canada
Pêches et Océans Canada
Canada

About the *Species at Risk Act* Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003 and one of its purposes is *"to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency, and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37–46 of SARA (http://www.sararegistry.gc.ca/the_act/) outline both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the SARA Public Registry (http://www.sararegistry.gc.ca/) and the Web site of the Recovery Secretariat (http://www.speciesatrisk.gc.ca/recovery/).

Recovery Strategy for the Eastern Sand Darter (*Ammocrypta pellucida*) in Canada [Proposed]

July 2007

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Additional copies:

You can download additional copies from the SARA Public Registry (http://www.sararegistry.gc.ca/)

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DECLARATION

The recovery strategy for the eastern sand darter was developed by members of the Ontario Eastern Sand Darter Recovery Team (OESDRT) and the Quebec Cyprinidae and Small Percidae (CSP) Recovery Team, using provincially based recovery strategies for this species. It defines recovery goals, approaches and objectives which have been deemed necessary to the species' recovery. It does not necessarily reflect the opinions of each of the recovery team's members, nor the official positions of the organizations with which team members are associated. Fisheries and Oceans Canada has reviewed and accepts this document as its recovery strategy for the eastern sand darter as required by the *Species at Risk Act*.

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. In the spirit of the National Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans invites all Canadians to join Fisheries and Oceans Canada in supporting and implementing this strategy for the benefit of the eastern sand darter and Canadian society as a whole. Fisheries and Oceans Canada will support implementation of this strategy to the extent possible, given available resources and its overall responsibility for species at risk conservation. Implementation of the strategy by other participating jurisdictions and organizations is subject to their respective policies, appropriations, priorities, and budgetary constraints.

The goals, objectives and recovery approaches identified in the strategy are based on the best existing knowledge and are subject to modifications resulting from new findings and revised objectives. The Minister of Fisheries and Oceans will report on progress within five years.

This strategy will be complemented by one or more action plans that will provide details on specific recovery measures to be taken to support conservation of the species. The Minister will take steps to ensure that, to the extent possible, Canadians interested in or affected by these measures will be consulted.

RESPONSIBLE JURISDICTIONS

Under the *Species at Risk Act*, the responsible jurisdiction for eastern sand darter is Fisheries and Oceans Canada. Eastern sand darter occurs in Ontario and Quebec, and their respective provincial governments also cooperated in the production of this recovery strategy:

AUTHORS

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Maps were developed by Alan Dextrase (OMNR) and Andrew Doolittle (DFO).

STRATEGIC ENVIRONMENTAL ASSESSMENT STATEMENT

In accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*, the purpose of a Strategic Environmental Assessment (SEA) is to incorporate environmental considerations into the development of public policies, plans, and program proposals 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 on non-target species or habitats.

This recovery strategy will clearly benefit the environment by promoting the recovery of the eastern sand darter. The potential for the strategy to inadvertently lead to adverse effects on other species was considered. The SEA concluded that this strategy will clearly benefit the environment and will not entail any significant adverse effects. Refer to the following sections of the document in particular: Description of the species' needs – habitat and biological needs, ecological role and limiting factors; Recovery Feasibility; Approaches Recommended to Meet Recovery Objectives; and, Possible Recovery Effects on Non-targeted Species.

RESIDENCE

SARA defines residence as: "*a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating*" **[SARA S2(1)]**.

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted on the SARA public registry:
http://www.sararegistry.gc.ca/plans/residence_e.cfm

PREFACE

The responsible jurisdiction for the eastern sand darter under the *Species at Risk Act* (SARA) is Fisheries and Oceans Canada. Section 37 of SARA requires the competent minister to prepare recovery strategies for listed extirpated, endangered and threatened species. The eastern sand darter is a freshwater fish and was listed as threatened under SARA in June 2003. Fisheries and Oceans Canada – Central and Arctic Region led, with the help of DFO-Quebec Region, the development of this recovery strategy. The proposed strategy meets SARA requirements in terms of content and process (Sections 39-41). It was developed in cooperation or consultation with:

- Ontario Ministry of Natural Recources
- Ministère des Ressources Naturelles et de la Faune du Québec
- New York Department of Environmental Conservation

EXECUTIVE SUMMARY

The eastern sand darter [*Ammocrypta pellucida* (Agassiz, 1863)] is a small benthic and translucent fish whose North American range is discontinuous and composed of two disjunct areas. One element occurs in the Great Lakes and Ohio River drainage, while the other occurs in Lake Champlain and the St. Lawrence River. In Ontario, it has been collected from shallow habitats in Lake Erie and Lake St. Clair, and from the Grand, Sydenham and Thames rivers. In Quebec, eastern sand darter occur, for the most part, in the St. Lawrence and its tributaries between Lake of Two Mountains and Leclercville, downstream from Lake St. Pierre. The species was reported in a few tributaries in six areas of the province: Centre du Quebec, Lanaudière, Laval, Maurice, Montérégie and Montreal.

There is little data available on the eastern sand darter throughout its Canadian range. Nevertheless, the little data that are available suggest that eastern sand darter populations are declining throughout their entire range. In Canada, total numbers have been declining since 1950. The silting of sandy habitats represents the main cause for the decline in abundance and range of eastern sand darter. Threats to Canadian populations include: agricultural pollution; urban and industrial pollution; loss of riparian cover; dam construction; stream channelization and change to natural flow regimes; riparian pastures; wave action from boats; lower water levels in the St. Lawrence River; exotic or invading species; commercial bait fishing; and, pet trade.

This recovery strategy defines the goal, objectives and recommended approaches considered necessary for the protection and recovery of the eastern sand darter in Canada.

The long-term goal of this recovery strategy is to prevent the further decline of eastern sand darter populations and the deterioration of their habitat in Canada. It is also to ensure the species' sustainability by increasing the distribution and abundance of eastern sand darter throughout its current Canadian range through improvements to habitat quality and reintroductions (if feasible).

Short-term Recovery Objectives (5 year)
As available information on current and historic eastern sand darter populations is very limited, it is quite difficult to establish precise objectives in terms of the absolute number of individuals. Thus, the objectives presented here are more qualitative in nature.

i. Protect known populations and habitats.
ii. Determine the extent, abundance and demographics of existing populations through a focused sampling program.
iii. Determine the extent, abundance and quality of existing habitat (sandy patches) in areas of occurrence through a focused sampling program.
iv. Identify key habitat requirements to define critical habitat and implement strategies to protect known habitats.
v. Establish a long-term population and habitat monitoring program.
vi. Clarify threats and identify remedial actions to reduce their effects.
vii. Examine the feasibility of translocations, reintroductions and captive rearing.

viii. Increase awareness of the significance of this species and its status as an aquatic species at risk and indicator of ecosystem health.

ix. Develop linkages among partners, including watershed-based recovery teams, interest groups, industry, agencies and landowners interested in supporting the recovery of the eastern sand darter.

Some measures have already been implemented for the recovery of the eastern sand darter in both Ontario and Quebec. In Ontario, several eastern sand darter surveys have been conducted from 1997 to 2005 in nine historically and/or currently occupied waterbodies. Also, five ecosystem or multi-species recovery strategies that address eastern sand darter recovery have been initiated in Ontario. In Quebec, a provincial Cyprinidae and Small Percidae Recovery Team was formed in February 2006. Its central focus for 2006-2007 is on the following three species: the eastern sand darter, the channel darter (*Percina copelandi*) and the bridle shiner (*Notropis bifrenatus*). Inventories were done in 2002 in the southern part of the Assomption River drainage basin in the Lanaudière area, and, in 2006, in the drainage basins of the Châteauguay River in Montérégie and the Outaouais River in Outaouais. In 2005 and 2006, a study was also conducted to assess the impact of the fall baitfish commercial fishery on the eastern sand darter, as well as on four other imperilled species designated under the *Species at Risk Act*.

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1. BACKGROUND

1.1 Species Information

Scientific Name: *Ammocrypta pellucida* (Agassiz 1863)
Common Name: Eastern sand darter, dard de sable
Current COSEWIC Status & Year of Designation: Threatened 2000
Canadian Occurrence: Ontario, Quebec
Reason for Designation: Loss of habitat and deteriorating water quality since the 1950s due to siltation, impoundments and chemical pollutants has resulted in reduced distribution and population declines. In Canada, this species has a limited disjunct distribution; populations are isolated and there is little chance of re-colonization if local extinctions occur.
Status History: Designated Threatened in April 1994. Status re-examined and confirmed in November 2000. Last assessment based on an existing status report with an addendum.

Classification: The current classification of the eastern sand darter is (from the Integrated Taxonomic Information System on-line database, http://www.itis.usda.gov. Retrieved March 07, 2005):

Phylum:	Chordata
Subphylum:	Vertebrata
Superclass:	Osteichthyes
Class:	Actinopterygii
Subclass:	Neopterygii
Infraclass:	Teleostei
Superorder:	Acanthopterygii
Order:	Perciformes
Suborder:	Percoidei
Family:	Percidae
Species:	*Ammocrypta pellucida*

Recent molecular analyses support a monophyletic genus *Ammocrypta* (Song *et al*. 1998, Near *et al.* 2000, Sloss *et al*. 2004). *Ammocrypta clara* (western sand darter) and *A. vivax* (scaly sand darter) have previously been considered subspecies and/or synonyms of *A. pellucida* (Grandmaison *et al.* 2004); both are now considered valid species. Records of *A. pellucida* in the Mississippi River drainage north of the Ohio River confluence represent *A. clara* while records from the southern reaches represent *A. clara* or *A. vivax* (Williams 1975). *Ammocrypta pellucida* and *A. clara* have overlapping distributions in Indiana and Illinois within the Wabash River drainage, and in Kentucky within the Cumberland and Green river drainages.

1.2 Species Description

The eastern sand darter is a small fish with translucent flesh and an elongate body, almost round in cross-section (Scott 1955) (Figure 1). Adults range in length from 46-71 mm TL (Trautman 1981), averaging 64 mm TL (Scott and Crossman 1973). Adults exhibit a faint yellowish or greenish colouration on the dorsal surface of the head and body, a narrow metallic

gold to olive-gold band passing subcutaneously along a line of lateral green rounded blotches, and a white or silvery hue on the ventral surface (Trautman 1981). Young fish are more silvery with little or no yellow (Scott and Crossman 1973, Trautman 1981). Males in breeding condition are flushed with a yellowish colouration and develop tubercles on their pelvic fins. A row of 12 - 16 dark greenish blotches are located along the dorsum, which differentiate into rows of paired spots along the base of the dorsal fins, one spot on either side of the fin (Trautman 1981). Nine to 14 (10-14 Scott and Crossman 1973; 9-14 Trautman 1981; 10-14 Holm and Mandrak 1996) spots also occur along the lateral line (Trautman 1981). Webbing of fins is transparent; although some individuals sport a yellowish tinge (Trautman 1981). Dorsal fins are separate; the first dorsal fin is spiny (8-11 weak spines), and the second dorsal has soft rays (9-12 rays) (Scott and Crossman 1973). Males have black pigment on the pelvic fin (Page and Burr 1991). Scales are absent from its ventral side 1-3 scale rows immediately beneath the lateral line (Trautman 1981).

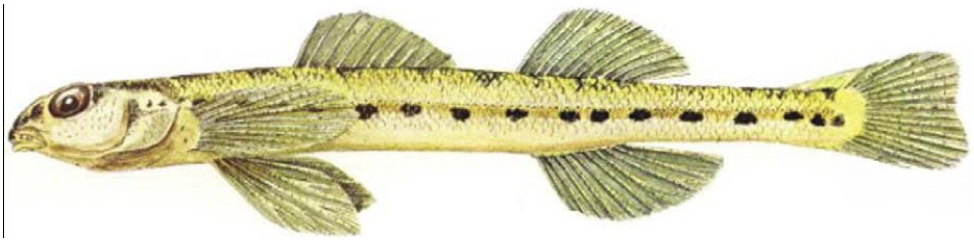

Figure 1. The eastern sand darter (*Ammocrypta pellucida*).

1.3 Populations and Distribution

Distribution:

Global Range (Figure 2): The eastern sand darter inhabits the Ohio River and Great Lakes drainage and is also found in the Lake Champlain and St. Lawrence River drainages (Figure 2) (Scott and Crossman 1973) which forms part of a disjunct element of the distribution. It occurs in the Canadian provinces of Ontario and Quebec and nine American states: Illinois, Indiana, Kentucky, Michigan, New York, Pennsylvania, Ohio, Vermont and West Virginia.

