Species at Risk Act
Recovery Strategy Series

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

Eastern Sand Darter

2012

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 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.

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PREFACE

A proposed recovery strategy for this species was posted on the SARA Public Registry in July 2007, but did not include the identification of critical habitat; the current document includes critical habitat identification to the extent possible based on the best available information. Additionally, COSEWIC has determined the Ontario and Quebec populations to be separate Designatable Units. Due to the differences between the Designatable Units, each will have a separate recovery strategy.

The Eastern Sand Darter is a freshwater fish and is under the responsibility of the federal government. The *Species at Risk Act* (SARA, Section 37) requires the competent minister to prepare recovery strategies for listed Extirpated, Endangered and Threatened species. The Eastern Sand Darter was listed as Threatened under SARA in June 2003. The development of this recovery strategy was led by Fisheries and Oceans Canada – Central and Arctic region, in cooperation and consultation with many individuals, organizations and government agencies, as indicated below. The strategy meets SARA requirements in terms of content and process (Sections 39-41).

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 party, alone. This strategy provides advice to jurisdictions and organizations that may be involved, or wish to become involved, in the recovery of the species. In the spirit of the National Accord for the Protection of Species at Risk, the Minister of Fisheries and Oceans invites all responsible jurisdictions and 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.

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 information. 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 of Fisheries and Oceans 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. The Ontario government and Environment Canada (Canadian Wildlife Service) also cooperated in the production of this recovery strategy.

AUTHORS

This document was prepared by Amy Boyko (DFO), Becky Cudmore (DFO), and Andrea Doherty (DFO) on behalf of Fisheries and Oceans Canada.

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Maps were developed by Carolyn Bakelaar (DFO), Alan Dextrase (OMNR), Shady Abbas (DFO), 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. In cases where critical habitats of multiple species occur, an ecosystem approach to the management of habitat is required to maximize benefit to co-occurring species at risk (of all taxa, including fishes, birds, reptiles, etc). Such an approach recognizes that negative impacts to some species and their habitats may result from habitat management practices aimed at achieving an overall net benefit to the ecosystem and the species at risk that it supports. The SEA concluded that such an ecosystem approach in the implementation of this strategy will benefit the environment and will minimize any adverse effects. Refer to the following sections of the document in particular: Description of the species' habitat and biological needs, ecological role and limiting factors (1.4); Recovery feasibility (2.1); Approaches

recommended to meet recovery objectives (2.5); Critical habitat (2.7) and, Effects on other species (2.10).

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)]**.

In this context, Eastern Sand Darter do not construct residences during their life cycle and therefore the concept does not apply (Bouvier and Mandrak 2010).

EXECUTIVE SUMMARY

The Eastern Sand Darter 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 recently collected in Lake Erie, Lake St. Clair, the Grand, Sydenham and Thames rivers, and Big Creek.

There are limited data available on the Eastern Sand Darter throughout its Canadian range. Nevertheless, the 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: sediment loading, nutrient loading, and pollution resulting from agricultural and urban development. Barriers to movement (e.g., dams and impoundments) and alterations in flow regimes and coastal processes negatively affect the Eastern Sand Darter. Invasive species, such as the Round Goby, may also be negatively impacting the species.

This recovery strategy defines the goal, objectives and recommended approaches considered necessary for the protection and recovery of the Eastern Sand Darter in Ontario.

The long-term goal (> 20 years) of this recovery strategy is to maintain self-sustaining, extant populations and to restore self-sustaining populations to formerly occupied habitats where feasible. In some locations, permanent changes in the fish community, as a result of the establishment of exotic species, may impact the feasibility of re-establishing Eastern Sand Darter populations.

The population and distribution objective for Eastern Sand Darter is to ensure the survival of self-sustaining population(s) at the six extant locations (Sydenham River, Thames River, Lake St. Clair, Big Creek, Grand River, Lake Erie [Long Point Bay]) and restore self-sustaining population(s) at the following locations: Ausable River, Lake Erie (Rondeau Bay and Pelee Island), Catfish Creek, and Big Otter Creek, where feasible.

Short-term recovery objectives (5 - 10 years)
In support of the long-term goal, the following short-term recovery objectives will be addressed over the next 5 -10 years:

i. Refine population and distribution objectives;
ii. Ensure the protection of critical habitat;
iii. Determine long-term population and habitat trends;
iv. Evaluate and minimize threats to the species and its habitat;
v. Investigate the feasibility of population supplementation or repatriation for populations that may be extirpated or reduced;

vi. Enhance efficiency of recovery efforts through coordination with aquatic and terrestrial ecosystem recovery teams and other relevant or complementary groups/initiatives; and,
vii. Improve overall awareness of the Eastern Sand Darter and the role of healthy aquatic ecosystems, and their importance to humans.

Using best available information, the area in which critical habitat is found has been identified to the extent possible for extant Eastern Sand Darter locations in the Sydenham River, Thames River, Grand River, Big Creek (Norfolk County), and Lake Erie (Long Point Bay). A schedule of studies has been developed that outlines necessary steps to obtain the information to refine these critical habitat descriptions.

Some measures have already been implemented for the recovery of the Eastern Sand Darter in Ontario. Several Eastern Sand Darter surveys have been conducted from 1997 to 2010 in historically and/or currently occupied waterbodies. Also, five ecosystem or multi-species recovery strategies that include Eastern Sand Darter recovery have been initiated in Ontario.

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1. BACKGROUND

1.1 Species assessment information from COSEWIC

Scientific name: *Ammocrypta pellucida* (Girard 1856)
Common name: Eastern Sand Darter, dard de sable
Current COSEWIC status & year of designation: Threatened 2009
Canadian occurrence: Ontario, Quebec
Reason for designation: This species prefers sand bottom areas of lakes and streams in which it burrows. There is continuing decline in the already small and fragmented populations; four (of 11) have probably been extirpated. The extent of occurrence of this species in Ontario is approximately half of what it was in the 1970s as a result of habitat loss and degradation from increasing urban and agricultural development, stream channelization and competition with invasive alien species.
Status history: The species was considered a single unit and designated Threatened in April 1994 and November 2000. When the species was split into separate units in November 2009, the "Ontario populations" unit was designated Threatened.

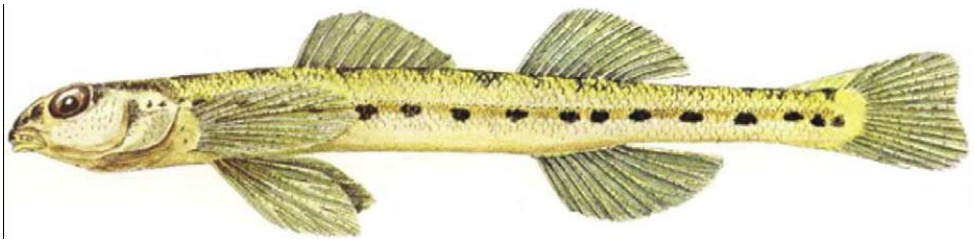
Classification: The current classification of the Eastern Sand Darter (*Ammocrypta pellucida*) is from the Integrated Taxonomic Information System on-line database (accessed March 07, 2005):

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). *A. 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). *A. 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 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 total length (TL) from 46-71 mm (Trautman 1981), averaging 68 mm TL (Scott and Crossman 1973). The largest individual captured in Ontario, from the Grand River in 1987 (Holm and Mandrak 1996), was 84 mm TL. 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; 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 with 1-3 scale rows immediately beneath the lateral line (Trautman 1981).



(Drawing by E. Edmonson & H. Crisp [NYSDC])

Figure 1. The Eastern Sand Darter (*Ammocrypta pellucida*).

1.3 Populations and 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, Ohio, Pennsylvania, Vermont, and West Virginia.

Ontario range (Figure 3): The Eastern Sand Darter has been recently collected in lakes Erie and St. Clair, and from the Sydenham, Grand and Thames rivers, as well as

Big Creek (Norfolk County) (Holm and Mandrak 1996, Fisheries and Oceans Canada [DFO], unpublished data, A. Dextrase, Ontario Ministry of Resources [OMNR], unpublished data). Populations are presumed to be extirpated from Big Otter Creek, Catfish Creek, and the Ausable River (Ausable River Recovery Team [ARRT] 2005).

Lake Erie: In Lake Erie, Eastern Sand Darter records exist for Pelee Island (last collected in 1953), the north shore of Lake Erie (Colchester Beach and Holiday Beach Provincial Park; last collected 1975), Rondeau Bay, and Inner Long Point Bay.

Lake St. Clair: Eastern Sand Darter has been collected from several areas of Lake St. Clair over the past 25 years, specifically the south shore between the outlet of Pike Creek and the Thames River, and Mitchell's Bay.

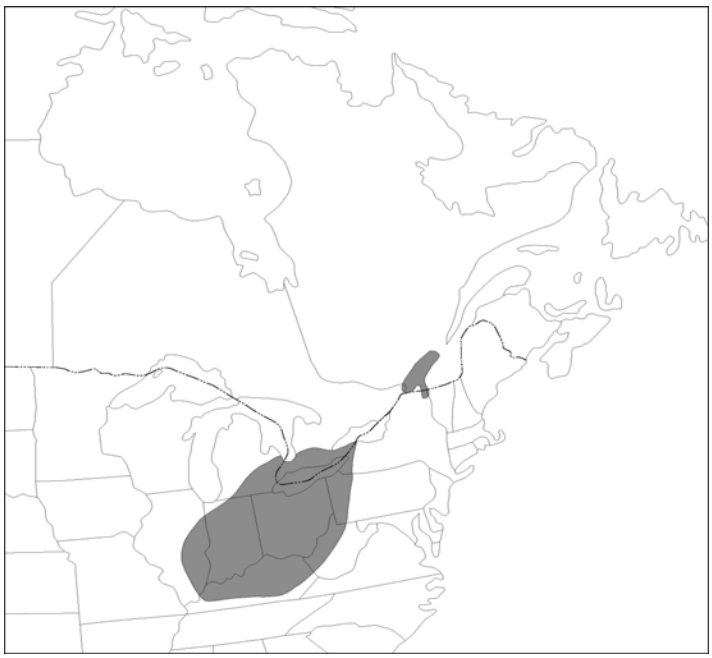


Figure 2. Global Eastern Sand Darter distribution in North America.