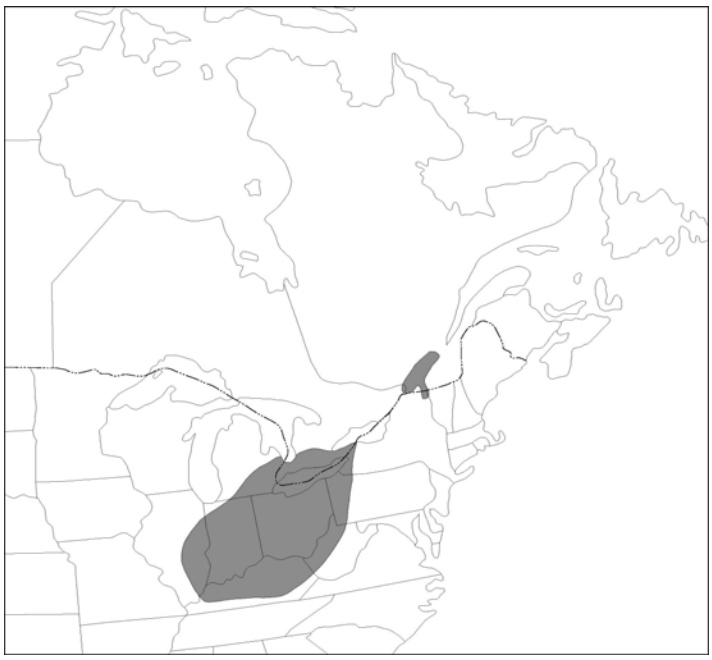

Figure 2. Eastern sand darter distribution in North America

Canadian Range:

Ontario – In Ontario, it has been collected from shallow habitats in lakes Erie and St. Clair, and from the Grand, Sydenham and Thames rivers (Holm and Mandrak 1996) (Figure 3). Populations are presumed to be extirpated from the Ausable River, Catfish Creek, Big Creek and Big Otter Creek (ARRT 2005).

Sydenham River: Along the East Branch between the Shetland Conservation Area and Dawn Mills, with a disjunct population further upstream between Strathroy and Alvinston (Dextrase *et al.* 2003).

Ausable River: There is a single record of eastern sand darter occurring in the river near Ailsa Craig from a 1928 survey. Subsequent searches at this site failed to recapture the species.

Catfish Creek: The eastern sand darter was collected from Catfish Creek in 1922 and 1941. It has not been collected in more recent surveys.

Big Creek: The eastern sand darter was collected from Big Creek in 1923 and 1955. It has not been collected in more recent surveys.

Big Otter Creek: The eastern sand darter was collected from Big Otter Creek in 1923 and 1955. It has not been collected in more recent surveys.

Grand River: All sandy areas in the lower main stem from Brantford to Cayuga.

Lake Erie: Pelee Island (no recent collections), Rondeau Bay and Inner Long Point Bay.

Lake St. Clair: Eastern sand darter has been collected from two areas of Lake St. Clair over the past 25 years. The south shore between the outlet of Pike Creek and the Thames River, and Mitchell's Bay.

Thames River: This species has been found in suitable habitat in the lower Thames River watershed, mainly between Komoka and Kent Bridge. ROM surveys from 1981-1991, and DFO surveys from 2003-2005, found this species extant at most historical sites.

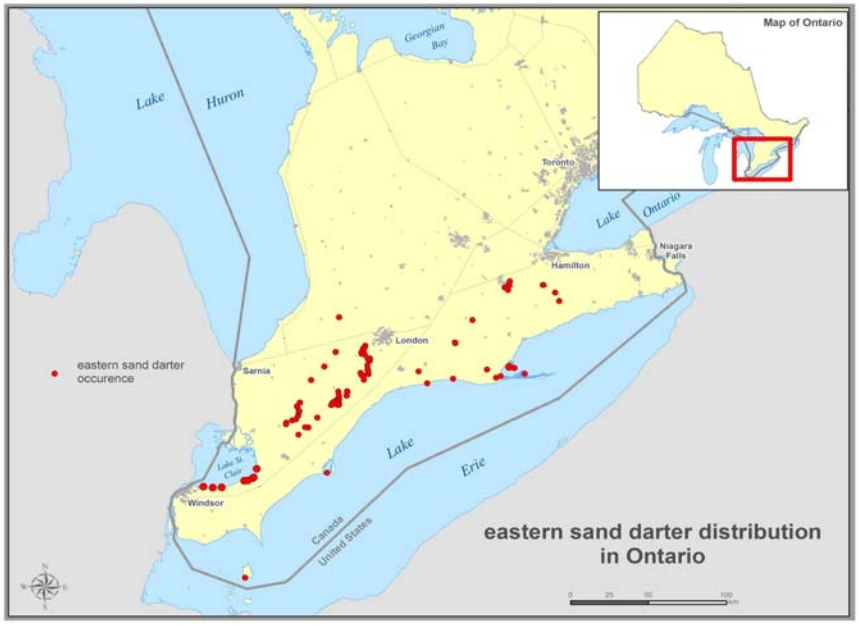

Figure 3. Ontario distribution of the eastern sand darter.

Quebec – In Quebec, eastern sand darter is found mainly in the St. Lawrence River and its tributaries, between Lake of Two Mountains and Leclercville, downstream from Lake St. Pierre (Figure 4) (Gaudreau 2005). In the St. Lawrence River, a few specimens have recently been collected in Lake St. Pierre and in its archipelago, as well as in a reach between Montreal and Sorel (N. La Violette, unpublished data, Gaudreau 2005). The species was also identified in a few tributaries from six areas of the province: Centre du Québec, Lanaudière, Laval, Mauricie, Montérégie and Montreal.

From the time eastern sand darter was first officially caught in 1941, the species has been identified in 11 rivers in Quebec (Table 1). Prior to 1985, its presence was confirmed in nine streams in the areas of Centre du Québec, Lanaudière, Laval, Mauricie, Montérégie and Montreal. Since 1985, the presence of eastern sand darter has been re-confirmed only in the Richelieu and Assomption rivers, and specimens have recently been collected in the Ouareau River in 2002 and 2003 (Holm and Mandrak 2000, Gaudreau 2005)

The eastern sand darter was caught in Lake of Two Mountains in 1941 and 1946. This area was sampled again in 1964, 1977 and 1990, but no specimens were caught (Holm and Mandrak 1996, Gaudreau 2005).

The species was observed in the Châteauguay River in 1941 (Vladykov 1942) and more than 180 specimens were caught in 1943 (Cuerrier *et al.* 1946). A few catches were made in 1975 and 1976 (Mongeau *et al.* 1979; cited *in* Gaudreau 2005). However, eastern sand darter was not detected during the 1993 sampling campaigns (La Violette and Richard 1996). In 2006, a specimen was caught in the Trout River (a tributary of the Châteauguay River) (S. Garceau, pers. comm.).

Sampling was conducted on the Yamaska River in 1995 and 2003 and no eastern sand darter were captured, even though they had been observed in this river in 1967 (Mongeau 1979; cited *in* Gaudreau 2005, La Violette 1999).

Cuerrier (1946) mentioned that eastern sand darter was abundant in the St. François River in 1944. However, no specimens were caught in this river during surveys conducted in 1965, 1974, 1991, 2002 and 2003 (Mongeau and Legendre 1976, Richard 1996, Gaudreau 2005).

In Quebec, the species has never been the target of a specific study, other than a rare fish species inventory conducted in the southern part of the Assomption River drainage basin in the Lanaudière area in 2002. A total of nine eastern sand darter were collected during this inventory in the Assomption and Ouareau rivers (CARA 2002).

The little data available concerning eastern sand darter populations does not provide sufficient proof to definitely confirm its disappearance from certain streams in Quebec. Many streams where it had been previously caught have not been sampled for approximately fifteen years. Furthermore, it's a difficult species to track visually and catch because of its small size, its benthic lifestyle, its burrowing behaviour and its translucency (Gaudreau 2005).

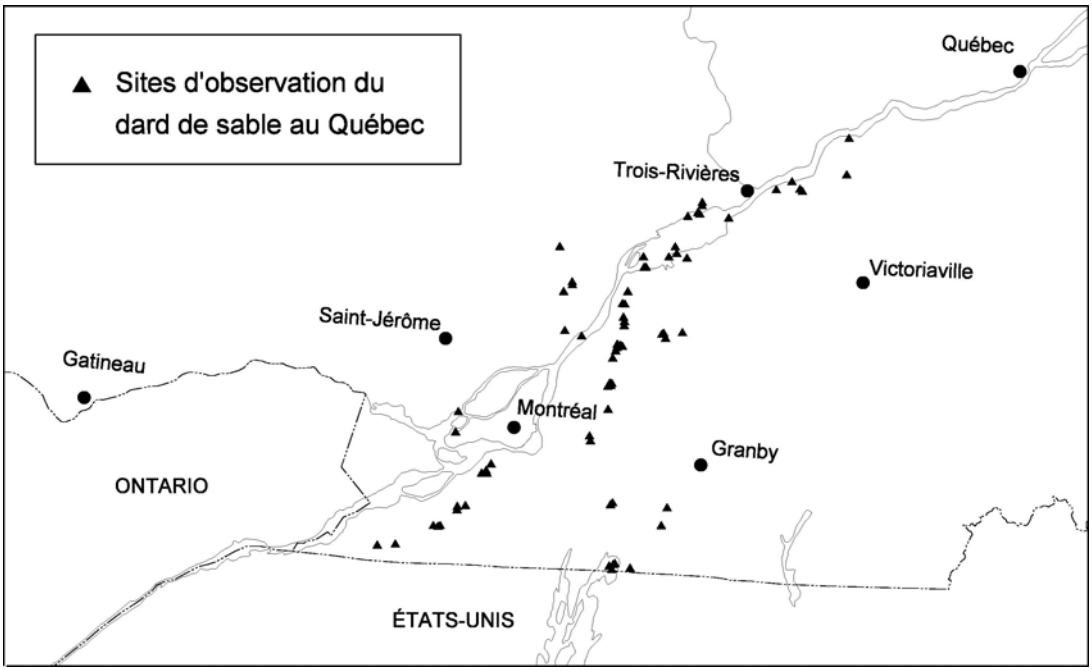

Figure 4. Eastern sand darter observation sites in Quebec.

Table 1. Eastern sand darter reported occurrence in Quebec.
(√ = *Occurrence of the species; x = the species was not caught during sampling)*

Waterbody	1940-1959	1950-1969	1970-1979	1980-1989	1990-2001	2002-2006	References
St. Lawrence River							
[1] St. François Lake					*x*	*x*	*
St. Louis Lake					*x*		*
Montréal-Sorel reach			*x*		√		*
Lake St. Pierre archipelago	√		√		*x*	√	*, 11, 24, 39
Lake St. Pierre			*x*		*x*	√	*, 24, 39
[1] Gentilly-Batiscan reach					*x*		*
[1] Grondines-Donnacona reach					*x*		*
Tributaries							
Lake of Two Mountains	√	*x*	*x*		*x*		24, 28
Châteauguay River	√		√		*x*	√	11, 24, 37, 46, 78
Trout River						√	**
Assomption River		√		√	*x*	√	8
Ouareau River					*x*	√	8
Richelieu River			√		√	√	24
Yamaska River		√			*x*	*x*	24, 38, 47
St. François River	√	*x*	*x*		*x*	*x*	11, 24, 45
Yamachiche River	√		√				24, 28
Bécancour River				√			24, 28
Gentilly River	√			√			24, 28
Orignaux River				√			24, 28
Du Chêne River				√			24, 28

[1] Eastern sand darter has never been caught in these sections of the St. Lawrence River in spite of experimental fisheries carried out by the *Réseau de suivi ichtyologique* (RSI).

*: La Violette, N., unpublished data.

**: Garceau, S., personal communication

Percent of Global Range in Canada: NatureServe (2005) estimates just over 100 extant occurrences of eastern sand darter in North America. Grandmaison *et al.* (2004) identified approximately 75 streams where eastern sand darter is extant. As there are approximately 12 extant occurrences in Canada, around 10 to 16% of the eastern sand darter's global range is found in Canada.

Distribution Trend: Habitat loss and poor water quality have resulted in a reduced distribution. In Canada, eastern sand darter has declined or become extirpated from 12 of 21 locations. Over the past 50 years, 45% of population occurrences in Ontario have been lost (ARRT 2005). Several new sites have been found since the 1970s; however, the net result is a reduction in distribution (Holm and Mandrak 1996). In Quebec, inventories conducted since 1990 at seven of the 12 ″historical″ sites where the species' presence has been documented (Table 1), have confirmed its presence in four of the seven sites (57%). These inventories have led to the addition of four new observation sites. However, five sites where eastern sand darter was documented during the 1970s and 1980s have not been sampled since that time. The eastern sand darter seems to have been extirpated from Lake

of Two Mountains as well as the Yamaska and St-François rivers. Its range in Quebec, therefore, seems to have been reduced.