Sydenham River: Eastern Sand Darter records exist in the East Sydenham River between the Shetland Conservation Area and Dawn Mills, with a disjunct population further upstream between Strathroy and Alvinston (Dextrase et al. 2003).

Thames River: This species has been found in the lower Thames River watershed between Komoka and Kent Bridge.

Grand River: In the Grand River, Eastern Sand Darter occurs in all sandy areas in the lower main stem from Brantford to just downstream of Cayuga.

Big Creek (*Norfolk County*): The Eastern Sand Darter was collected from Big Creek in 1923 and 1955. It had not been collected in more recent surveys until three adults were

captured from three different sites in 2008, confirming the continued presence of the species in the watershed.
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.

Catfish Creek: The Eastern Sand Darter was collected from Catfish Creek in 1922 and 1941. It has not been collected in more recent surveys.

*Ausable Riv*er: 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, and elsewhere in the watershed in potentially suitable habitat, failed to recapture the species.

Percent of global range in Canada: NatureServe (2012) estimates just over 100 recent (since 1970) 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 16 extant occurrences in Canada, around 10 to 20% of the Eastern Sand Darter's global range is found in Canada, and approximately 50% of this is in Ontario.

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 11 of 21 locations. Over the past 50 years, 45% of population occurrences in Ontario have been lost (Committee on the Status of Endangered Wildlife in Canada [COSEWIC] 2009). Several new sites have been found since the 1970s; however, the net result is a reduction in distribution (Holm and Mandrak 1996).

Global population size and status: There is little information available concerning the abundance of Eastern Sand Darter over its entire global range. The short-term rate of decline would be between 10% and 30%, whereas long-term decline ranges between 50% and 75% (COSEWIC 2000). NatureServe (2012) estimates Eastern Sand Darter global abundance to be greater than 10 000 individuals.

The Eastern Sand Darter has experienced population declines throughout its global range (Page and Burr 1991, Holm and Mandrak 1996). It is considered globally secure (G4) (NatureServe 2012) and was designated as Vulnerable by The World Conservation Union (IUCN) in 1996 (Gimenez Dixon 1996).

The Eastern Sand Darter is not listed federally in the U.S. The American Fisheries Society has designated this species as Vulnerable (Jelks et al. 2008). It is listed as Endangered in Pennsylvania (State of Pennsylvania 2005) and Threatened in Illinois (Illinois Department of Natural Resources 2010), New York (New York State Department of Environmental Conservation 2010), Michigan (Michigan Department of Natural Resources 2010), and Vermont (Vermont Fish and Wildlife Department 2010). It is considered a Species of Concern in Ohio (Ohio Department of Natural Resources 2010). It was previously listed as Special Concern in Indiana; however, it was down-listed after a state-wide survey in 2004 determined it to be well distributed (B. Fisher, Indiana Department of Natural Resources, pers. comm., 2005).

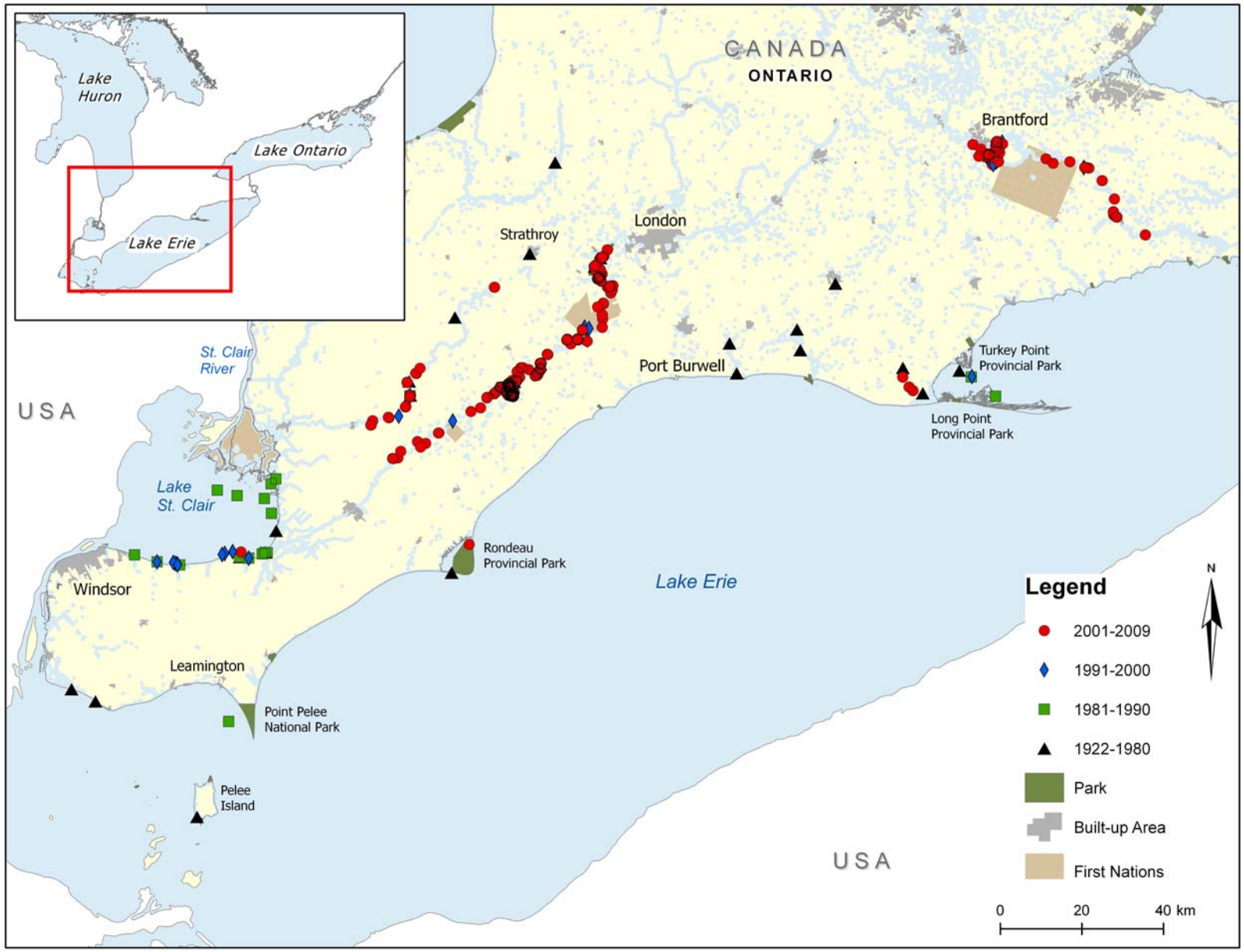


Figure 3. Ontario distribution of the Eastern Sand Darter.

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. COSEWIC (2000) estimated that the rate of decline would have reached 50% between 1955 and 1970. It 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 extent of occurrence is 10 840km^2 (COSEWIC 2009).

The Eastern Sand Darter is listed as Threatened on Schedule 1 of the Canadian *Species at Risk Act* (SARA). It is ranked N2N3 in Canada (NatureServe 2012) and the COSEWIC designated it as Threatened. It is also listed as Threatened in Ontario under the *Endangered Species Act 2007* (Ontario Ministry of Natural Resources [OMNR] 2010b), and Threatened in Quebec by the Ministere des Ressources Naturelles et de la Faune (MRNF) (in French only). See Table 1 for national and sub-national ranks.

Table 1. Global, national and sub-national heritage ranks from NatureServe 2012.

Rank level	Rank[1]	Jurisdictions
Global	G4	
National	N4 (30Aug2009)	United States
	N2N3 (17Nov2010)	Canada
Sub-national	S4	Indiana, Kentucky
	S3	Ohio
	S2S3	West Virginia
	S2	New York, Ontario, Quebec
	S1S2	Michigan
	S1	Illinois, Pennsylvania, Vermont

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.

The status of Eastern Sand Darter populations in Ontario was assessed by Bouvier and Mandrak (2010). Populations were ranked with respect to abundance and trajectory. Population abundance and trajectory were then combined to determine the population status. A certainty level was also assigned to the population status, which reflected the lowest level of certainty associated with either population abundance or trajectory. A summary is provided in Table 2. Refer to Bouvier and Mandrak (2010) for further details on the methodology.

[1] See Appendix 1 for description of ranks.

Table 2. Relative abundance index, population trajectory and population status of each Eastern Sand Darter population in Ontario.

Population[2]	Relative abundance index	Certainty[3]	Population trajectory	Certainty	Population status
Lake Huron					
Ausable River	Extirpated	2	Not applicable	2	Extirpated
Lake St. Clair					
Lake St. Clair	Low	2	Declining	3	Poor
Thames River	High	1	Stable	1	Good
Sydenham River	Low	2	Unknown	3	Poor
Lake Erie					
Pelee Island	Unknown	3	Unknown	3	Unknown
Rondeau Bay	Unknown	3	Unknown	3	Unknown
Long Point Bay	Low	2	Declining	2	Poor
Catfish Creek	Extirpated	3	Not applicable	3	Extirpated
Big Otter Creek	Extirpated	3	Not applicable	3	Extirpated
Big Creek	Low	3	Unknown	3	Poor
Grand River	High	2	Stable	2	Good

(Modified from Bouvier and Mandrak 2010)

1.4 Needs of the Eastern Sand Darter

1.4.1 Habitat and biological needs

Spawning habitat description: 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 but may be as early as late April (Finch 2009), or as late as mid-August as seen in the U.S. (Spreitzer 1979, Johnston 1989, Facey 1995, 1998). Spawning has not been observed in the wild. In the laboratory, Eastern Sand Darter has spawned on substrates that were a mixture of sand and gravel (Johnston 1989). Spawning does not seem to depend on time of day.

Young of the Year (YOY) and juvenile habitat description: There is little known about YOY and juvenile habitat requirements, but recently transformed juveniles have been caught in the same habitat as adults (A. Dextrase, OMNR, unpublished data). Simon and Wallus (2006) found that early juveniles were more tolerant of the silt margins than adults. Drake et al. (2008) found that juvenile growth was faster in habitats with less silt. There is some evidence that Eastern Sand Darter have a larval drift phase, which

[2] Note that, for lack of supporting data, a location was assumed to have a single population when population status was assessed by Bouvier and Mandrak (2010).
[3] Certainty is listed as: 1=quantitative analysis; 2=CPUE or standardized sampling; 3=best guess.

emphasizes the importance of having suitable nursery habitat downstream of spawning areas (Simon and Wallus 2006).

Adult habitat description: The Eastern Sand Darter inhabits streams, rivers and sandy shoals in lakes, and is typically strongly associated with fine sandy substrates and fine gravel (greater than 90% sand) (Daniels 1993, Facey 1995, Facey and O'Brien 2004, Drake et al. 2008). 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 Darter are also found near sandbars, in shallow pools (Welsh and Perry 1997), and in the sandy raceways of streams and rivers (Kuehne and Barbour 1983, Page 1983).

Lentic populations of Eastern Sand Darter in lakes Erie and St. Clair 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). Additionally, YOY surveys indicate that Eastern Sand Darter were found at river/stream mouths (OMNR, unpublished data).

The Eastern Sand Darter was thought to be typically found in shallow habitats. Facey (1995) did not find Eastern Sand Darter in deep habitats characterized by high velocities and coarser sand. Lack of capture from deep habitats may be, in part, an artefact 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 2008, Drake et al. 2008). In Lake Erie, Scott and Crossman (1973) reported a trawl-caught individual at a depth of 14.6 m and more than 100 individuals were caught in the Grand River in depths > 1.5 m (N. Mandrak, DFO, pers. comm., 2010). However, Eastern Sand Darter were not captured during the systematic trawl sampling of western Lake St. Clair in water deeper than 2 m (Thomas and Haas 2004)

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 member of the genus *Ammocrypta* 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). Additionally, the Eastern Sand Darter is a potential fish host for the Round Hickorynut (*Obovaria subrotunda*), a freshwater mussel that is endangered in Canada (Clarke 1981).

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 sand), thus it is vulnerable to any factor likely to affect its habitat (COSEWIC 2000, Grandmaison et al. 2004, Gaudreau 2005, NatureServe 2012). 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.

The fecundity of the Eastern Sand Darter is low (clutch sizes of 35-123 mature ova) (Finch 2009), which could contribute to yearly population fluctuations (Facey 1998) and population declines. Females reach sexual maturity at about one year (42 mm TL) (Spreitzer 1979) and generally live for over two years. Females older than three have been found on the Thames River (Finch 2009).

1.5 Threats

1.5.1 Threat classification

Bouvier and Mandrak (2010) assessed threats to Eastern Sand Darter populations in Ontario. Table 3 provides a summary of threats to Eastern Sand Darter populations in Ontario. Known and suspected threats were ranked with respect to threat likelihood and threat impact for each population. The threat likelihood and threat impact were then combined to produce an overall threat status. A certainty level was also assigned to the overall threat status, which reflected the lowest level of certainty associated with either threat likelihood or threat impact. See Bouvier and Mandrak (2010) for further details. The threats to Eastern Sand Darter populations overlap and their cumulative impacts may exacerbate their decline. The cumulative impacts cannot be quantified so each threat was reviewed independently. Additional information is provided in the subsequent threat descriptions.

Table 3. Summary of threats to Eastern Sand Darter populations in Ontario.
Threat Status for all Eastern Sand Darter populations in Ontario, resulting from an analysis of both the Threat Likelihood and Threat Impact. The number in brackets refers to the level of certainty assigned to each Threat Status, which reflects the lowest level of certainty associated with either initial parameter (Threat Likelihood, or Threat Impact). Certainty has been classified as: 1= causative studies; 2=correlative studies; and, 3=expert opinion. Gray cells indicate that the threat is not applicable to the population due to the nature of the aquatic system where the population is located.

	Lake Huron	Lake St. Clair			Lake Erie						
Threats	**Ausable River**	**Lake St. Clair**	**Thames River**	**Sydenham River**	**Pelee Island**	**Rondeau Bay**	**Long Point Bay**	**Catfish Creek**	**Big Otter Creek**	**Big Creek**	**Grand River**
Turbidity and sediment loading	High (3)	High (3)	High (3)	High (3)	Medium (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)
Contaminants and toxic substances	High (3)	High (3)	High (3)	High (3)	Unknown (3)	High (3)	Medium (3)	Unknown (3)	Unknown (3)	Unknown (3)	Medium (3)
Nutrient loading	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Low (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)
Barriers to movement				High (3)					Medium (3)	Low (3)	Medium (3)
Altered flow regimes	High (3)		High (3)	High (3)				High (3)	Medium (3)	High (3)	High (3)
Shoreline modifications	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (3)	High (3)	Low (3)	Medium (3)	**TBD**	**TBD**	High (3)
Exotic species and disease	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)	High (3)
Incidental harvest	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)

(Table taken from Bouvier and Mandrak 2010)

1.5.2 Description of threats

The following has been adapted and revised from Bouvier and Mandrak (2010).

Turbidity and sediment loading: Siltation may be the leading cause of habitat degradation in Canada (Holm and Mandrak 1996). Increased turbidity and sediment loading can result from deforestation and the loss of riparian strips, which is often a result of intensive agricultural practices, tile drainage, channel alterations, poorly constructed water crossing, dams, and increasing urban development. Increased sediment loading can decrease bank stability downstream, which also increases erosion downstream and the process can continue for extended distances (Dextrase et al. 2003).

The impacts of silt are pervasive and extensive. Excessive siltation can affect all life stages of the Eastern Sand Darter (COSEWIC 2009). Increased turbidity and sediment loading can:

- Completely smother the eggs (Finch 2009);
- Reduce the number and quality of suitable spawning areas leading to decreases in egg survival (Finch 2009);
- Decrease or restrict growth rates of juveniles (Drake et al. 2008);
- Reduce available substrate oxygen (Holm and Mandrak 1996, Essex-Erie Recovery Team [EERT] 2008); and,
- Adversely affect prey abundance (Holm and Mandrak 1996, EERT 2008).

It is thought that standard tobacco farming practices near Big Otter Creek between the 1930s and 1960s, which resulted in heavy siltation, may have been the main reason for the extirpation of Eastern Sand Darter from this watershed (Holm and Mandrak 1996). Fortunately programs such as the Environmental Farm Plan promote changes in agricultural practices to lower the potential severity of this threat. The relatively few areas of silt-free suitable habitat in the Sydenham River may be the main limiting factor for Eastern Sand Darter in this system (Dextrase et al. 2003). However, the impacts from increased turbidity and sediment loading may be reversible, if caught early; populations of Eastern Sand Darter in Vermont and New York have benefited from decreased silt loads as a result of reforestation of stream slopes (Daniels 1993).

Contaminants and toxic substances: Contaminants and toxic substances are a pervasive threat for Eastern Sand Darter (COSEWIC 2009). These substances can come from urban, industrial or agricultural activities. Their presence in aquatic environments leads to decreased water quality and can have a negative impact on each stage of a fish's life cycle. The severity of impacts is likely linked to duration and intensity of exposure. Contaminants can directly kill the individual, its food or can slowly degrade the watercourse affecting all life history parameters. Contaminants can be chronic or episodic and may also be cumulative (EERT 2008).

The Eastern Sand Darter is considered to be intolerant to pollution (Barbour et al. 1999) but species-specific tolerances have not been investigated. Since the Eastern Sand

Darter buries itself and its eggs in the substrate, the consequence of toxic substances may be greater on this species than other fishes (Grandmaison et al. 2004).

Nutrient loading: Nutrient loading can have impacts on water quality, especially in riverine systems. One pathway is through the eutrophication of streams. Excessive growth of aquatic plants, algae, or periphyton as a result of increased nutrient input, can reduce the amount of oxygen found in the water, which threatens benthic species such as the Eastern Sand Darter (FAPAQ 2002). Nutrient loading primarily comes from manure and fertilizer applications or sewage treatment facilities (Page and Retzer 2002). Between 1955 and 1980, Lake Erie experienced excessive nutrient input resulting in extensive oxygen depletion (Koonce et al. 1996).

In the Ausable, Sydenham, and Thames rivers (Staton et al. 2003, Taylor et al. 2004, Nelson 2006) and in Lake St. Clair and Lake Erie (EERT 2008), nutrient loading has been identified as a primary threat to species at risk. In the Sydenham River, high levels of nitrates have been associated with low numbers of Eastern Sand Darter (Poos et al. 2008).

Barriers to movement: Dams are the most obvious, but not the only, barrier to movement for Eastern Sand Darter. Improperly designed and installed culverts could create a physical barrier or may preclude the Eastern Sand Darter from being able to move upstream due to high velocities or shallow water depth in the culvert. This may be relevant if Eastern Sand Darter are found in smaller tributaries where culverts are common. There are two large dams on the Grand River, and one dam on the Sydenham River within the range of Eastern Sand Darter. Data from the Grand River show that on the upstream side of a dam, locations close to the dam are less likely to be occupied by Eastern Sand Darter (A. Dextrase, OMNR, unpublished data).