Population Size and Status:

Global Population Size and Status: There is little information available concerning the abundance of the eastern sand darter over its entire global range. The little data that are available suggest that eastern sand darter populations are declining throughout their entire range. The short-term rate of decline would be between 10% and 30%, whereas long-term decline would fluctuate between 50% and 75% (Holm and Mandrak 2000). NatureServe (2006) estimates the eastern sand darter global abundance to be between 2,500 and 100,000 individuals.

The eastern sand darter has experienced population declines throughout its global range (Page and Burr 1991, Holm and Mandrak 1996). It has been considered globally rare (G3) since 1996 (NatureServe 2005) and was designated as Vulnerable by The World Conservation Union (IUCN) in 1996 (Gimenez 1996).

The eastern sand darter is not listed federally in the United States. The American Fisheries Society has designated this species as Threatened in the United States since 1989 (Williams *et al.* 1989). It is listed as Endangered in Pennsylvania (State of Pennsylvania 2005) and Threatened in Illinois (Illinois Department of Natural Resources 2003), New York (New York State Department of Environmental Conservation 2003), Michigan (Michigan Department of Natural Resources undated) and Vermont (M. Ferguson, Vermont Agency of Natural Resources, pers. comm.). It is considered a Species of Concern in Ohio (Ohio Department of Natural Resources 2002). It was previously listed as Special Concern in Indiana; however, it was downlisted after a statewide survey in 2004 determined it to be well distributed (B. Fisher, Indiana Department of Natural Resources, pers. comm.).

Canadian Population Size and Status: In Canada, eastern sand darter population sizes are unknown, but numbers are nevertheless in decline since 1950 according to estimates. Holm and Mandrak (2000) estimated that the rate of decline would have reached 50% between 1955 and 1970. They also estimated that the species' extent of occurrence (based on the length in km of the rivers occupied by the species) was less than 20,000 km^2.

The eastern sand darter is listed on Schedule 1 of the Canadian *Species at Risk Act*. It is ranked N3 in Canada and COSEWIC designated it as Threatened. It is designated Threatened in Ontario by the OMNR and has an S-rank of S2 in both Ontario and Quebec. It is also in the process of being designated as Threatened in Quebec by the *Ministere des Ressources naturelles et de la Faune* (D. Banville, comm. pers.). See Table 2 for national and sub-national ranks.

Percent of Global Abundance in Canada: No global or Canadian abundance estimates have been undertaken.

Population Trend: The eastern sand darter was presumed common and widespread in the early 1900s (Holm and Mandrak 1996). However, it is estimated to have disappeared from half of its historical locations and its abundance reduced in remaining populations.

Stable populations are presumed to exist in the Grand and Thames rivers in Ontario (Holm and Mandrak 1996). It is not clear whether populations are stable in Lake Erie as standard fish surveys in suitable habitat areas along the Lake Erie shoreline have not been completed and the species may be data deficient. Eastern sand darter are extant at Rondeau Bay and Long Point but may be heavily impacted by the round goby (*Neogobius melanostomus*) (French and Jude 2001, Baker 2005) , and there have been no recent collections at Pelee Island.

In Quebec, presumed stable populations are present in Lake St. Pierre in the St. Lawrence River and from ten other tributaries of the St. Lawrence. It is thought to be present in the Assomption River. Populations are believed to have declined or become extirpated from the Châteauguay, Gentilly, Yamaska and St. François rivers (Gaudreau 2005). Trends at remaining locations are unknown.

Table 2. Rank and status given to the eastern sand darter (from Gaudreau 2005).

Location	Status rankings [1]	Organization responsible for providing the status or rank
North America	**Vulnerable G3**	World Conservation Union (IUCN); NatureServe
United States	**Threatened N3**	American Fisheries Society (AFS); NatureServe
Illinois	S1	NatureServe
Pennsylvania	S1	NatureServe
Vermont	S1	NatureServe
Michigan	S1S2	NatureServe
Indiana	S2	NatureServe
New York	S2	NatureServe
West Virginia	S2S3	NatureServe
Ohio	S3	NatureServe
Kentucky	S4S5	NatureServe
Canada	**Threatened N3**	Committee on the Status of Endangered Wildlife in Canada (COSEWIC); NatureServe
Ontario	S2	NatureServe
Québec	In process: Threatened S2	*Ministère des Ressources naturelles et de la Faune* (MRNF); *Centre de données sur le patrimoine naturel du Québec* (CDPNQ)

1.4 Needs of the Eastern Sand Darter

1.4.1 Habitat and Biological Needs

Habitat Description: The eastern sand darter inhabits streams, rivers and sandy shoals in lakes, and is typically strongly associated with fine sandy substrates (greater than 90% sand) in areas of shallow water (<0.5 m deep) with relatively slow currents (<0.2 m/s)

[1] *The definition of ranks appears in Appendix 1.*

(Daniels 1993, Facey 1995, Facey and O'Brien 2003). Abundance is greatest on the depositional side of bends along small- to medium-sized rivers with a gentle current and minimal fine sediment deposition (Trautman 1981, Facey 1995). Few fishes of temperate streams are as strongly associated with a specific habitat type as this species. Daniels (1993) found the nearest neighbouring fish was overwhelmingly (93%) another eastern sand darter, showing also that individuals aggregate in areas of suitable habitat. Eastern sand darters are also found near sandbars, in shallow pools (Welsh and Perry 1997), in the sandy raceways of streams and rivers (Kuehne and Barbour 1983, Page 1983), or in gravelly riffles.

Lentic populations of eastern sand darter in Ontario (i.e. lakes Erie and St. Clair) and Quebec, are typically associated with nearshore habitats such as wave-protected sandy beaches, sandy shores and shallow bays (van Meter and Trautman 1970, Thomas and Haas 2004, Gaudreau 2005).

The eastern sand darter is typically found in shallow habitats. Facey (1995) did not find eastern sand darters in deep habitats characterized by high velocities and coarser sand. However, lack of capture from deep habitats may be, in part, an artifact of sampling method and accessibility rather than habitat preference (i.e. choice of sampling stations is typically dictated by accessibility) (Daniels 1993, Facey 1995, Welsh and Perry 1997, O'Brien and Facey 2003). In Lake Erie, Scott and Crossman (1973) reported a trawl-caught individual at a depth of 14.6 m.

Currently Occupied Habitat:

Ontario Populations

Sydenham River: Relatively continuous distribution along the eastern branch between the Shetland Conservation Area and Dawn Mills, with a disjunct population further upstream between Strathroy and Alvinston.

Grand River: Lower Grand River: Brantford downstream to Cayuga.

Lake Erie: Rondeau Bay and Inner Long Point Bay (Surveys in areas of suitable habitat along the shore of Lake Erie have not been completed; therefore, species may be data deficient).

Lake St. Clair: The south shore between the outlet of Pike Creek and the Thames River, and Mitchell's Bay.

Thames River: The lower Thames River between Komoka and Kent Bridge.

Quebec Populations

St. Lawrence River: from Montréal to Lake St. Pierre

St. Lawrence River tributaries:
Lake of Two Mountains: Anse à l'Orme and Sainte-Marthe-sur-le Lac.
Châteaugay River: Near Mercier and between Châteauguay and Athelstan.
Trout River:
Assomption River: In the vicinity of L'Assomption and Joliette.
Ouareau River: Near Crabetree.

Richelieu River: Between McMasterville and the mouth of the Saint-Marc River; in the Chambly Basin; and in Missisquoi Bay.
Yamachiche River: Near the mouth.
Bécancour River
Gentilly River: In the vicinity of Bécancour.
Aux Orignaux River
Du Chêne River

Historically Occupied Habitat: This is defined as "all areas of current occupation as well as all areas of historical occurrence". Re-introductions should not be considered until it can be demonstrated that habitat at historical sites is suitable.

Ontario Populations

Lake Huron Drainage: Ausable River

Lake St. Clair Drainage: Lake St. Clair, Sydenham River, Thames River

Lake Erie Drainage: Lake Erie (including Pelee Island), Catfish Creek, Big Creek, Big Otter Creek, Grand River

Quebec Populations

St. Lawrence River: From Montréal to Lake St. Pierre

St. Lawrence River Tributaries: Châteauguay River, Trout River, Assomption River, Ouareau River, Richelieu River, Yamaska River, St. François River, Yamachiche River, Bécancour River, Gentilly River, Orignaux River, Du Chêne River, Lake of Two Mountains

Habitat Trends in Ontario: In most eastern sand darter watersheds, increased siltation as a result of intensive agricultural practices is believed to have degraded its preferred sand habitats (Holm and Mandrak 1996). In the Sydenham and Ausable rivers, high turbidity and nutrient levels have likely contributed to habitat degradation. Habitats along the Sydenham River have been affected by siltation (Holm and Mandrak 1996) and relatively few silt-free patches remain (Dextrase *et al.* 2003). Heavily impacted by agricultural and urban development, the Thames River is adversely affected by high nutrient loads (phosphorous and nitrogen) and turbidity levels (TRRT 2004). In Big Otter Creek and Catfish Creek, where the species is extirpated, agricultural nutrient and sediment loading is considered a severe obstacle to recovery.

In the Grand River watershed, efforts to improve water quality have been largely successful (Plummer *et al.* 2005). However, the human population is expected to increase by 37% over the next 20 years (Krause *et al.* 2001) and stresses on the aquatic ecosystem resulting from land use changes, water utilization, sewage disposal and recreational activities are expected to increase. Along the lower Grand River, the Caledonia dam is a permanent barrier to two-way movement between eastern sand darter populations in the area of the Oxbow and those between Caledonia and Cayuga. Higher levels of sedimentation and turbidity downstream of Caledonia may also restrict the range of eastern sand darter in this stretch of the river.

Over the period of 1955 to 1980, Lake Erie was affected by extensive oxygen depletion and changes in the benthos that resulted from its eutrophic state (Koonce *et al.* 1996). While water quality has improved greatly, the nearshore of Lake Erie and of Lake St. Clair has been extensively modified by shoreline hardening, groynes, jetties and breakwaters, thereby, reducing aquatic habitat diversity and altering nearshore sediment transport (Koonce *et al.* 1996). By disrupting natural erosion processes and nearshore sediment transport, nearshore habitats such as wave-protected sandy beaches, sandy shores and shallow bays are likely to be negatively affected.

Habitat Trends in Quebec: In Quebec, eastern sand darter inhabited or currently inhabits four of the most polluted rivers of Quebec, i.e. the Assomption, Richelieu, Yamaska and St. François rivers. The species has likely been extirpated from the St. François and Yamaska rivers. It's status in the Assomption and Richelieu rivers is not known with certainty. These rivers flow through areas consisting primarily of agricultural and urban lands. Consequently, water quality is very poor, with high turbidity, as well as high concentrations of nutrients, pesticides, suspended solids and organic matter. Moreover, these waters drain directly into Lake St. Pierre, an area where eastern sand darter is also present. It is estimated that these four rivers inject nearly 800,000 tons of suspended solids into Lake St. Pierre annually as a result of agricultural land erosion, They also contain massive quantities of nitrogen and phosphorus, resulting from excessive spreading of solid and liquid manures (MDDEP 2007). The nitrogenous products (nitrates) and the phosphates cause imbalances in the rivers, which result in their eutrophication. The excessive development of aquatic plants, algae or periphyton, results in a decrease in the quantity of dissolved oxygen in the water. This poses a serious threat to benthic species such as the eastern sand darter (FAPAQ 2002).

In Lake St. Pierre, the some 4,000 high-tonnage ships transiting there, increases the intensity of the waves which move several tons of sediment. The passage of high-tonnage ships also provokes bank erosion and accelerates silting (Gaudreau 2005). The impact of recreational boating on the smallest rivers, for example the Richelieu River, is also considerable.

The massive deforestation on each side of the St. Lawrence River and of the majority of the rivers where eastern sand darter is found, to increase cultivable areas, increases runoff, sedimentation and nutrient enrichment in the brooks and rivers, which will affect the habitat of eastern sand darter (FAPAQ 2002, Vachon 2003).

In Quebec, certain rivers where populations of eastern sand darter were historically and are currently found, are harnessed, in particular the Ouareau, Richelieu and Yamaska rivers. The construction of dams modifies the flow of the rivers and supports eastern sand darter habitat sedimentation and destruction (Holm and Mandrak 1996, Grandmaison *et al.* 2004, Gaudreau 2005, NatureServe 2006).

Habitat Protection

Federal: Once defined, the critical habitat of the eastern sand darter will receive protection under the *Species at Risk Act*, as it is a Threatened species listed under Schedule 1 of the Act. The eastern sand darter receives general protection under the habitat provisions of the federal *Fisheries Act*. Under the *Fisheries Act*, its habitat is protected from disruption or destruction unless authorized by the Minister of Fisheries and Oceans or his/her delegate.