Barriers to movement could lead to the fragmentation of Eastern Sand Darter populations. Small, increasingly isolated populations may suffer inbreeding effects and a loss of genetic diversity that could impair their ability to respond to changing environmental conditions (Grandmaison et al. 2004).

Altered flow regimes: There are many activities that can alter the flow within a riverine system, such as the presence of a dam and impoundment, water-taking for agricultural or urban purposes, construction of tile drains, or channel modifications.

The construction of a dam changes stream flow by transforming a lotic (moving water) environment into a lentic (standing water) environment, flooding upstream riffles and sandbars and allowing the growth of aquatic macrophytes. When current speed is slowed or eliminated, sedimentation increases. In addition, dams increase sedimentation by mitigating spring freshets (Grandmaison et al. 2004). Dams can also produce scouring flows downstream contributing to unnaturally high bank erosion. They can interfere with the natural variation in the magnitude, frequency, timing, and variability in flows.

Eastern Sand Darter requires habitat with predominantly sand substrate. These are usually depositional areas (Daniels 1989, Holm and Mandrak 1996). A specific or narrow flow regime may be required to maintain sand but not silt in these depositional areas. The loss of natural channels and flow regimes may have a large impact on Eastern Sand Darter (Dextrase et al. 2003).

Shoreline modifications: In lakes Erie and St. Clair, Eastern Sand Darter has 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 suitable sand habitat. Dredging of river mouths that drain into Lake St. Clair has the potential to directly alter habitat, increase turbidity, and trap individuals in the dredgate.

The shoreline of Lake St. Clair has been substantially altered, mainly through the installation shorewalls, offshore breakwalls, groynes, jetties, docks, and marinas (Reid and Mandrak 2008). Those areas that have not been hardened or filled have been dredged for human use (EERT 2008).

In riverine systems, shoreline modifications are typically bank hardening, channel realignments, agricultural drain creation and maintenance, and the installation of docks and marinas. Shore erosion combined with agricultural fields (e.g., ploughed land) or from tile drainage transports fine particles to streams, which accumulate on river/stream bottoms. Furthermore, the channelization of streams changes the physical processes, which can alter the formation of sandbars that are often associated with the occurrence of Eastern Sand Darter (FAPAQ 2002, Gaudreau 2005).

As discussed in altered flow regimes above, all of these types of activities (such as the presence of a dam and impoundment, water-taking for agricultural or urban purposes, construction of tile drains, or channel modifications) have the potential to alter flow regimes and natural channel processes, which may have a substantial impact on Eastern Sand Darter (Dextrase et al. 2003).

Exotic species and disease: Round Goby (*Neogobius melanostomus*), an exotic 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 basin (Bernatchez and Giroux 2000, Poos et al. 2010). The Round Goby 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) such as the Eastern Sand Darter.

The ranges of the Eastern Sand Darter and Round Goby overlap in Lake St. Clair (since 1993) and the lower Thames River, Sydenham River, Big Creek and Lake Erie (since

1996). Additionally, Round Goby have recently colonized the Grand River system. Since its introduction into the lower Great Lakes, the Round Goby has been implicated in the declines of native benthic fish species such as: Logperch (*Percina caprodes*) and Mottled Sculpin (*Cottus bairdii*) populations in the St. Clair River (French and Jude 2001); Johnny Darter (*Etheostoma nigrum*), Logperch, and Trout-Perch (*Percopsis omiscomaycus*) in Lake St. Clair (Thomas and Haas 2004); and, Channel Darter (*P. copelandi*), Fantail Darter (*E. flabellare*), Greenside Darter (*E. blennioides*), Johnny Darter, and Logperch in the Bass Islands of western Lake Erie (Baker 2005). Preliminary evidence from the lower Grand River notes a negative relationship between the abundances of Round Goby and Eastern Sand Darter based on one year of data. (A. Dextrase, OMNR, unpublished data). Potential causes of declines of native species include Round Goby predation on eggs and juveniles, competition for food and habitat, and interference competition for nests (French and Jude 2001, Janssen and Jude 2001, Poos et al. 2010).

Round Goby has been caught in all Eastern Sand Darter river systems in Ontario (A. Dextrase, OMNR pers. comm., 2010). The full impacts of the introduction of Round Goby in Eastern Sand Darter locations may not be determined for years as Round Goby populations are still actively colonizing these river systems.

Incidental harvest: The use of Eastern Sand Darter as a baitfish is illegal in Ontario (OMNR 2010a). Although Eastern Sand Darter is not a targeted baitfish, incidental harvest may occur due to co-occurrences (i.e., distributional overlap) between Eastern Sand Darter and some targeted bait species (e.g., Common Shiner [*Luxilus cornutus*], Creek Chub [*Semotilus atromaculatus*], White Sucker [*Catostomus commersonii*]). Although baitfish harvest may theoretically occur from a variety of riverine and Great Lakes nearshore localities that may support Eastern Sand Darter, these specific localities of Eastern Sand Darter occurrences are not preferentially harvested. An intensive sampling program of 68 retail tanks and baitfish purchases, examining 16 886 fishes, did not find any Eastern Sand Darter (A. Drake, University of Toronto, pers comm. 2010). This does not mean that they are not caught but that they are not being sold in the commercial harvest.

Expert opinion (Bouvier and Mandrak 2010) maintains that baitfish harvesting is an activity with minimal impact on Eastern Sand Darter populations and is an activity that may be permitted (see Section 2.8 Activities permitted by the recovery strategy).

1.6 Actions already completed or underway

Surveys: A summary of surveys conducted within the range of Eastern Sand Darter in recent years is provided in Table 4.

Table 4. Summary of recent Eastern Sand Darter surveys in Ontario (since 1997).

Waterbody	Recent surveys[4]
Ausable River	• Targeted and non-targeted sampling by DFO, OMNR, and Ausable Bayfield Conservation Authority using seine, backpack electrofisher, and boat electrofisher (2002).
Catfish Creek	• Targeted and non-targeted sampling by DFO, OMNR, Royal Ontario Museum (ROM), and University of Guelph, using seine and boat electrofisher (1997, 2002, 2008).
Big Otter Creek	• Targeted and non-targeted sampling by DFO, OMNR, and University of Guelph using seine (2002 – 04, 2008).
Big Creek	• Targeted sampling by DFO and OMNR using seine (2004).
Sydenham River	• Targeted and non-targeted sampling by DFO, OMNR, ROM, and University of Guelph using seine, backpack and boat electrofisher (1997 - 99, 2002 – 04, 2009).
Grand River	• Targeted and non-targeted sampling by DFO, OMNR, ROM, and Trent University using seine, backpack electrofisher, boat electrofisher, and trawl (1997, 1999 – 2000, 2002, 2004, 2006 – 10).
Thames River	• Targeted and non-targeted sampling by DFO, University of Waterloo, and Trent University using seine and trawl (1997 – 98, 2003 – 09).
Lake Erie	• Non-targeted sampling by DFO, OMNR, and Parks Canada Agency (PCA) (Long Point Bay, Rondeau Bay, and Point Pelee) using seine and trawl (1997 – 2008).
Lake St. Clair	• Non-targeted sampling by DFO, OMNR, and Michigan Department of Natural Resources using seine and trawl (1997 – 2001, 2005, 2007, 2008).

Aquatic ecosystem-based recovery strategies: The following aquatic ecosystem-based recovery strategies include the Eastern Sand Darter and are currently being implemented by their respective recovery teams. Each recovery team is co-chaired by DFO and a conservation authority, and receives support from a diverse partnership of agencies and individuals. Recovery activities implemented by these teams include active stewardship and outreach/awareness programs to reduce identified threats; for further details on specific actions currently underway, please refer to the approaches identified in Table 5. Funding for these actions is supported by Ontario's Species at Risk Stewardship Fund and the Government of Canada's Habitat Stewardship Program (HSP) for species at risk. Additionally, research requirements for species at risk identified in recovery strategies are funded, in part, by the federal Interdepartmental Recovery Fund (IRF). Note: Although these recovery strategies are supported by DFO, they are not formally endorsed as recovery strategies under SARA.

[4] Non-targeted sampling includes, but is not limited to, general species at risk sampling and monitoring, fish community surveys, and index netting programs.

Sydenham River ecosystem recovery strategy:
The primary objective of the Sydenham River ecosystem recovery 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 ecosystem recovery strategy:
The goal of the Thames River Recovery Team (TRRT) 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.

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. 2007). Included in this strategy are recovery initiatives for the Eastern Sand Darter and five other fish species at risk.

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 ARRT has developed a recovery strategy for the 14 aquatic species at risk in the Ausable River basin, including the Eastern Sand Darter.

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 to support viable populations of fish species at risk, across their current and former range" (EERT 2008). Included in this strategy are recovery initiatives for the Eastern Sand Darter and 17 other fish species at risk.

Research: 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 Darter populations (2005-present).

Great Lakes outreach program: The Toronto Zoo has included the Eastern Sand Darter as part of its awareness and curriculum-based education Great Lakes Outreach Program.

1.7 Knowledge gaps

In Canada, the Eastern Sand Darter has never been thoroughly studied. The few recent studies on Eastern Sand Darter in Ontario (Drake et al. 2008, Finch 2009, A.

Dextrase, OMNR, unpublished data) have provided some answers, but also raised additional questions. 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.

Therefore, knowledge acquisition on the biology (clutch size and fecundity), behaviour, adaptability as well as the species' population dynamics and abundance in Canada is critical to implement recovery measures. Additional baseline data regarding habitat needs (tolerance to temperature, pH, dissolved oxygen, and pollution), distribution, and threats (including severity of threats) to the species' survival will be necessary to examine and monitor Eastern Sand Darter population trends.

2. RECOVERY

2.1 Recovery feasibility

The recovery of the Eastern Sand Darter is considered to be both biologically and technically feasible. The following feasibility criteria[5] have been met for the species:

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. 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). However, due to the short generation time (almost annual) as well as the protracted spawning period, the potential for a relatively quick recovery exists if juvenile survival is high.

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. However, sustaining this species in the long-term could not be ensured until pressures on its habitat are abated (COSEWIC 2000, Gaudreau 2005, NatureServe 2012). Better water quality and existing habitat management (through stewardship and Best Management Practices [BMPs]) 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 restoration of silted substrates with sand substrates (Gaudreau 2005).

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

[5] Draft Policy on the Feasibility of Recovery, *Species at Risk Act* Policy. January 2005.

Yes, in some areas. Significant threats to Eastern Sand Darter habitat, such as increased siltation and turbidity, can be addressed through recovery actions. Stewardship and implementation of 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. BMPs 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).

   Repatriations 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 U.S. towards the recovery of other endangered darter species (Shute et al. 2005). For example, populations of imperilled species such as the Snail Darter (*P. tanasi*) and Fringed Darter (*E. crossopterum*) have been established through adult transfers (Etnier and Starnes 1993, Poly 2003). However, these darter species did not include any in the *Ammocrypta* genus. Several populations of Eastern Sand Darter in the U.S. and Canada (e.g., Thames River) are stable, and genetic analyses would determine their appropriateness as sources for repatriations. 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, Thames and Grand 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 three 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.

2.2 Recovery goal

The long-term goal (>20 years) of this recovery strategy is to maintain self-sustaining, extant populations and to restore self-sustaining populations to formerly occupied habitats where feasible. In some locations, permanent changes in the fish community, as a result of the establishment of exotic species, may impact the feasibility of re-establishing Eastern Sand Darter populations.

2.3 Population and distribution objectives(s)

COSEWIC assessed the Eastern Sand Darter as Threatened in 2000 and reassessed it as the same status in 2009, in part, because of its small area of occupancy, number of locations, and the continuing decline in habitat quality. The Eastern Sand Darter is considered extant at six locations in Ontario, unknown at two locations, and extirpated from three locations (Bouvier and Mandrak 2010). Currently, the total number of confirmed Eastern Sand Darter locations, both extant and extirpated, is 11.

An important factor to consider when determining population and distribution objectives is the number of populations that may be at a given location, as it is possible that a location may contain more than one discrete population. In this context, location does not refer to the locality of the discrete population, but rather a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of this species present (COSEWIC 2011).

To recover the species to a level lower than Threatened under COSEWIC criteria, a minimum of 11 extant locations with at least one self-sustaining population are required. Where present, multiple populations at a single location should be maintained. At present, the number of populations present at each Eastern Sand Darter location in Canada is unknown and further research is required to investigate this.

The population and distribution objective for Eastern Sand Darter is to ensure the survival of self-sustaining population(s) at the six extant locations (Sydenham River, Thames River, Lake St. Clair, Big Creek, Grand River, Lake Erie [Long Point Bay]) and restore self-sustaining population(s) at the following locations: Ausable River, Lake Erie (Rondeau Bay and Pelee Island), Catfish Creek, and Big Otter Creek, where feasible.

Results from the recovery potential modelling conducted by Finch et al. (2011), indicated that the estimated minimum viable population size (MVP) for Eastern Sand Darter is 52 822 adults, given a 10% chance of a catastrophic event occurring per generation. However, the implementation of such a target is difficult without also having information on population(s) size, trends, and spatial distribution, as well as habitat quality; this information is mostly lacking for the majority of Eastern Sand Darter locations in Ontario. Further research is required to validate the model results and to obtain the aforementioned information. More quantifiable objectives relating to MVP will be developed once abundance information can be obtained. This will also inform the refinement of the recovery goal.

2.4 Recovery objectives

Short-term recovery objectives (5 – 10 years)
In support of the long-term goal, the following short-term recovery objectives will be addressed over the next 5 -10 years:

i. Refine population and distribution objectives;
ii. Ensure the protection of critical habitat;

iii. Determine long-term population and habitat trends;
iv. Evaluate and minimize threats to the species and its habitat;
v. Investigate the feasibility of population supplementation or repatriation for populations that may be extirpated or reduced;
vi. Enhance efficiency of recovery efforts through coordination with aquatic and terrestrial ecosystem recovery teams and other relevant or complementary groups/initiatives; and,
vii. Improve overall awareness of the Eastern Sand Darter and the role of healthy aquatic ecosystems, and their importance to humans.

2.5 Approaches recommended to meet recovery objectives

2.5.1 Recovery planning

Recovery approaches have been organized into three categories: 'Research and Monitoring' (Table 5), 'Management and Habitat Protection' (Table 7), and 'Stewardship, Outreach and Education' (Table 8). Table 6 identifies the survey needs for Eastern Sand Darter in specific waterbodies in Ontario as part of a strategy identified under the Research and Monitoring category. Although approaches have been prioritized, all are important to meet recovery goals and objectives. A narrative has been included where deemed appropriate.

Table 5. Recovery approaches for Eastern Sand Darter in Ontario – research and monitoring.

Priority	Objective addressed	Threats addressed	Broad strategy to address threats	Recommended approaches to meet recovery objective(s)	Outcomes or deliverables (identify measurable targets)
High	ii	All	R1. Habitat requirements	Refine knowledge of seasonal habitat requirements for all life stages especially juvenile.	Will allow for refinement of critical habitat. Will assist with the development of a habitat model.
High	i, ii	All	R2. Habitat surveys and mapping	Evaluate and map the distribution, quantity and quality of habitat in the vicinity of known populations.	Will allow for refinement of critical habitat.

Priority	Objective addressed	Threats addressed	Broad strategy to address threats	Recommended approaches to meet recovery objective(s)	Outcomes or deliverables (identify measurable targets)
High	i, iii, v	All	R3. Background surveys and monitoring – extant, historic and potential new locations	Develop a long-term monitoring program that includes standardized sampling protocol to monitor for trends over time in distribution and abundance for all life stages. Incorporate findings into a routine population monitoring program.	Will determine presence/absence, health, range, abundance and population demographics, and contribute to the refinement of critical habitat.
High	iv	All habitat related threats (barriers to movement, altered flow regimes, shoreline modifications)	R4. Threat clarification - habitat	Investigate and evaluate the significance of habitat threat factors that may be impacting extant populations. Take steps to mitigate immediate threats identified.	Will determine the severity of specific threats to individual populations and will direct stewardship activities to alleviate their impacts.
High	iv	Exotic species	R5. Threat clarification – exotic species	Investigate the mechanisms of impact of Round Goby on Eastern Sand Darter. Monitor distribution of Round Goby in areas of Eastern Sand Darter populations.	Will identify the degree to which Round Goby may impact Eastern Sand Darter.
Moderate	v	All	R6. Captive rearing and repatriations	Where repatriations are deemed appropriate for restoring populations (historical or degraded), develop a repatriation plan.	Determine the feasibility and appropriateness of repatriations in areas of suitable habitat.
Low	v	All	R7. 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.	Will help to distinguish populations and determine if there is more than one population at a location. Will contribute necessary info should population enhancement through repatriations or captive rearing be required

Priority	Objective addressed	Threats addressed	Broad strategy to address threats	Recommended approaches to meet recovery objective(s)	Outcomes or deliverables (identify measurable targets)
Low	i	All	R8. Habitat modelling	Develop a predictive habitat model to identify potential Eastern Sand Darter sites and significant habitat areas.	Will use model to further refine critical habitat and identify potential Eastern Sand Darter sites for additional survey investigation.

Background surveys and monitoring (R3)

The Eastern Sand Darter is known from only a few locations in watersheds throughout its range. 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. 2007). Survey needs are provided in Table 6. In the vicinity of current and historical occurrence, surveys are required to:

- Confirm the spatial distribution of extant populations;
- Confirm the loss of historical populations;
- Identify suitable habitat (distribution, quantity and quality of sandy patches);
- Provide an index of abundance and trend over time data; and,
- Detect the presence of Round Goby.

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	
Grand River	To determine if Wilkes dam is a barrier to fish passage and if populations are present between Brantford and Paris.
Thames River	Routine monitoring of population.
Sydenham River	To determine the extent and status of the populations.
Lake St. Clair	
Lake Erie	
Big Creek	

It is recommended that riverine populations be surveyed using a variety of methods during periods of low flow (e.g., summer and early fall). Field surveys should target shallow habitats with sand and/or mixed sand/gravel bed material.

Captive rearing and repatriation (R6)

Repatriation efforts need to consider the following:

i) Many of the extirpations are presumed to be the result of habitat degradation. The success of repatriations 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;

ii) Repatriations should not be considered until the factors for extirpation are understood and addressed or there is suitable habitat present to support a viable population;

iii) Source populations to support repatriations 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;

iv) Removal of individuals from source populations should not negatively affect the status of these populations;

v) 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;

vi) 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. However, proper application of PVA tools may require improved information on the life history and demographics of the species targeted for repatriation;

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

viii) All proposed repatriations associated with this strategy will involve the preparation of a repatriation plan that will address the logistic and ecological aspects discussed above, as well as stakeholder issues.

Repatriations should follow the American Fisheries Society Guidelines for Introductions of Threatened and Endangered Fishes and the National Code on Introductions and Transfers or Aquatic Organisms.

Table 7. Recovery approaches for Eastern Sand Darter in Ontario – management and habitat protection.