Ontario: Planning authorities "must be consistent with" the provincial Policy Statement under Section 3 of Ontario's *Planning Act* that prohibits development and site alteration in

the habitat of Endangered and Threatened species. The Ontario *Lakes and Rivers Improvement Act* prohibits the impoundment or diversion of a watercourse if siltation will result and the voluntary Land Stewardship II program of the Ontario Ministry of Agriculture, Food and Rural Affairs is designed to reduce erosion on agricultural lands. Stream-side development in Ontario is managed through floodplain regulations enforced by local conservation authorities. A majority of the land adjacent to the rivers inhabited by eastern sand darter is privately owned; however, the river-bottom is generally owned by the Crown.

Quebec: Two provincial acts protect the habitat of all fishes, including the eastern sand darter, in Quebec: 1) the *Conservation and Development of Wildlife Act*; and, 2) the *Environment Quality Act*.

1.4.2 Ecological Role

The eastern sand darter is one of the rare species that exploits sandy habitats and related resources. It is also the only *Ammocrypta* type representative in Canada and, consequently, an integral part of Canada's wildlife heritage. In addition to contributing to the biodiversity of aquatic ecosystems, this species is an indicator of unpolluted streams (Gaudreau 2005).

1.4.3 Limiting Factors

The eastern sand darter is not very flexible in terms of habitat needs (i.e. it is dependent on silt-free, soft, fine sand). It is vulnerable to any factor likely to affect its habitat (Holm and Mandrak 2000, Grandmaison *et al.* 2004, Gaudreau 2005, NatureServe 2006). The silting of sandy bottoms and sedimentation reduce the oxygen concentrations in the substrate and therefore affects the species' burrowing and reproductive behaviour. Silting can also reduce the number of spawning sites available and egg survival; well-oxygenated clean sand is required for the survival of eggs, in which they are deposited and incubated. Siltation can also cause significant changes in the community structures of aquatic invertebrates on which the eastern sand darter feeds (Holm and Mandrak 2000, Vachon 2003, Grandmaison *et al.* 2004, Gaudreau 2005, NatureServe 2006).

The eastern sand darter is a small fish with limited dispersal ability that exists as a collection of disjunct populations in Canada. Therefore, extirpated populations have little opportunity to be re-established through natural movements.

Reproductive Attributes: The fecundity of the eastern sand darter is low (30–170 mature eggs per female) (Holm and Mandrak 1996), which could contribute to yearly population fluctuations (Facey 1998) and population declines. Females reach sexual maturity at about one year (36 mm SL) and live for over 2 years (Holm and Mandrak 1996, Derosier 2004). Spawning generally occurs at temperatures between 20.5 and 25.5^{o}C (Johnston 1989, Facey 1995, 1998). Based on gonadal examination, Holm and Mandrak (1996) estimated spawning in Ontario to occur between late June and late July. In Illinois, Ohio and Vermont, spawning activity occurs between early April and mid-August (Spreitzer 1979, Johnston 1989, Facey 1995, 1998).

1.5 Threats

1.5.1 Threat Classification

Table 3. Summary of threats to eastern sand darter populations in Canada.

Ontario:

System	Status	Distribution	Threats (severity rank*)
Ausable River	extirpated	single collection record from Ailsa Craig (1929)	• siltation **(HIGH)** • high nutrient levels **(HIGH)** • toxic chemicals **(MEDIUM)** • altered flow regime **(MEDIUM)**
Big Creek	extirpated		• siltation **(HIGH)** • agricultural nutrient loading **(HIGH)** • water-taking associated with agriculture **(MEDIUM)**
Big Otter Creek	extirpated		• siltation **(HIGH)** • agricultural nutrient loading **(HIGH)** • water-taking associated with agriculture **(MEDIUM)**
Catfish Creek	extirpated		• turbidity and siltation **(HIGH)**
Grand River	possibly declining	lower Grand River (Brantford to Cayuga)	• siltation **(HIGH)** • nutrient loading **(LOW)** • dams **(UNKNOWN)** • urban-based toxins **(UKNOWN)**
Lake Erie	stable?	Inner Long Point Bay, Rondeau Bay, Pelee Island	• invasive species (i.e. round goby, tubenose goby (*Proterorhinus marmoratus*) **(UNKNOWN)**
Lake St. Clair	declining?	Mitchell's Bay, Pike Creek to Thames River outflow	• invasive species (i.e. round goby, tubenose goby) **(UNKNOWN)**
Sydenham River	declining	East Branch	• siltation **(HIGH)** • high nutrient levels **(HIGH)** • toxic chemicals**(MEDIUM)** • land-use practices and/or dams that interfere with channel forming processes **(MEDIUM)** • invasive species (i.e. round goby) **(UNKNOWN)**
Thames River	stable	Lower Thames River (Komoka to Kent Bridge)	• siltation **(HIGH)** • land-use practices and/or dams that interfere with channel forming processes **(HIGH)** • invasive species (i.e. round goby) **(UNKNOWN)** • urban-based toxins **(UNKNOWN)**

Quebec:

System	Status	Distribution	Threats (severity rank*)
St. Lawrence River:			
Montréal-Sorel Reach	Stable?	Saint-Sulpice	• Agricultural pollution (HIGH) • Urban pollution **(HIGH)** • Loss of riparian cover **(HIGH)** • Dams **(HIGH)** • **Commercial bait fishing (UNKNOWN)**
Lake St. Pierre archipelago	Stable?	Sainte-Anne-de-Sorel, Saint-Ignace-de-Loyola, Du Moine Island.	• Agricultural pollution **(HIGH)** • Wave action from boats **(MODERATE)** • Decrease in water levels **(MODERATE)** • Commercial bait fishing **(UNKNOWN, PRESUMED LOW)**
Lake St. Pierre	Stable?	North and south shores of the lake.	• Agricultural pollution **(HIGH)** • Wave action from boats **(MODERATE)** • Decrease in water levels **(MODERATE)** • Commercial bait fishing **(UNKNOWN, PRESUMED LOW)**
Other Waterbodies:			
Lake of Two Mountains	Extirpated?	Anse à l'Orme and Sainte-Marthe-sur-le Lac.	• Agricultural pollution **(LOW)** • Urban pollution **(MEDIUM)** • Loss of riparian cover **(LOW)** • Dams **(LOW)** • Wave action from boats **(MEDIUM)** • Exotic or invasive species **(UNKNOWN)** • Commercial bait fishing **(UNKNOWN)**
Châteauguay River	Stable?	Near Mercier and between Châteauguay and Athelstan.	• Agricultural pollution **(HIGH)** • Urban pollution **(HIGH)** • Loss of riparian cover **(HIGH)** • Dams **(HIGH)** • Modification of hydrology **(HIGH)** • Agricultural land use **(MEDIUM)** • Wave action from boats **(NULL)** • Decrease in water levels **(HIGH)**

			• Exotic or invasive species **(UNKNOWN)** • Commercial bait fishing **(UNKNOWN, PRESUMED MODERATE)**
Trout River	Stable?		• Agricultural pollution **(HIGH)** • Urban pollution **(LOW)** • Loss of riparian cover **(HIGH)** • Dams **(MEDIUM)** • Modification of hydrology **(HIGH)** • Agricultural land use **(MEDIUM)** • Wave action from boats **(NULL)** • Decrease in water levels **(LOW)** • Exotic or invasive species **(UNKNOWN)** • Commercial bait fishing **(UNKNOWN)**

Table 3 (Con't.)

System	Status	Distribution	Threats (severity rank*)
Richelieu River	Stable?	Between McMasterville and the mouth of the Saint-Marc River; in the Chambly Basin; and in Missisquoi Bay.	• Agricultural pollution **(HIGH)** • Urban pollution **(HIGH)** • Loss of riparian cover **(HIGH)** • Dams **(LOW)** • Modification of hydrology **(LOW)** • Wave action from boats **(MODERATE)** • Decrease in water levels **(NULL)** • Exotic or invasive species **(UNKNOWN)** • Commercial bait fishing **(UNKNOWN, PRESUMED MODERATE)**
Yamaska River	Extirpated?	Between the mouth and Hugues Rapids.	• Agricultural pollution **(HIGH)** • Urban pollution **(HIGH)** • Loss of riparian cover **(HIGH)** • Dams **(NUL)** • Modification of hydrology **(HIGH)** • Agricultural land use (pâturages) **(HIGH)** • Exotic or invasive species **(UNKNOWN)** • Commercial bait fishing **(UNKNOWN, PRESUMED MODERATE)**
L'Assomption River	Stable?	L'Assomption and Joliette.	• Agricultural pollution **(HIGH)** • Loss of riparian cover **(HIGH)** • Modification of hydrology **(HIGH)** • **Commercial bait fishing (UNKNOWN)**
Ouareau River	Stable?	Crabetree	• Agricultural pollution **(LOW)** • Dams **(HIGH)** • **Commercial bait fishing (UNKNOWN)**
Saint-François River	Extirpated?	Notre-Dame-de-Pierreville	• Agricultural pollution **(HIGH)** • Urban pollution **(HIGH)** • Loss of riparian cover **(HIGH)** • **Commercial bait fishing (UNKNOWN)**
Yamachiche River	Unknown?	Near the mouth	Threats unknown in this river.
Bécancour River	Unknown?		• Agricultural pollution **(HIGH)**

			• Loss of riparian cover **(HIGH)** • **Commercial bait fishing (UNKNOWN)**
Gentilly River	Unknown?	Bécancour	• Agricultural pollution **(HIGH)** • Urban pollution **(HIGH)** • Loss of riparian cover **(HIGH)** • **Commercial bait fishing (UNKNOWN)**
Orignaux River	Unknown?	Rivière-aux-Orignaux	Threats unknown in this river.
Du Chêne River	Unknown?		Threats unknown in this river.

1.5.2 Description of Threats

a) Agricultural pollution:

Nutrient loading (N, P) – In Quebec, the eastern sand darter is mostly found in the St. Lawrence River and its tributaries between Lake of Two Mountains and Leclercville. The expanding hog industry in this region, both in terms of number of animals and in land size to meet its needs, represents one of the most significant threats to aquatic wildlife and its habitats. The excessive use of fertilizers is the main consequence resulting from this industry, impacting fish habitats by the eutrophication of the streams. The excessive growth of aquatic plants, algae, or periphyton reduces the amount of oxygen found in the water, which threatens benthic species such as the eastern sand darter (FAPAQ 2002).

Use of pesticides – Hog production is closely linked to corn farming since it is part of the hog diet. Corn farming in Quebec has increased since 1970 and now covers over 436 000 ha, mostly in the Montérégie area. This type of farming uses the largest proportion of commercial pesticides and herbicides in Quebec, a non-point source of pollution that alters water quality in the rivers in the southern part of the province where populations of eastern sand darter are found (FAPAQ 2002).

b) Urban and industrial pollution:

Untreated wastewater disposal – Resource development and exploitation along with urbanization are at the heart of several sources of pollution. The presence of urban and industrial pollutants in aquatic environments leads to decreased water quality and dissolved oxygen and can have a negative impact on different stages of a fish's life cycle. Wastewaters from cities, textile factories, pulp and paper mills and from mines contain several chemicals such as heavy metals (i.e. lead and mercury), chlorinated hydrocarbons (i.e. DDT and PCBs) and polycyclic aromatic hydrocarbons (i.e. benzopyrene). Some of these chemicals harm the endocrine systems of organisms exposed to this wastewater and cause malformations, as well as reproductive and development problems in many fish species (i.e. white sucker (*Catostomus commersonii*), copper redhorse (*Moxostoma hubbsi*), whitefish (*Coregonus clupeaformis*) (Jobling and Tyler 2003; cited *in* de Lafontaine *et al.* 2002, Environment Canada 2006).

Thermal pollution – Urban activities also represent a source of thermal pollution. This problem may be caused by factories (e.g. refineries, steel plants) using water circuits to cool certain installations and dispose of this water, which is sometimes high in temperature, into the rivers. With higher temperatures, the metabolic reactions of the organisms present in the area are accelerated, as long as the water remains within the organism's zone of tolerance. If the temperature rises above the critical threshold, metabolic reactions slow down. Although the specific critical threshold for eastern sand darter is not known, in most percid species, it is relatively low and usually varies between 30°C and 38°C (Lydy and Wissing 1988, Smith and Fausch 1997, Beitinger *et al.* 2000). Thermal effects on fishes can be lethal but are also likely to impact their behaviour (i.e. migration), their metabolism (i.e. oxygen consumption), reproduction (i.e. reproductive success), their embryonic and larval development, feeding (i.e. deterioration of food sources) and their growth (Beitinger *et al.* 2000).

The eastern sand darter is considered to be intolerant to pollution (Barbour *et al.* 1999). It has possibly been extirpated from two highly polluted rivers, the St. François and Yamaska rivers, and it's status is not definitively known in two other polluted rivers (Assomption and Richelieu). As with most other percid species, urban or industrial pollutants could affect

eastern sand darter populations (Holm and Mandrak 2000, Grandmaison *et al.* 2004, Gaudreau 2005, NatureServe 2006). Scott and Crossman (1973) mentioned that it is unlikely that the eastern sand darter will survive very long due to the environmental assaults from highly industrialized areas such as Montreal.

c) Loss of riparian cover: Riparian strips play a significant role in protecting the quality of water in agricultural areas. These strips slow and catch particles running off on the ground surface as well as keeping the soil in place while protecting the banks from surface erosion. Deforestation and the disappearance of riparian strips in order to increase crop acreage and corn farming lead to higher water temperatures but also increased runoff, sedimentation and nutrient enrichment in streams and rivers likely to effect eastern sand darter habitats (FAPAQ 2002, Vachon 2003). Excessive siltation can smother deposited eggs, reduce available substrate oxygen and adversely affect prey abundance (Holm and Mandrak 1996). Eastern sand darter populations in Vermont and New York have benefited from decreased silt loads as a result of reforestation of stream slopes (Daniels 1993).

d) Dam construction: The construction of a dam changes the stream flow by transforming a lotic environment into a lentic environment. When the current's speed is slowed or eliminated, sedimentation increases. In addition, dams increase sedimentation by mitigating spring freshets. In Quebec, certain rivers harbouring eastern sand darter populations are harnessed, such as the Ouareau, Richelieu and Yamaska rivers (Holm and Mandrak 2000, Grandmaison *et al.* 2004, Gaudreau 2005, NatureServe 2006). The presence of dams could also lead to the fragmentation of eastern sand darter populations. Small, increasingly isolated populations may suffer inbreeding effects and a loss of genetic variability that could impair their ability to respond to changing environmental conditions.

e) Stream channelization and changes to natural flow regimes: In Quebec, nearly 40,000 km of streams have been straightened to increase agriculture production. These interventions involve uniformity and commonality of streams as well as changing their hydrologic regime. After a rainfall or during the spring snowmelt, flow velocity increases and can cause banks to collapse and shores to erode more rapidly (FAPAQ 2002). Shore erosion combined with eroding fields (i.e. ploughed land) or from tile drainage brings fine particles to the streams that choke the bottoms of streams and rivers. Furthermore, the straightening of streams changes the physical process leading to the formation of sand banks, often associated with the occurrence of eastern sand darter (FAPAQ 2002, Gaudreau 2005). Tile drainage is a serious threat to eastern sand darter in southwestern Ontario, as it speeds up the surface and subsurface water flow into drains, causing even greater erosion of drains or channels created under the Drainage Act. The Drainage Act itself is a major impediment to restoration as it is a very powerful but archaic piece of legislation, designed to remove water at the expense of soil and water quality throughout a watershed.

Activities that alter channel structure and flow conditions, as to interfere with sand deposition and erosion, are likely associated with the decline of the eastern sand darter (Dextrase *et al.* 2003).

In lakes Erie and St. Clair, eastern sand darter have been collected from nearshore habitats such as wave-protected sandy beaches, sandy shores and shallow bays (van Meter and Trautman 1970, Thomas and Haas 2004). Shoreline hardening has affected natural erosion processes and, thereby, altered nearshore sediment transport (Edsall and Charlton 1997). Disruption of sediment transport and deposition processes may reduce the availability of nearshore habitats with suitably sized sand. However, as nearshore Great Lakes ecosystems

and associated impacts of shoreline alteration are poorly understood (Goforth and Carman 2003), it is difficult to assess the severity of this stressor.

f) Riparian pastures: Some agricultural practices accelerate silting and increase turbidity in streams. Grazing and treading of riparian vegetation by livestock destroy its buffering ability, increases bank erosion and the silting of streams while returning sediments to suspended matter (FAPAQ 2002, Vachon 2003).

g) Wave action from boats: Waves hitting the shores of a stream as a result of passing boats can cause bank erosion. On the St. Lawrence River, high tonnage vessels erode the banks and accelerate silting (Gaudreau 2005). In the St. Lawrence River freshwater reach, where the eastern sand darter lives, wave action from boats is estimated to push back banks up to 3 m per year. The impact of smaller pleasure boats in smaller rivers and streams is also considerable.

h) Lower water levels in the St. Lawrence River: Fluctuating water levels in the St. Lawrence River stem from the combined action of several natural factors (e.g. climate and climatic variations), but also from human intervention. The flow of the river is influenced by water control works used principally to limit spring flooding, facilitate commercial shipping and generating hydroelectric power. The construction of the St. Lawrence Seaway also brought about considerable changes in flow. Dredging of the shipping channel and shoals, which concentrates the flow in the main channel and reduces current speed in the shallows, has had an ongoing effect on water levels.

Species residing in the shallows such as the eastern sand darter could be considerably affected by the lower water level issue in the St. Lawrence River. The loss of sand banks could result in reduced habitat area for this species (Gaudreau 2005).

i) Exotic or invading species: Round goby, an introduced species, can cause considerable harm in North American aquatic ecosystems. Since its discovery in the St. Clair River in 1990, this species has quickly colonized the Great Lakes and spread to the St. Lawrence River (Bernatchez and Giroux 2000). In 2000, the round goby had only been observed in a few locations in the St. Lawrence, particularly in the area of Quebec. It is now very widespread in the river and even overlaps the distribution of eastern sand darter in some areas. A single specimen was caught by a sport fisherman in the St. Lawrence River in the vicinity of Longueuil, close to Montreal, in 2004 (M. Bernard, MRNF, pers. comm.). In Lake St. Pierre, sampling indicated that the round goby is very widespread in the lake, at depths greater than 2 m, but is not very abundant in shallower habitats. It was associated with johnny darter (*Etheostoma nigrum*), with which it may compete as has been shown in the Great Lakes (French and Jude 2001, Baker 2005, Y. Mailhot, pers. comm.). Round goby can supplant indigenous fishes through predation on eggs and young as well as through competition for habitat and food. The round goby also spawns several times throughout the summer and is tolerant of polluted waters; these characteristics may give it a competitive edge over native species. This is a benthic species that, once established, could have a direct impact on darter species (Bernatchez and Giroux 2000).

The ranges of the eastern sand darter and round goby overlap in Lake St. Clair (since 1993), the lower Thames River, and Lake Erie (since 1996). Since its introduction into the lower Great Lakes, the round goby has been implicated in the following declines of native benthic fish species: logperch (*Percina caprodes*) and mottled sculpin (*Cottus bairdii*) populations in the St. Clair River (French and Jude 2001); johnny darter, logperch and trout-perch (*Percopsis omiscomaycus*) in Lake St. Clair (Thomas and Haas 2004); and, channel darter (*Percina*

copelandi), fantail darter (*E. flabellare*), greenside darter (*E. blennioides*), johnny darter, and logperch in the Bass Islands of western Lake Erie (Baker 2005). Potential causes of these declines include goby predation on eggs and juveniles, competition for food and habitat, and interference competition for nests (French and Jude 2001, Janssen and Jude 2001). The impacts of the round goby on eastern sand darter populations have not been studied.

NatureServe (2005) suggests that lampricide use for sea lamprey control could impact populations in Lake Erie and Lake Champlain. However, the eastern sand darter has been shown to be moderately tolerant of stream lampricide treatments (3-trifluoromethyl-4-nitrophenol (TFM)) at routine treatment concentrations based on a series of TFM toxicity studies (Neuderfer 1987, 2000, MacKenzie 1991, 1995; cited *in* U.S. Fish and Wildlife Service 2001).

j) Commercial bait fishing: A study on the assessment of commercial bait fishing on five vulnerable fish species was conducted in the fall of 2005 in nine regions in Quebec (i.e. Centre-du-Québec, Chaudière-Appalaches, Lanaudière, Laurentians, Laval, Mauricie, Montérégie, Montreal and Outaouais) (Boucher *et al.*, 2006). There were no eastern sand darter in the fall catches during the sampling campaign. The particular morphological characteristics of this species make it easily identifiable for fishermen.

Although the fishing sites, especially in the Richelieu River, cross over the species' known distribution area, eastern sand darter was not caught by harvesters. This was likely a result of the fishing practices used during this period, as well as the rarity of the species. However, the spring and summer fishing seasons have not been monitored, consequently, it is difficult to assess the risk of capture for these two periods. In spring and summer, harvest sites are much more varied, and the likelihood that they will cross over eastern sand darter habitats is probably high (Boucher *et al.*, 2006).

The eastern sand darter is not a legal baitfish in Ontario (Cudmore and Mandrak 2005) and its habitat is not suitable for bait harvesting. The extent to which eastern sand darter are a by-catch of bait harvesting in Ontario is unknown; however, at an expert opinion workshop held in Ontario indicated that the probability of baitfish harvesting impacting Ontario eastern sand darter populations was low but the magnitude would be high (N. Mandrak, DFO, pers. comm.).

It has been suggested that native darter species are becoming increasingly popular in the international aquarium business, especially in New York (McKeown and Stegemann 1999); however, it is not known if this is a significant threat in Ontario.

1.6 Actions Already Completed or Underway

Ontario Populations:

i) There have been several surveys conducted in Ontario for eastern sand darter in recent years (1997-2005).

Table 4. Summary of recent eastern sand darter surveys in Ontario.

Waterbody	Recent Surveys
Ausable River	• Non-targeted species at risk sampling, plus re-sampling of the 1928 eastern sand darter record (DFO 2002)[A,C,D]
Catfish Creek	• OMNR-ROM targeted sampling (1997)[A] • DFO-University of Guelph fish community sampling (2002)[C]
Big Otter Creek	• DFO-University of Guelph fish community sampling (2002-

	2003) • OMNR-DFO targeted sampling (fall 2004) [A]
Big Creek	• OMNR-DFO targeted sampling (fall 2004) [A]
Sydenham River	• ROM non-targeted species at risk sampling (1997)[A] • DFO-University of Guelph (2002-03) [A, C]
Grand River	• DFO targeted sampling (2002)[A] • ROM targeted sampling (1999-2000)[A] • ROM non-targeted sampling (1997)[A,C,D] • OMNR fish community sampling (2004)[D]
Thames River	• DFO targeted sampling using mark-recapture tagging to determine life history characteristics (2002-05) [A]
Lake Erie	• OMNR Index Surveys of western basin and Long Point Bay (yearly)[B] • DFO Point Pelee (2002)[B] • OMNR-DFO beach fish community survey (2005)[A] • Ontario Parks/DFO – Rondeau Provincial Park (2005)[A]
Lake St. Clair	• OMNR nearshore fish community survey (2005)[A] • Michigan DNR fish community survey (1996-2001)[B]

Gear type: A: seine; B: trawl; C: backpack electro-fisher; D: boat electro-fisher

ii) The following ecosystem or multi-species recovery strategies that address eastern sand darter recovery in Ontario have been initiated:

Sydenham Recovery Ecosystem Strategy - The primary objective of the Sydenham Recovery Ecosystem Strategy is to, "sustain and enhance the native aquatic communities of the Sydenham River through an ecosystem approach that focuses on species at risk" (Dextrase *et al.* 2003). The recovery strategy focuses on the 16 aquatic species at risk within the basin, including the eastern sand darter.

Thames River Recovery Ecosystem Strategy - The goal of the Thames River Recovery Team is to develop, "a recovery plan that improves the status of all aquatic species at risk in the Thames River through an ecosystem approach that sustains and enhances all native aquatic communities" (TRRT 2004). The eastern sand darter is one of 25 aquatic species at risk included in this strategy.

Ausable River Ecosystem Recovery Strategy - The long-term goal of the Ausable River Ecosystem Recovery Strategy is, "to sustain a healthy native aquatic community in the Ausable River through an ecosystem approach that focuses on the recovery of species at risk" (ARRT 2005). The Ausable River Recovery Team has developed a recovery strategy for the 14 aquatic species at risk in the Ausable River basin, including the eastern sand darter.

Grand River Fish Species at Risk Recovery Strategy - The goal of Grand River Fish Species at Risk Recovery Team is to, "conserve and enhance the native fish community using sound science, community involvement and habitat improvement measures" (Portt *et al.* 2004). Included in this strategy are recovery initiatives for the eastern sand darter and five other fish species at risk.

Essex-Erie Recovery Strategy – The goal of the Essex-Erie Recovery Strategy is "to maintain and restore ecosystem quality and function in the Essex-Erie region in order to support viable populations of fish species at risk, across their current and former range". Included in this strategy are recovery initiatives for the eastern sand darter and 17 other fish species at risk.

iii) University graduate students (University of Waterloo and Trent University) are researching life history characteristics and conducting population and habitat modeling of southwestern Ontario eastern sand darters populations (2005-present).