Priority	Objective addressed	Threats addressed	Broad strategy to address threats	Recommended approaches to meet recovery objective(s)	Outcomes or deliverables (identify measurable targets)
High	vi, vii	All	M1. Coordination with other recovery teams and relevant organizations	Work with relevant organizations (e.g., conservation authorities, OMNR), First Nations, and ecosystem/single species recovery teams to share knowledge, and implement recovery actions.	Will combine resources, ensure information dissemination, help to prioritize most urgent actions across the species' range and allow for a coordinated approach to recovery.
High	iii, iv	All habitat threats	M2. Habitat management and policy	Ensure planning and management agencies, including local First Nations, recognize the importance of fluvial and long-shore processes and sources of sand bedload in the maintenance of Eastern Sand Darter habitats. Ensure that flow requirements of the Eastern Sand Darter are considered in the management of water supply and flow regimes.	Will result in protection of important habitat from development activities. For example: consistent plan for reducing shoreline hardening or removal of obsolete dams.
High	vi	All threats	M3. Assessment of watershed-scale stressors	In cooperation with relevant ecosystem recovery teams and First Nations, address watershed-scale stressors to populations and their habitat.	Will identify areas in which cumulative effects of threats may be significant
High	vi, vii	Exotics	M4. Exotic species management plan	Develop a management plan addressing potential risks and proposed actions in response to the arrival or establishment of exotic species, such as the Round Goby.	Will ensure timely response should this threat fully materialize.

Priority	Objective addressed	Threats addressed	Broad strategy to address threats	Recommended approaches to meet recovery objective(s)	Outcomes or deliverables (identify measurable targets)
Moderate	vi, vii	Habitat threats	M5. Municipal planning	Encourage municipalities and First Nations to include the concerns about Eastern Sand Darter habitat conservation in the municipal planning documents.	Will prevent further impairment of water quality and quantity.

Table 8. Recovery approaches for Eastern Sand Darter in Ontario – stewardship and outreach and education.

Priority	Objective addressed	Threat addressed	Broad strategy to address threats	Recommended approaches to meet recovery objective(s)	Outcomes or deliverables (identify measurable targets)
High	v	All	S1. Stewardship - awareness	Encourage and strengthen stewardship efforts with managers, stakeholders, First Nations and citizens aimed at protecting Eastern Sand Darter habitats.	Will address local concerns about implications of recovery of Eastern Sand Darter.
High		Turbidity and sediment loading, contaminants and toxic substances, nutrient loading, shoreline modifications	S2. Stewardship – implementation of BMP's	Work with landowners and First Nations to implement BMPs in areas that will provide the most benefit. Encourage the completion and implementation of Environmental Farm Plans and Nutrient Management Plans	Will minimize threats from soil erosion, stream sedimentation and nutrient and chemical contamination.

Priority	Objective addressed	Threat addressed	Broad strategy to address threats	Recommended approaches to meet recovery objective(s)	Outcomes or deliverables (identify measurable targets)
High	v, vi	all	S3. Communication plan[6]	Develop a communication and awareness-raising plan that identifies partners and target audiences. Raise the awareness and develop information products, educational and outreach opportunities, stewardship resources and specific BMP's that will assist with the recovery of the Eastern Sand Darter.	Will provide a strategic basis for improving public awareness of species at risk and promote ways in which community and public involvement can be most effectively solicited fro the recovery of Eastern Sand Darter.
Moderate	v, vi	all	S4. Coordination with other groups[6]	Collaborate with relevant groups, including First Nations groups and recovery teams to address recovery actions to benefit Eastern Sand Darter	Will combine efficiencies in addressing common recovery actions, and ensure information is disseminated in a timely cooperative fashion.
Moderate	v, vi	Exotic species and disease	S5. Exotic species - awareness	Increase public awareness of the impacts of invasive species on the natural ecosystem, encourage the use of the Ontario invasive species reporting system.	Will reduce the transport and release of exotics and prevent their establishment in new areas.
Moderate		All	S6. Stewardship-financial assistance/ incentives[6]	Facilitate access to funding sources for landowner and local community groups engaged in stewardship activities.	Will facilitate the implementation of recovery efforts. BMP's associated with water quality improvements, sediment load reduction, etc.

Stewardship and habitat initiatives (S1)

Basin-wide efforts to improve habitat quality will be required in all watersheds. This represents an important opportunity to engage landowners, local communities, First Nations, and stewardship councils on the issues of Eastern Sand Darter recovery, ecosystem and environmental health, clean water protection, nutrient management, BMPs, stewardship projects, and associated financial incentives. To accomplish this,

[6] Approaches currently being implemented by one or more ecosystem-based recovery programs.

the members of the Ontario Freshwater Fish Recovery Team (OFFRT) 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 (S2)
The members of the OFFRT, together with watershed Recovery Implementation Groups (RIGs) (for stewardship, awareness and community outreach), will work with landowners, First Nations, and stewardship groups to implement BMPs. Establishing riparian buffers reduces nutrient (nitrogen and phosphorus) and sediment inputs 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 and other aquatic organisms. The RIGs can work with landowners to mitigate the impacts of tile drainage, thereby, reducing sediment and nutrient inputs. No-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. The RIGs can work with Drainage Engineers to improve upon and incorporate features beneficial to Eastern Sand Darter while providing for drainage activities through an Engineer's Report, which will allow these features to be protected under the *Drainage Act.*

Coordination with other recovery teams (S4)
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 Grand, Sydenham, and Thames rivers, and the Essex-Erie watershed, 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 OFFRT and multi-species recovery teams that maximizes opportunities to share resources, information, and combine efficiencies is recommended. The members of the OFFRT should also coordinate efforts with recovery teams focused on the recovery of Spiny Softshell Turtle (*Apalone spinifera*) and Round Hickorynut.

2.6 Performance measures

The overall success of implementing the recommended recovery approaches will be evaluated primarily through routine population (distribution and abundance) and habitat (quality and quantity) surveys and monitoring. During the next five years, focus will be placed on completing recovery actions identified as "high priority" for the Eastern Sand Darter. The recovery strategy will be reported on in five years to evaluate the progress made toward population and distribution objectives and will be reviewed within an adaptive management planning framework,

with input from ecosystem recovery teams. Performance measures to evaluate the recovery process in meeting recovery objectives over the next five years are outlined in Table 9.

Table 9. Performance measures 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 • Implementation of management measures in Table 7.
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 refine critical habitat and implement strategies to protect known habitat.	• Complete 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, repatriations and captive rearing.	• Research has been conducted to evaluate feasibility of translocations, repatriations, 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.

2.7 Critical habitat

2.7.1 General identification of the Eastern Sand Darter's critical habitat

The identification of critical habitat for species that are listed as Threatened, Endangered or Extirpated, on Schedule 1, is a requirement of SARA. Once identified, SARA includes provisions to prevent the destruction of critical habitat. Critical habitat is defined under Section 2(1) of SARA as:

> "…the habitat 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". [s. 2(1)]

SARA defines habitat for aquatic species at risk as:

> "… spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced." [s. 2(1)]

Critical habitat has been identified to the extent possible, using the best information currently available, for Eastern Sand Darter populations in Ontario. The critical habitat identified in this recovery strategy describes the geospatial areas that contain the habitat necessary for the survival or recovery of the species. The current areas identified may be insufficient to achieve the population and distribution objectives for the species. As such, a schedule of studies has been included to further refine the description of critical habitat (in terms of its biophysical functions/features/attributes as well as its spatial extent) to support its protection.

2.7.2 Information and methods used to identify critical habitat

Using the best available information, critical habitat has been identified using a 'bounding box' approach for the following areas where the species presently occurs: Sydenham River, Thames River, Grand River, Big Creek, and Long Point Bay. Additional areas of potential critical habitat within the Lake St. Clair/Walpole Island area will be considered in collaboration with Walpole Island First Nation. Using this approach, the 'bounding box' outlines areas in which the species is known to occur (i.e., areas where multiple adults and/or YOY have been captured). It is further refined through the use of essential functions, features, and attributes for each life stage of the Eastern Sand Darter to identify patches of critical habitat within the 'bounding box'. Life stage habitat information was summarized in chart form using available data and studies referred to in Section 1.4.1 (Habitat and biological needs). The 'bounding box' approach was the most appropriate, given the limited information available for the species and the lack of detailed habitat mapping for these areas. Where habitat information was available (e.g., bathymetry data), it was used to inform the identification of critical habitat.

For all river locations, critical habitat was identified based on a 'bounding box' approach and further refined with an ecological classification system, the Aquatic Landscape Inventory System (ALIS version 1) (Stanfield and Kuyvenhoven 2005). ALIS was developed by the OMNR to define stream segments based on a number of unique characteristics found only within those valley segments. Each valley segment is defined by a collection of landscape variables that are believed to have a controlling effect on the biotic and physical processes within the catchments. Therefore, if a population has been found in one part of the ecological classification, there is no reason to believe that it would not be found in other spatially contiguous areas of the same valley segment. Critical habitat for the Eastern Sand Darter was therefore identified as the reach of rivers that includes all contiguous ALIS segments from the uppermost stream segment with the species present to the lowermost stream segment with the species present.

For lake locations, critical habitat is currently identified, based on a 'bounding box' approach, and refined using National Oceanic and Atmospheric Administration (NOAA) bathymetry data.

Any additional detail on the specific methods used to identify critical habitat is provided in the individual critical habitat descriptions (below), when relevant.

Sydenham River: Sampling data in the river was taken from the DFO database for the period from 1927 to 2009. There were only 43 individuals caught in the last 10 years (Bouvier and Mandrak 2010).

Thames River: Sampling data in the river was taken from the DFO database for the period from 1923 to 2009. There has been extensive targeted sampling for Eastern Sand Darter in the river. This population is considered the largest population of Eastern Sand Darter in Canada with more than 5000 individuals caught in the last 10 years (Bouvier and Mandrak 2010).