Quebec Populations:

i) In 2006, an ichthyological inventory was conducted on species at risk in the Montérégie and Outaouais areas in order to corroborate the distribution of the eastern sand darter, channel darter and bridle shiner (*Notropis bifrenatus*). This inventory targeted more precisely the drainage basins of the Châteauguay River in Montérégie and the Outaouais River in Outaouais.

ii) In 2005-2006, a study was conducted on the impact of the fall commercial bait fishing on five vulnerable fish species under the Species at Risk Act (copper redhorse, grass pickerel (*Esox americanus vermiculatus*), bridle shiner, eastern sand darter, channel darter) and a report was presented to DFO in cooperation with the *Ministère des Ressources naturelles et de la Faune du Québec* and the *Société Provancher d'histoire naturelle du Canada* (Boucher *et al.*, 2006).

iii) In 2002, an ichthyological inventory was conducted on rare species (eastern sand darter, channel darter, bridle shiner) in the southern part of the Assomption River drainage basin in Launaudière area. This inventory specifically targeted the Achigan, Assomption and Ouareau rivers.

1.7 Knowledge Gaps

In Canada, the eastern sand darter has never been thoroughly studied. Knowledge gaps concerning this species can be attributed to its scarcity, small size, benthic and burrowing lifestyle as well as its translucency, which make the eastern sand darter rarely seen or caught. The only available information on the species is mention of its capture and the description of its habitat at catch sites (Gaudreau 2005). Knowledge acquisition on the biology, behaviour, adaptability as well as the species' population dynamics and abundance in Canada is therefore critical to implement recovery measures in both Ontario and Quebec. Furthermore, additional basic data regarding habitat needs, distribution areas (especially in Quebec) and threats to the species' survival will be necessary in order to examine and monitor eastern sand darter population trends.

2. RECOVERY

2.1 Recovery Feasibility

Recovery feasibility is determined according to the four criteria as outlined by the Government of Canada (2006):

1. *Are individuals capable of reproduction currently available to improve the population growth rate or population abundance?*

   Yes. While successful spawning requires specific habitat conditions, the species' continued presence in a number of Ontario watersheds, as well as the presence of multiple year-classes, indicates that reproduction is occurring. In Quebec, specimens have recently been caught from at least five sites since 1995, which indicates the ongoing presence of the eastern sand darter in Quebec (Holm and Mandrak 1996). Although spawning requires specific habitat conditions, the permanent occurrence of the species in certain streams (i.e. Assomption and Richelieu rivers, Lake St. Pierre archipelago) indicates that reproduction has occurred in recent years. Due to the relatively low fecundity of eastern sand darter, a long time frame may be required for populations to recover or re-establish (Holm and Mandrak 1996).

2. *Is sufficient suitable habitat available to support the species or could it be made available through habitat management or restoration?*

   Yes. Suitable habitat does occur for this species; although knowledge of suitable habitat is higher in Ontario and more limited in Quebec. Based on the little available information, the species' range is receding in Quebec. Sustaining this species in the long term could, therefore, not be ensured until assaults on its habitat are abated (Holm and Mandrak 2000, Gaudreau 2005, NatureServe 2006). Better water quality and existing habitat management (through stewardship and better management practices) could improve and increase appropriate habitats. In addition, the eastern sand darter could have the opportunity of repopulating a portion of a stream following the replacement of a silty substrate with a sandy substrate (Gaudreau 2005).

3. *Can significant threats to the species or its habitat be avoided or mitigated through recovery actions?*

   Yes. Significant threats to eastern sand darter habitat, such as increased siltation and turbidity, can be addressed through recovery actions. Stewardship and implementation of best management practices (BMPs) would mitigate these threats. Basin-wide efforts to reduce siltation and sediment input into areas of eastern sand darter occurrence due to overland, bank and bed erosion, drainage tiles and additional sources will be necessary to significantly improve water quality and reduce human pressure on the species and its habitats. (Dextrase *et al.* 2003, ARRT 2005).

4. *Do the necessary recovery techniques exist and are they demonstrated to be effective?*

Yes. Best management practices and stewardship activities are available to improve water quality in lakes and rivers. Water quality improvements associated with a decreased silt load benefited eastern sand darter populations in Vermont and New York (Daniels 1993). The integrated water management strategy by drainage basin in Quebec is a good example because it merges all the water uses and their impacts throughout the territory and uses different techniques to ensure the restoration of the streams (i.e. water quality and sediment control, inventories, raising awareness, planning and making developments). Encouraging results have already been observed for the American smelt (*Osmerus mordax*) on the Boyer and Fouquette rivers, where the actions performed by the drainage basin management committee restored several riparian habitats and reduced various sources of water pollution (Équipe de rétablissement de l'éperlan arc-en-ciel 2003). Similar efforts are also being deployed in the Outardes East River drainage basin (G. Audet, pers. comm.).

Re-introductions may be feasible through captive rearing or adult transfers. Although there are no published studies on the husbandry of eastern sand darter (ARRT 2005), captive rearing and translocations have been used in the southeastern United States towards the recovery of other endangered darter species (Shute *et al*. 2005). For example, populations of imperiled species such as the snail darter (*Percina tanasi*) and fringed darter (*Etheostoma crossopterum*) have been established through adult transfers (Etnier and Starnes 1993, Poly 2004). However, these darter species did not include any in the *Ammocrypta* genus. Alternatively, several populations of eastern sand darter in the United States and Canada (e.g. Thames River) are stable and genetic analyses would determine their appropriateness as sources for reintroductions. A plan will need to be developed for repatriation initiatives, should they be deemed feasible and appropriate.

The above criteria indicate that recovery is biologically and technically feasible for Ontario populations. The level of effort required for the recovery of the Sydenham and Thames river populations would be moderate due to a focus on habitat restoration and protection (Dextrase *et al.* 2003). Where the eastern sand darter has been extirpated from systems in Ontario, which may be the case in four river systems, the level of effort required for population recovery would be high as it would entail both habitat restoration and repatriation (ARRT 2005). Management priorities should be given to high quality habitat areas currently supporting eastern sand darter populations. The cost of restoring degraded, highly impacted habitat is high.

The recovery of the eastern sand darter is also feasible in Quebec. Even though the species is not very abundant, it still occurs in certain Quebec streams. The eastern sand darter situation can be improved by effectively protecting and increasing the number and quality of habitats frequented by the species. A global improvement of the environmental condition of the drainage basins could also lead to the improvement of water quality in the tributaries where the species is found. The current knowledge gaps concerning the species must initially be filled in order to set up protection measures, effective developments and thus ensure that the objectives of the recovery strategy are met.

2.2 Recovery Goal

The long-term goal of this recovery strategy is to prevent the further decline of eastern sand darter populations and the deterioration of their habitat in Canada. It is also to ensure its sustainability by increasing the distribution and abundance of eastern sand darter throughout its current Canadian range by improving habitat quality and through reintroductions, if feasible.

2.3 Recovery Objectives

Short-term Recovery Objectives (5 year)

As available information on current and historical eastern sand darter populations is very limited, it is quite difficult to establish precise objectives in terms of absolute number of individuals. Thus, the objectives presented here are more qualitative in nature. It is also important to note that not all recovery objectives will apply to all populations.

i. Protect known populations and habitats.
ii. Determine the extent, abundance and demographics of existing populations through a focused sampling program.
iii. Determine the extent, abundance and quality of existing habitat (sandy patches) in areas of occurrence through a focused sampling program.
iv. Identify key habitat requirements to define critical habitat and implement strategies to protect known habitats.
v. Establish a long-term population and habitat monitoring program.
vi. Clarify threats and identify remedial actions to reduce their effects.
vii. Examine the feasibility of translocations, reintroductions and captive rearing.
viii. Increase awareness of the significance of this species and its status as an aquatic species at risk and indicator of ecosystem health.
ix. Develop linkages among partners, including watershed-based recovery teams, interest groups, industry, agencies and landowners interested in supporting the recovery of the eastern sand darter.

2.4 Approaches Recommended to Meet Recovery Objectives

2.4.1 Recovery Planning

Recovery approaches have been organized into three categories: 'Research and Monitoring', 'Management and Habitat Protection' and 'Stewardship, Outreach and Education' (Table 5). Although approaches have been prioritized, all are important to meet recovery goals and objectives. A narrative has been included after Table 5, where deemed appropriate.

Table 5. Recovery approaches for eastern sand darter in Canada.

No.	Priority	Objective	Threat Addressed (S. 1.5.2)	Broad strategy to Address Threats	Recommended Approaches to Meet Recovery Objective(s)
Research and Monitoring (R)					
R.1	High	iii		Habitat Surveys & Mapping	Evaluate and map the distribution, quantity and quality of sand habitats in the vicinity of known populations.
R.2	High	ii, iii, iv, v		Background Surveys and Monitoring	Develop a long-term monitoring program that includes a sampling protocol and training Sample sites of known occurrence and suitable habitat using appropriate gear (seine or trawl). Incorporate findings into a routine population monitoring program.
R.3	High	vii		Captive Rearing and Repatriation	Determine the feasibility and appropriateness of repatriations in areas of suitable habitat. Where repatriations are deemed appropriate for restoring populations (historical or degraded), develop a repatriation plan.
R.4	High	iii, iv		Habitat Assessment – Occupied Habitat Habitat Assessment – Historical and Unoccupied Habitat	Identify environmental parameters as well as abiotic and biotic features of habitat with eastern sand darter occupancy. Identify environmental parameters, as well as abiotic and biotic characteristics, of areas of suitable habitat but void of eastern sand darter. Conduct statistical comparisons with results of R.3 to determine if unoccupied areas have habitat limitations.
R.5	High	iv		Critical Habitat Characterization	Describe and identify the main components of the species' critical habitat at each stage of its life cycle.

Table 5 (Con't). Recovery approaches for eastern sand darter in Canada.

No.	Priority	Objective	Threat Addressed (S. 1.5.2)	Broad strategy to Address Threats	Recommended Approaches to Meet Recovery Objective(s)
Research and Monitoring (R)					
R.6	High	ii, v		Inventories	Establish a standard sampling method for catching and identifying all life stages of the eastern sand darter and conduct targeted inventories in the species' currently and historically occupied sites to define and complete current knowledge on the species' range in Canada, particularly in Quebec.
R.7	Moderate	vi	i	Invasive Species - Monitoring	Monitor watersheds, in cooperation with existing ecosystem recovery teams, for the presence of the round goby, particularly in the East Sydenham River, Thames River and Grand River.
R.8	Moderate	iii, iv		Surficial Geology Evaluation	Evaluate the surficial geology of areas where the eastern sand darter occurs to identify locations of sand sources needed to create habitat.
R.9	Moderate	ii		Research	Improve knowledge on population dynamics.
R.10	Moderate	vi		Research	Better describe threats that can limit eastern sand darter abundance and distribution in Quebec.
R.11	Moderate	iv		Research	Determine the species' physiological thresholds for the relevant water quality parameters (water temperature, turbidity, dissolved oxygen, nutrients).
R.12	Moderate	ii, v		Inventories	Conduct inventories in streams where eastern sand darter is known to occur (currently and historically) and in the areas of potential habitat.
R.13	Moderate	v		Communication and Coordination	Develop a central database for recording species' data and integrate these observations into the *Centre de données sur le patrimoine naturel du Québec* system.

Table 5 (Con't). Recovery approaches for eastern sand darter in Canada.

No.	Priority	Objective	Threat Addressed (S. 1.5.2)	Broad strategy to Address Threats	Recommended Approaches to Meet Recovery Objective(s)
Research and Monitoring (R)					
R.14	Moderate	vi	a-k	Threat Clarification	Some examples: Pollution/Toxicity: i) determine significant sources of sediment input, point and non-point source contamination. ii) determine vulnerability to known and suspected contaminants affecting eastern sand darters. Baitfish Harvesting: determine the risk of by-catch as a result of baitfish harvesting. Shoreline Alteration: determine impact of shoreline alteration of coastal processes responsible for maintaining eastern sand darter habitat. Channel & Dam Modification: - assess the potential impacts of dam modifications and channel alteration on habitat. Invasive Species: determine risk of negative effect resulting from expansion of round goby and other aquatic invasive species.
R.15	Low	ii		Gear Selectivity	Determine best methods for sampling eastern sand darter in riverine and lake habitats.
R.16	Low	i, vi		Conservation Genetics	Examine the degree of genetic variation and isolation within (i.e. small populations and inbreeding concerns) and among populations across its North American range.
R.17	Low	iii, iv		Habitat Modeling	Develop a predictive habitat model in order to identify the potential eastern sand darter sites and significant habitat areas.

Table 5 (Con't). Recovery approaches for eastern sand darter in Canada.