Grand River: The first capture of Eastern Sand Darter in the Grand River was in 1987. Since then there have been more than 735 individuals caught through targeted sampling (Bouvier and Mandrak 2010).

Big Creek (Norfolk County): Eastern Sand Darter were found in 1923 and 1955 (Holm and Mandrak 1996, COSEWIC 2009). This population was thought to be extirpated, but in 2008 three individuals were captured (A. Dextrase, OMNR, unpublished data, DFO, unpublished data).

Long Point Bay (Lake Erie): The Eastern Sand Darter has been captured from Inner Long Point Bay at four locations. Index netting trawls by OMNR since 1972 captured Eastern Sand Darter every year between 1979 and 1987 except 1983 (Holm and Mandrak 1996). These locations overlap with the limited sand substrate, as much of the bay has aquatic vegetation. Using available sampling data, critical habitat has currently been identified based on a 'bounding box' approach, and refined using NOAA bathymetry data.

2.7.3 Identification of critical habitat: biophysical functions, features and their attributes

There is limited information on the habitat needs for the various life stages of the Eastern Sand Darter. Table 10 summarizes available knowledge on the essential functions, features and attributes for each life stage. Refer to Section 1.4.1 (Habitat and biological needs) for additional information and full references. Note that not all attributes in Table 10 must be present for a feature to be identified as critical habitat. If the features as described in Table 10 are present and capable of supporting the associated function(s), the feature is considered critical habitat for the species, even though some of the associated attributes might be outside of the range indicated in the table.

Table 10. Essential functions, features and attributes of critical habitat for each life stage of the Eastern Sand Darter[7].

Life stage	Habitat requirement (function)	Feature(s)	Attribute(s)
Spawn to larvae (< 18 mm TL)	• Spawning (likely occurs in June and July in Ontario) • Nursery	• Reaches of streams and rivers with sand substrate • Sandy shoals in lakes	• Moderate current • Mix of sand and gravel (e.g., 0.06 to 64 mm) • Well oxygenated substrates • Little to no aquatic vegetation • Warm water temperatures (spawning in Ontario generally thought to occur from 20.5 to 25.5°C)
Juveniles (> 18 mm TL)	• Feeding • Cover (fossorial behaviour)	• Reaches of streams and rivers with sand substrate • Sandy shoals, bars and beaches • Shallow pools and bays in lakes	• Recently transformed juveniles have been caught in the same habitat as adults.
Adult (ages one [sexual maturity] to three years old)	• Feeding • Cover (fossorial behaviour)	• Reaches of streams and rivers with sand substrates • Sandy shoals, bars and beaches • Shallow pools and bays in lakes	• Moderate current or wave action (e.g., depositional areas) • Sand or gravel (e.g., 0.06 to 64 mm) with minimal fines (< 0.06 mm) • Little or no aquatic vegetation

[7] Where known or supported by existing data.

Studies to further refine knowledge on the functions, features, and attributes for various life stages of the Eastern Sand Darter are described in Section 2.7.5 (Schedule of studies to identify critical habitat).

2.7.4 Identification of critical habitat: geospatial

Using the best available information, critical habitat has been identified for Eastern Sand Darter populations in the following locations:

- Sydenham River;
- Thames River;
- Grand River;
- Big Creek (Norfolk County); and,
- Long Point Bay (Lake Erie).

In the future, with new information, additional areas could be identified and/or additional information may be obtained to allow further clarification about the functional descriptions. Areas of critical habitat identified at some locations may overlap with critical habitat identified for other co-occurring species at risk; however, the specific habitat requirements within these areas may vary by species.

The areas delineated on the following maps (Figures 4-8) represent the area within which critical habitat is found for the above-mentioned populations. Using the 'bounding box' approach, critical habitat is not comprised of all areas within the identified boundaries, but only those areas where the biophysical features/attributes are present that are capable of supporting one or more habitat functions (refer to Table 10). Note that existing permanent anthropogenic features that may be present within the areas delineated (e.g., marinas) are specifically excluded from the critical habitat description*;* it is understood that maintenance or replacement of these features may be required at times. Brief explanations for the areas identified as critical habitat are provided below.

Table 11 provides the geographic coordinates that situate the boundaries within which critical habitat is found for the Eastern Sand Darter at the five locations; these points are indicated on Figures 4-8.

Table 11. Coordinates locating the boundaries within which critical habitat is found for the Eastern Sand Darter at five locations.

	Coordinates locating areas of critical habitat			
Location	**Point 1 (NW)**	**Point 2 (NE)**	**Point 3 (SE)**	**Point 4 (SW)**
Big Creek[8]	42°40'19.570"N[9] 80°31'43.828"W	42°35'39.772"N 80°28'56.167"W		
Grand River[8]	43°11'57.347"N 80°21'52.463"W	42°55'43.385"N 79°40'46.810"W		

[8] Riverine habitats are delineated to the midpoint of channel of the uppermost stream segment and lowermost stream segment (i.e., two points only).
[9] All coordinates obtained using map datum NAD 83.

	Coordinates locating areas of critical habitat			
Location	**Point 1 (NW)**	**Point 2 (NE)**	**Point 3 (SE)**	**Point 4 (SW)**
Thames River[8]	42°58’38.384”N 81°22’15.789”W	42°30’35.205”N 82°04’26.745”W		
Sydenham River[8]	42°57’11.590”N 81°38’02.949”W	42°33’07.504”N 82°25’06.911”W		
Long Point Bay	42°40’01.093”N 80°19’48.514”W	42°33’01.370”N 80°02’27.572”W	42°34’51.795”N 80°26’12.446”W	42°36’49.952” N 80°27’23.015” W

Sydenham River: The area within which critical habitat is found in the east branch of the Sydenham River includes all contiguous ALIS segments from the uppermost stream segment with the species present to the lowermost stream segment with the species present. This represents a stretch of river approximately 155 km long from Strathroy downstream to Walpole Island/Lake St. Clair. However, there may be limited suitable habitat for Eastern Sand Darter downstream of Dawn Mills (Figure 4). The critical habitat geospatial limit extends to the high water mark, which is defined as the usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land. In flowing waters (rivers, streams), this refers to the active channel/bankfull, which is often the 1:2 year flood flow return level and which plays an essential role in maintaining channel forming flows and clean sand substrates.

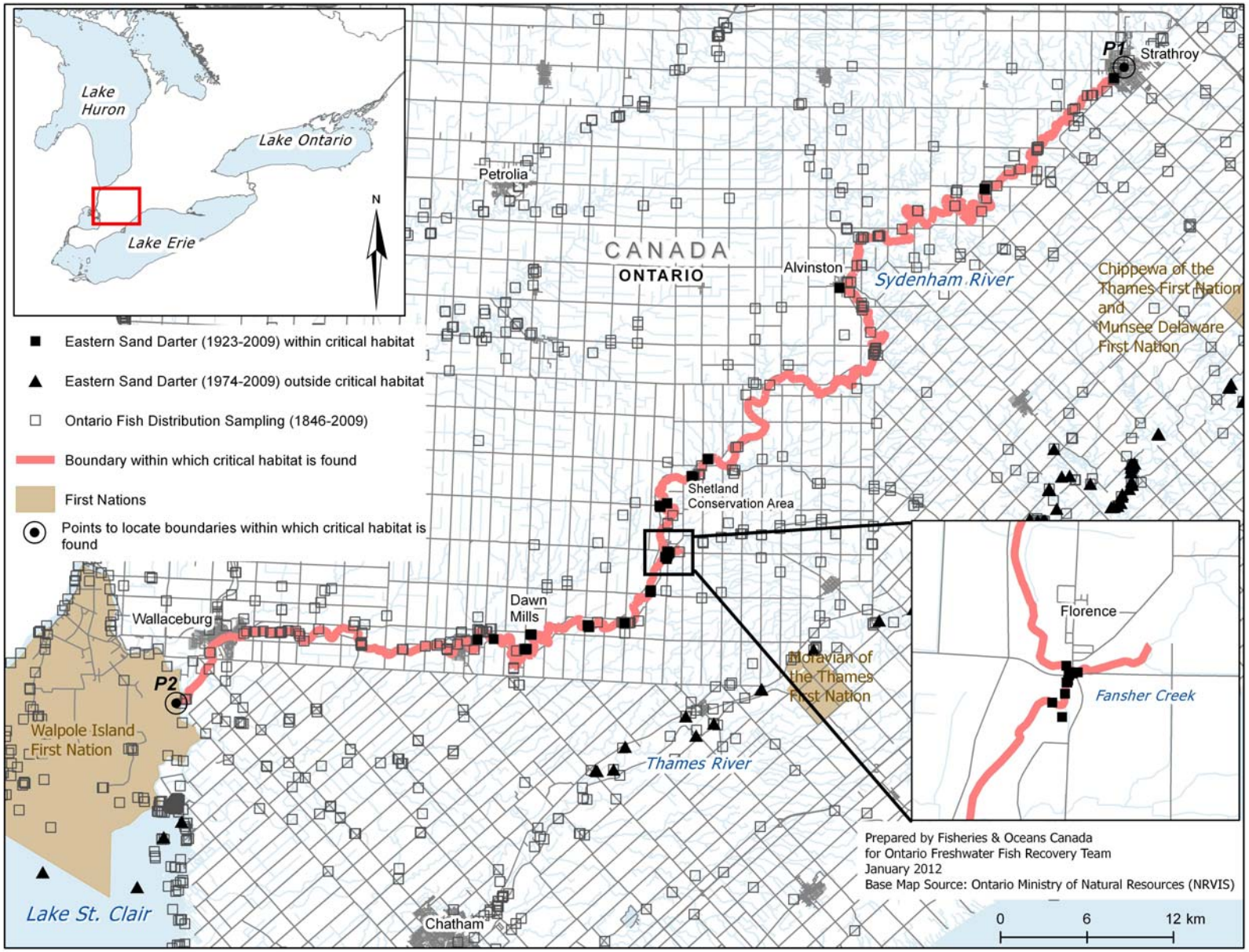


Figure 4. Area within which critical habitat is found for the Eastern Sand Darter in the Sydenham River.