No.	Priority	Objective	Threat Addressed (S. 1.5.2)	Broad strategy to Address Threats	Recommended Approaches to Meet Recovery Objective(s)
Management and Habitat Protection (M)					
M.1	High	i	d,e,g,h	Management and Policy	Recognize the importance of fluvial and longshore processes and sources of sand bedload in the maintenance of eastern sand darter habitats, and ensure that these are protected.
M.2	High	vi, ix		Assessment of Watershed-Scale Stressors	In cooperation with relevant ecosystem recovery teams, address watershed-scale stressors to populations and their habitat.
M.3	High	vi	i	Invasive Species Management Plan	Development of a management plan addressing potential risks and proposed actions in response to the arrival or establishment of invasive species, such as the round goby.
M.4	High	i		Habitat Management and Protection	Plan and draw up an eastern sand darter conservation plan for Quebec.
M.5	High	i		Habitat Protection	Protect habitats using legal and administrative means.
M.6	Moderate	viii, ix		Habitat Management and Municipal Planning	Encourage municipalities to include the concerns about eastern sand darter habitat conservation in the municipal territory planning documents.
M.7	Moderate	i	d,e,g,h	Water Flow Regimes	Ensure that flow requirements of the eastern sand darter are considered in the management of water supply and flow regimes.
Stewardship, Outreach, Education (S)					
S.1	High	viii, ix		Stewardship	Develop stewardship activities with managers, owners and citizens aimed at protecting aquatic habitats.
S.2	High	ix		Coordination	Set up a recovery strategy implementation team for Ontario.
S.3	High	ix		Partnerships	Form partnerships to obtain funding and to bring recovery strategy actions to term.
S.4	Moderate	vi		Inventories – Risk Assessment	Ask that an inventory specifically aimed at the eastern sand darter using appropriate techniques be included in the guidelines to consultants when conducting an impact study for a project on a given stream (current or potential habitat for the species).

Table 5 (Con't). Recovery approaches for eastern sand darter in Canada.

No.	Priority	Objective	Threat Addressed (S. 1.5.2)	Broad strategy to Address Threats	Recommended Approaches to Meet Recovery Objective(s)

Stewardship, Outreach, Education (S)					
S.5	Moderate	viii, ix		Coordination with Other Recovery Teams	Work with relevant ecosystem recovery teams and single species recovery teams to implement recovery action plans and to obtain incidental sightings.
S.6	Moderate	viii, ix		Relationship Building – Drainage	Establish good working relationships with drainage supervisors, engineers and contractors to limit the effects of drainage activities.
S.7	Moderate	viii, ix		Communication and Raising Awareness (Communication Plan)	Establish a communication and awareness-raising plan. Raise the awareness and develop information tools specific to agricultural, industrial and municipal stakeholders as to the impacts the pollution they generate have on the eastern sand darter. Develop awareness-raising and information tools to promote sound development practices on the territory – MRC, municipality, owners, vacationers, promoters and industries.
S.8	Moderate	vi, viii	i	Invasive Species	Increase public awareness of the impacts of invasive species on the natural ecosystem, encourage the use of the Ontario invasive species reporting system, and develop a round goby reporting system for Quebec.
S.9	Moderate			Management and Coordination	Develop an annual recovery actions assessment.
S.10	Moderate	viii, ix		Stewardship and Habitat Initiatives	Promote stewardship among landowners abutting aquatic habitats of eastern sand darter and other local residents. For significant habitat improvements to be made, basin wide efforts will be necessary.

Table 5 (Con't). Recovery approaches for eastern sand darter in Canada.

No.	Priority	Objective	Threat Addressed (S. 1.5.2)	Broad strategy to Address Threats	Recommended Approaches to Meet Recovery Objective(s)
Stewardship, Outreach, Education (S)					
S.11	Moderate	viii, ix		Stewardship - Implementation of BMPs	Work with landowners to implement BMPs including those relating to riparian buffers, soil conservation, herd management, nutrient and manure management, tile drainage; encourage the completion of Environmental Farm Management Plans (EFPs) and Nutrient Management Plans (NMPs).
S.12	Moderate	viii, ix		Financial Assistance of Local Landowners	Pursue additional sustainable funds for landowners and local community groups.
S.13	Moderate	viii, ix		Awareness - Addressing Landowner Concerns	Provision of clear communications addressing financial compensation opportunities and landowner concerns and responsibilities under SARA.
S.14	Moderate	viii, ix	j	Awareness – Incidental Bait Harvesting	Provide an information package to commercial bait fishermen regarding this species and its habitat. Request that they avoid these habitats within the reaches known to support this species, and release and report any eastern sand darters captured.
S.15	Low	viii, ix		Relationship Building	In cooperation with ecosystem recovery teams, build relationships among a diverse assemblage of interest groups and stakeholders within the watersheds where it occurs.
S.16	Low	viii, ix		Raising Awareness (Wildlife Officers)	Train responsible wildlife officers in Ontario and Quebec and raise their awareness of eastern sand darters and other fish species at risk.
S.17	Low	viii		Communication	Inform the public concerning research and restoration efforts.
S.18	Low	viii		Communication and Raising Awareness (Public) – Printed Documents	Produce information documents and a public education and awareness-raising pamphlet concerning the eastern sand darter.

Background Surveys and Monitoring (R.2): The eastern sand darter is known from only a few locations in watersheds throughout its range. As well, only a few specimen documentations have been made. In some cases, such as in the Ausable River, only historical records exist. This species may be somewhat more widely distributed than currently known, due to its cryptic burrowing behaviour (Portt *et al.* 2004). In the vicinity of current and historical occurrence, surveys are required to:

1. confirm the spatial distribution of extant populations;
2. confirm the loss of historical populations;
3. identify suitable habitat (distribution, quantity and quality of sandy patches);
4. provide an index of abundance and trend over time data; and,
5. detect the presence of round goby (R.7).

Table 6. Survey needs for eastern sand darter in specific waterbodies in Ontario.

Ontario Watershed	Survey Needs
Ausable River	To determine if populations are extant.
Catfish Creek	
Big Otter Creek	
Big Creek	
Sydenham River	To determine if populations are extirpated from the East Branch between Strathroy and Alvinston.
Grand River	To determine if populations are present between the Oxbow and Caledonia dam.
Thames River	Routine monitoring of populations.
Lake Erie	
Lake Huron	
Lake St. Clair	

It is recommended that riverine populations are surveyed during periods of low flow (i.e. summer and early fall). Field surveys should target shallow habitats with sand and/or mixed sand/gravel bed material.

Captive Rearing and Reintroduction (R.3)
Reintroduction efforts need to consider the following:

i. Prior to developing reintroduction plans, it is necessary to confirm through intensive sampling that eastern sand darter are no longer present.
ii. Many of the extirpations are presumed to be the result of habitat degradation. The success of reintroductions will depend on an understanding of the species' habitat needs and on a sufficient quantity of suitable habitat being available at the repatriation site. Surveys need to be undertaken to characterize current habitat conditions and identify appropriate actions to improve degraded habitats. If habitat requirements are poorly understood, then studies of habitat use will need to be undertaken.
iii. Reintroductions should not be considered until the factors for extirpation are understood and addressed.
iv. Source populations to support reintroductions need to be identified. Ideally, source populations possess a high level of genetic diversity and genetic composition developed under similar historic conditions as the repatriation site. Genetic comparisons with populations from other parts of its North American range will determine the

appropriateness of augmentation and selecting source populations when deemed necessary. Where possible, source populations within the same watershed are preferred.

v. Removal of individuals from source populations should not negatively affect the status of these populations.

vi. The preferred method of introduction (i.e. adult transfer versus captive-reared) needs to be determined. If captive-rearing is the preferred option, propagation and rearing methods and an appropriate rearing facility will need to be identified.

vii. To successfully establish self-sustaining populations and preserve the genetic composition, the number of individuals, appropriate life-stages, and the frequency and duration of supplemental stockings needs to be determined. Population Viability Analysis (PVA) or other population modeling approaches may help to provide this information. Proper application of PVA tools, however, may require improved information on the life history and demographics of the species targeted for reintroduction.

viii. Monitoring is required to ensure that newly established populations are viable, that the stocking rate is appropriate and habitat conditions continue to be suitable.

ix. All proposed reintroductions associated with this strategy will involve the preparation of a reintroduction plan that will address the logistic and ecological aspects discussed above, as well as stakeholder issues.

Reintroductions should follow the American Fisheries Society Guidelines for Introductions of Threatened and Endangered Fishes (Williams *et al*. 1988).

Coordination with Other Recovery Teams (S.5): Many of the threats facing the eastern sand darter are a result of habitat degradation that affects numerous aquatic species. Multi-species ecosystem recovery strategies, such as those for the Sydenham, Ausable, Grand and Thames rivers, have incorporated the requirements of the eastern sand darter in their basin-wide strategies. As well as species-specific considerations, these ecosystem-based strategies employ basin-wide strategies to improve environmental conditions such as water quality, benefiting the eastern sand darter and other species. A coordinated, cohesive approach between the Ontario members of the ESDRT and multi-species recovery teams that maximizes opportunities to share resources, information and combine efficiencies is recommended. The Ontario members of the ESDRT should conduct a science-based significance ranking of all eastern sand darter populations to provide guidance at the ecosystem level in terms of prioritization of approaches. The Ontario members of the ESDRT should also coordinate efforts with recovery teams focused on the recovery of spiny softshell turtle (*Apalone spinifera*) and round hickorynut (*Obovaria subrotunda*).

Communication and Raising Awareness (S.7): Public support and participation will be encouraged through the distribution of educational materials and the provision of stewardship resources and contacts.

Stewardship and Habitat Initiatives (S.10): Basin-wide efforts to improve habitat quality will be required in all watersheds. This represents an important opportunity to engage land owners, local communities and stewardship councils on the issues of eastern sand darter recovery, ecosystem and environmental health, clean water protection, nutrient management, best management practices, stewardship projects and associated financial incentives. On this effort, the Ontario members of the ESDRT will work closely with the various aquatic ecosystem recovery teams, many of which have already established stewardship liaisons and activities that will benefit the eastern sand darter.

Implementation of BMPs (S.11): The Ontario members of the ESDRT will work with watershed Stewardship, Awareness and Community Outreach Recovery Implementation Groups (RIG) will work with landowners and stewardship groups to implement BMPs including, but not limited to those listed in Table 5 (S.13). Establishing riparian buffers reduces nutrient (nitrogen and phosphorus) and sediment inputs to receiving waters and overland run-off. Restriction of livestock from watercourses, where feasible and appropriate, leads to reductions in erosion and sediment and nutrient loadings. Nutrient and manure management will reduce nitrogen and phosphorus inputs into adjacent waterbodies, thereby, improving water quality for the eastern sand darter among other aquatic organisms. The RIG can work with landowners to mitigate the impacts of tile drainage, thereby, reducing sediment and nutrient inputs. Low-till practices can reduce soil erosion and improve soil structure while reducing sediment loads in adjacent watercourses. Environmental Farm Plans prioritize BMP implementation at the level of the individual farm and are sometimes a pre-requisite for funding programs. Environmental Farm Plans are overseen by the Ontario Soil and Crop Improvement Associations. For more information on BMPs see: Ministry of Agriculture and Food, Best Management Practices Series: http://www.gov.on.ca/OMAFRA/english/environment/bmp/series.htm

Awareness – Incidental Bait Harvest (S.14): The eastern sand darter is not a legal baitfish in Ontario (Cudmore and Mandrak 2005). However, it is susceptible to seining and may be negatively affected as by-catch. The Grand River Fishes Recovery Team (Portt *et al.* 2004) identified the need for an information package to be developed and the potential opportunity of distributing it with baitfish licences for the areas occupied by this species in the Grand River. The package could include a description and photograph or drawing of the species, a description of its general occurrence, and its preferred habitats. Bait harvesters would be asked to avoid these areas and report any captures.

2.5 Critical Habitat

2.5.1 Description

As defined by the *Species at Risk Act* (SARA), critical habitat means “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”. The identification of critical habitat requires a thorough knowledge of the species’ environmental needs during all life stages, as well as an understanding of the distribution, quantity and quality of habitat across the species’ range. At present, this information is not available for Canadian populations of eastern sand darter, although Table 7 outlines activities that would assist with obtaining the required information. These activities are not exhaustive, but outline the range and scope of actions identified by the recovery team as necessary to identify critical habitat for the eastern sand darter in Ontario and Quebec. It is likely that during the process of investigating the actions in Table 7, discovery of further knowledge gaps may arise that need to be addressed. Until critical habitat can be defined, the recovery team has identified the areas listed as currently occupied habitat as areas in need of conservation.

2.5.2 Examples of Activities Likely to Result in the Destruction of Critical Habitat

Although critical habitat for the eastern sand darter has not yet been defined, it is possible to identify activities that would negatively affect the species habitat, including:

- construction of structures (e.g. dams and reservoirs) that alter sediment transport and flow conditions;

- dredging of sandbars;
- loss of riparian vegetation;
- shoreline protection (groynes, jetties, placement of rip-rap) that disrupts sediment transport and erosion process;
- activities promoting vegetative encroachment on sandbars; and,
- any land-based activities that result in the erosion of fine sediments (silts) into occupied watercourses.

2.5.3 Schedule of Studies to Determine Eastern Sand Darter Critical Habitat

Table 7. Schedule of activities to identify critical habitat of eastern sand darter in Canada

Activity	Anticipated Completion[1] (years after finalization of recovery strategy)
Conduct population surveys	1-5 years
Assess habitat variables in currently occupied areas at the site level, reach level and landscape level	1-5 years
Determine any life stage differences in habitat use	1-5 years
Determine demographic characteristics of populations	1-5 years
Begin to determine the species' physiological thresholds for the relevant water quality parameters (water temperature, turbidity, dissolved oxygen, nutriments, pollutants, pesticides).	1-5 years
Identify and describe the species' migratory behaviour.	1-5 years
Survey and map areas of identified critical habitat within currently and historically occupied habitats	3-5 years

[1]timeframes are subject to change as new priorities arise, or as a result of changing demands on resources of personnel.

2.6 Existing and Recommended Approaches to Habitat Protection

In Canada, the eastern sand darter is protected under the federal government's *Fisheries Act* and the *Species at Risk Act (SARA)*. It is prohibited to kill, harm, harass, capture or take a species listed under Schedule 1 of the SARA as extirpated, endangered or threatened, or destroy its critical habitat.

In Ontario, planning authorities "must be consistent with" the provincial Policy Statement under Section 3 of Ontario's *Planning Act* that prohibits development and site alteration in the habitat of Endangered and Threatened species. The Ontario *Lakes and Rivers Improvement Act* prohibits the impoundment or diversion of a watercourse if siltation will result and the voluntary Land Stewardship II program of the Ontario Ministry of Agriculture, Food and Rural Affairs is designed to reduce erosion on agricultural lands. Stream-side development in Ontario is managed through floodplain regulations enforced by local conservation authorities. A majority of the land adjacent to the rivers inhabited by eastern sand darter is privately owned; however, the river-bottom is generally owned by the Crown.

In the province of Quebec, two important provincial Acts protect the species' habitat: the *Conservation and Development of Wildlife Act* and the *Environment Quality Act*. These Acts provide overall protection for fish habitats, and the eastern sand darter can indirectly benefit from them. Any activity in the habitat of eastern sand darter is forbidden and must be authorized by the *Ministère des Ressources Naturelles et de la Faune* (MRNF) and the *Ministère du Développement Durable et de Parcs* (MDDEP).

Measures already taken or in progress in Quebec:

i) The provincial Cyprinidae and Small Percidae (CSP) recovery team was formed targeting, in priority, three species in 2006-2007 (eastern sand darter, channel darter and bridle shiner).

ii) In Quebec, the eastern sand darter appears on the *List of Species Likely to be Designated Threatened or Vulnerable* under the Quebec government's *Act Respecting Threatened or Vulnerable Species*. The species is currently under designation process. The Threatened species status was recommended for this species by the Advisory Committee on Threatened or Vulnerable Wildlife Species. When a wildlife species has been designated as Threatened or Vulnerable, its management and the protection of its habitats fall under the stewardship of the *Conservation and Development of Wildlife Act.*

2.7 Performance Measures

Measurable performance indicators have been identified for each recovery objective (Table 8). They will help determine the success obtained in achieving the eight listed objectives over the next five years.

Table 8. Performance indicators for evaluating the achievement of recovery objectives.

Recovery objectives	Performance indicators
i. Protect known populations and habitats	▪ monitoring indicates that populations remain extant at known sites
ii. Determine the extent, abundance and demographics of existing populations.	▪ Existing populations and historical sites and potential habitats have been sampled.
iii. Determine the extent, abundance and quality of existing habitat (sandy patches) in areas of occurrence through a focused sampling program.	▪ Gained knowledge of currently occupied and potential of historical habitats.
iv. Identify key habitat requirements to define critical habitat and implement strategies to protect known habitat	▪ Description of eastern sand darter critical habitat.
v. Establish a long-term population and habitat monitoring program.	▪ Monitoring program has been developed.
vi. Clarify threats and identify remedial actions to reduce their effects.	▪ Research has been conducted to clarify number, extent and severity of threats to eastern sand darter.
vii. Examine the feasibility of translocations, reintroductions and captive rearing.	▪ Research has been conducted to evaluate feasibility of translocations, reintroductions and captive rearing.
viii. Increase awareness of the significance of this species and its status as an aquatic species at risk and indicator of ecosystem health.	▪ Outreach program developed and materials distributed.
ix. Develop linkages among partners, including watershed-based recovery teams, interest groups, industry, agencies and landowners interested in supporting the recovery of the eastern sand darter.	▪ Formalized partnerships developed to increase awareness and formulate action plans towards recovery.

2.8 Possible Recovery Effects on Non-Targeted Species/Ecological Processes

A variety of COSEWIC-listed fishes have ranges and habitats that overlap with the eastern sand darter in Ontario and Quebec including: Ontario – black redhorse (*Moxostoma duquesnei*), channel darter, northern madtom (*Noturus stigmosus*), river redhorse (*Moxostoma carinatum*),

silver chub (*Macrhybopsis storeriana*), silver shiner (*Notropis photogenis*) and spotted sucker (*Minytrema melanops*); Quebec – bridle shiner, channel darter. There are also nine COSEWIC-listed freshwater mussel species that overlap in range with eastern sand darter in southwestern Ontario: kidneyshell (*Ptychobranchus fasciolaris*), mapleleaf mussel (*Quadrula quadrula*), mudpuppy mussel (*Simpsonaias ambigua*), rayed bean (*Villosa fabalis*), round hickorynut, round pigtoe (*Pleurobema sintoxia*) and snuffbox (*Epioblasma triquetra*) .

Also, in Ontario the round hickorynut may benefit directly as the eastern sand darter is a potential fish host for its glochidia (Clarke 1981). The distribution of eastern sand darter overlaps with the Threatened spiny softshell turtle in Ontario. Nesting habitats of these turtles have been found to occur on the inside of river bends, downstream of eroding slopes (Dextrase *et al.* 2003). Therefore, improvements to eastern sand darter habitat will likely benefit the spiny softshell turtle.

In general, as the eastern sand darter is considered pollution intolerant and requires non-degraded habitats, protection or restoration of its habitats would benefit other native aquatic species.

2.9 Statement of When One or More Action Plans in Relation to the Recovery Strategy Will Be Completed

Ontario Populations: One or more actions plans relating to this recovery strategy for Ontario populations will be produced within 5 years of the strategy being completed. Wherever possible, recovery action plans should be linked to existing watershed recovery plans in southwestern Ontario. Partnership with these other recovery teams will ensure that efforts are not duplicated and will help to prevent the implementation of potentially conflicting recovery efforts for different species.

Quebec Populations: An action plan for Quebec populations is currently being finalized (*Équipe de rétablissement des cyprinidés et des petits percidés* 2007**)** and will provide special details for implementing the recovery. On one hand, it will include measures for implementing and monitoring the recovery, solving issues concerning threats and make sure objectives are met. Furthermore, the action plan must include a schedule for applying these measures. It will also include a definition of the critical habitat to the extent possible, examples of activities that will likely lead to its destruction and recommendations as to protective measures. Finally, it will include a socio-economic cost assessment and a list of benefits that will result from its implementation.

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Appendix 1 – Definition of status rankings

G-Rank (global): Rank assigned to an element based on its range-wide conservation status rank (G1 to G5, in decreasing order of priority). Elements ranked G1, G2 or G3 are considered imperilled. G-rank is assigned by NatureServe or the conservation data centre responsible for the element in question.

N-Rank (national): Rank assigned to an element based on its national conservation status rank (N1 to N5, in decreasing order of priority). Elements ranked N1, N2 or N3 are considered imperilled.

S-Rank (subnational): Rank assigned to element based on its provincial or state conservation status rank (S1 to S5, in decreasing order of priority. Elements ranked S1, S2 or S3 are considered imperilled.

Priority ranking value	Priority ranking definition
1	Severely at risk in the province
2	At risk in the province
3	Rare or uncommon in the province
4	Widely spread, abundant and apparently out of danger in the province, but there are reasons for concern in the long term
5	Widely spread, abundant and established stability in the province

Appendix 2 – Record of Cooperation and Consultation

The Eastern Sand Darter Recovery Strategy was prepared by a writing team with members from the National Eastern Sand Darter Recovery Team (NESDRT). The NESDRT has members from both the Ontario Eastern Sand Darter Recovery Team, made up of representative from Fisheries and Oceans Canada-Central and Arctic Region (DFOCA), Ontario Ministry of Natural Resources, Royal Ontario Museum, Michigan State University, and St. Michael's College, Colchester Vermont; and the Quebec Cyprinidae and Small Percidae Recovery Team with representatives from DFO-Québec Region (DFOQ), Ministère des Ressources Naturelles et de la Faune, Secteur Faune Québec (MRNF), First Nations of Québec and Labrador Sustainable Development Institute (FNQLSDI), Comité de concertation et de valorisation du bassin de la rivière Richelieu (COVABAR), Nature Conservancy of Canada (NCC), Société de conservation et d'aménagement du bassin de la rivière Châteauguay (SCABRIC), Union des producteurs agricoles (UPA).

The eastern sand darter has been included in a number of watershed-based recovery strategies in Ontario. This species is included in five aquatic ecosystem recovery strategies for the Ausable River, Grand River, Sydenham River, Thames River and the Essex-Erie, which includes the major wetlands on the north shore of Lake Erie.

DFO has attempted to engage all potentially affected Aboriginal communities in Southern Ontario during the development of the proposed recovery strategy for the Eastern sand darter. In addition to the First Nations listed above, information packages were sent to the Chief and Council of Aamjiwnaang First Nation, Aamjiwnaang First Nation, Algonquins of Ontario - Mattawa/North Bay, Aundeck-Omni-Kaning, Batchewana First Nation, Beausoleil, Caldwell First Nation, Chippewas of Kettle & Stony Point, Chippewas of Georgina Island, Chippewas of Mnjikaning First Nation, Chippewas of Nawash First Nation, Dokis, Garden River First Nation, Henvey Inlet First Nation, Magnetawan, M'Chigeeng First Nation, Mississauga, Mississauga of the New Credit, Moose Deer Point, Moravian of the Thames, Munsee-Delaware Nation, Sagamok Anishnawbek, Saugeen, Serpent River, Shawanaga First Nation, Sheguiandah, Sheshegwaning, Thessalon, Wahta Mohawk, Wasauksing First Nation, Whitefish Lake, Whitefish River, Whitesand, Wikwemikong, Zhiibaahaasing First Nation. Information packages were also sent to Metis Nation of Ontario (MNO) Captains of the Hunt for Regions 4, 5, 7, 8, and 9 and the MNO senior policy advisor. In Quebec, DFO sent letters to Wendake, Wôlinak, Odanak, Kahnawake, Kanesatake and Akwesasne First Nations. Members of these communities may have traveled or harvested fish from the waters where the Eastern sand darter was historically found. Follow-up telephone calls were made to each community office to ensure that packages were received and to ask if they would like to schedule a meeting to learn more about Species at Risk in general and proposed recovery strategies.

As a result of these letters and calls, one meeting was held with the Chief and Councilor for environmental issues of the Munsee - Deleware First Nation. The Chippewas of Mnjikaning First Nation responded that they have no comments but would like to be kept informed of further development.

In addition to the above activities, DFO has established an ongoing dialogue with respect to aquatic species at risk in general with the policy advisor to the Southern First Nations Secretariat and has engaged the London Chiefs Council (an association of the 8 area First Nation governments in Southwestern Ontario) on several occasions. Meetings have been held with the director of the Walpole Island Natural Heritage Centre and the Fish and Game Enforcement Officer from Walpole Island First Nation. DFO also discussed SARA issues with a

representative of the Six Nations of the Grand who works for the Six Nations EcoCentre and who also represents First Nation interests on the Grand River Fishes at Risk Management Plan, the Thames River Fish Management Plan and the St. Clair River Management Strategy.

DFO has prepared a list of non-government organizations and municipalities which may be impacted by the proposed recovery strategy. Information packages have been prepared to inform these groups that the proposed recovery strategy is about to be approved and invites each group to comment on the strategy. As well, an announcement has been prepared and will be placed in newspapers with circulation in the area of Ontario and Quebec where this fish was historically found to inform landowners and the general public about the strategy and to request their comments. These packages will be sent and the announcements published at the time the proposed recovery strategy is posted on the SARA registry.

Comments on the proposed recovery strategy were solicited from Quebec (MNRF), Ontario (OMNR), Parks Canada Agency and Environment Canada.

The eastern sand darter is only found in Canada and the United States of America. The NESDRT has contacted representatives from resource management agencies from the states of New York, Michigan, Pennsylvania, Ohio, and Vermont where this fish species occurs.