Thames River - The area within which critical habitat is found in the Thames River includes all contiguous ALIS segments from the uppermost stream segment with the species present to the lowermost stream segment with the species present. This represents a stretch of river approximately 148 km long between Komoka and Kent Bridge (Figure 5). The critical habitat geospatial limit extends to the high water mark, which is defined as the usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land. In flowing waters (rivers, streams), this refers to the active channel/bankfull, which is often the 1:2 year flood flow return level and which plays an essential role in maintaining channel forming flows and clean sand substrates.

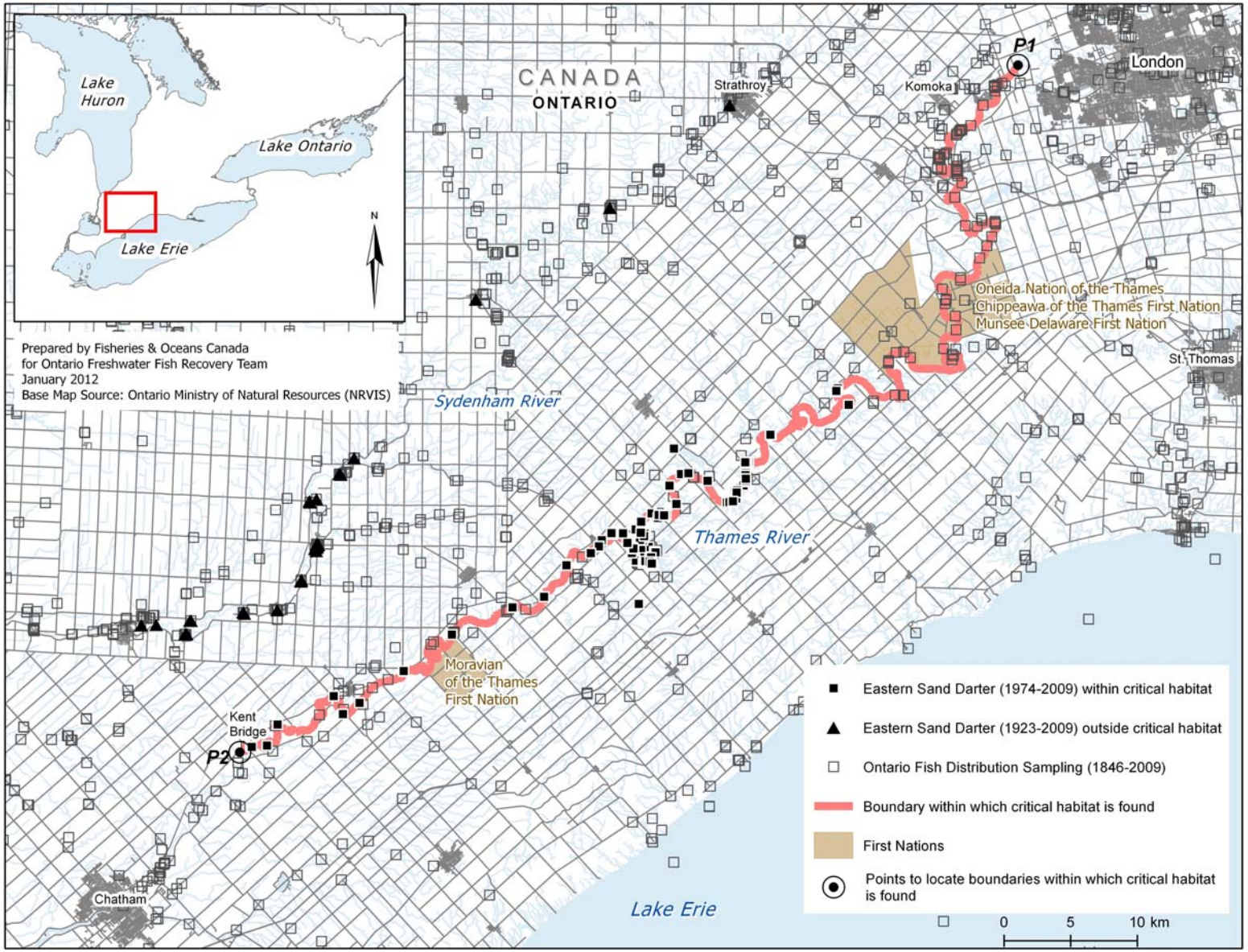


Figure 5. Area within which critical habitat is found for the Eastern Sand Darter in the Thames River.

Grand River - The area within which critical habitat is found in the Grand River includes all contiguous ALIS segments from the uppermost stream segment with the species present to the lowermost stream segment with the species present. This represents a stretch of river approximately 107 km long from Paris downstream to upstream of Dunnville (Figure 6). The critical habitat geospatial limit extends to the high water mark, which is defined as the usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land. In flowing waters (rivers, streams), this refers to the active channel/bankfull, which is often the 1:2 year flood flow return level and which plays an essential role in maintaining channel forming flows and clean sand substrates.

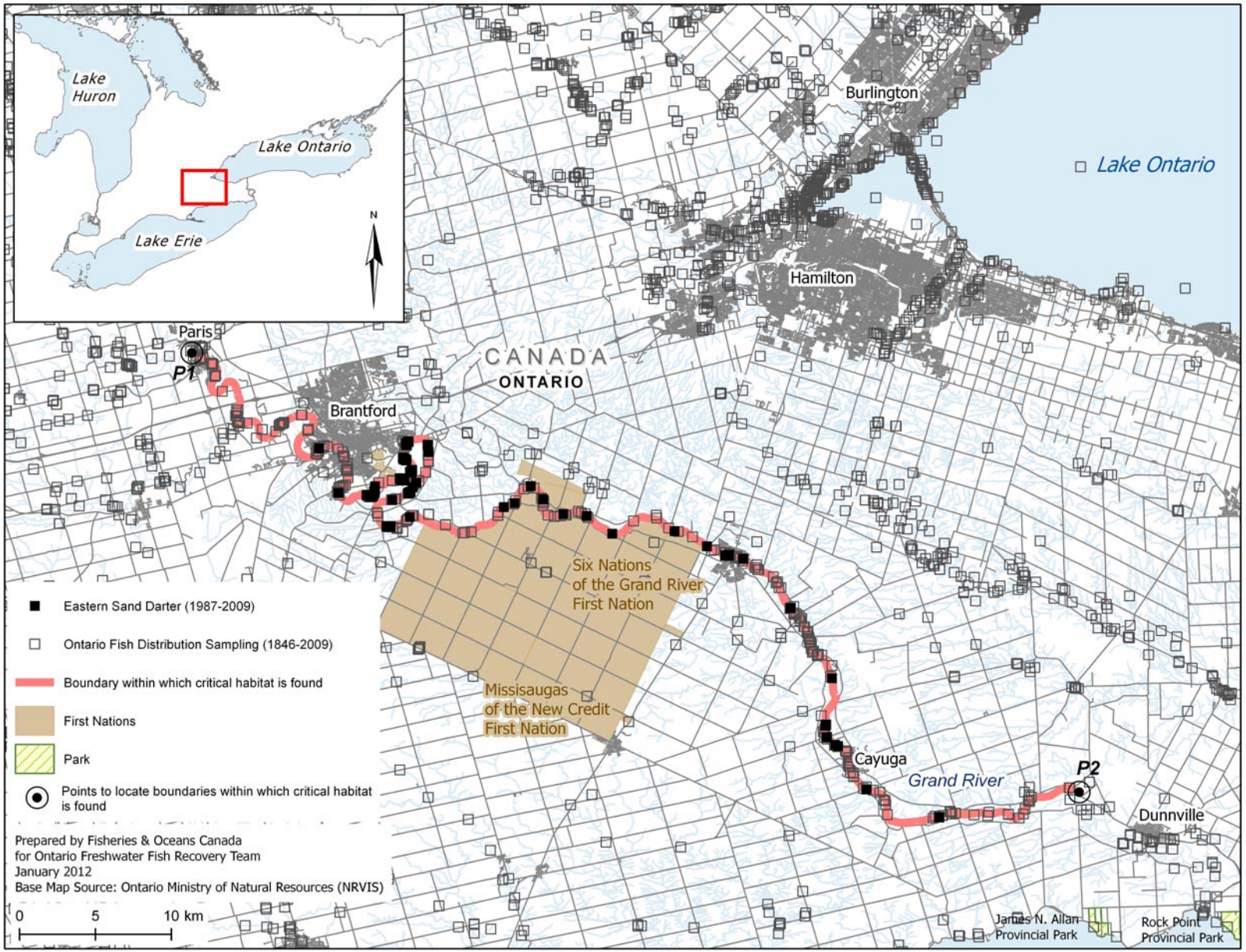


Figure 6. Area within which critical habitat is found for the Eastern Sand Darter in the Grand River.

Big Creek (Norfolk County) - The area within which critical habitat is found in Big Creek includes all contiguous ALIS segments from the uppermost stream segment with the species present to the lowermost stream segment with the species present. This represents a stretch of river approximately 17 km long from upstream of Spring Arbour, downstream to the start of the wetland at Big Creek National Wildlife Area (Figure 7). The critical habitat geospatial limit extends to the high water mark, which is defined as the usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land. In flowing waters (rivers, streams), this refers to the active channel/bankfull, which is often the 1:2 year flood flow return level and which plays an essential role in maintaining channel forming flows and clean sand substrates.

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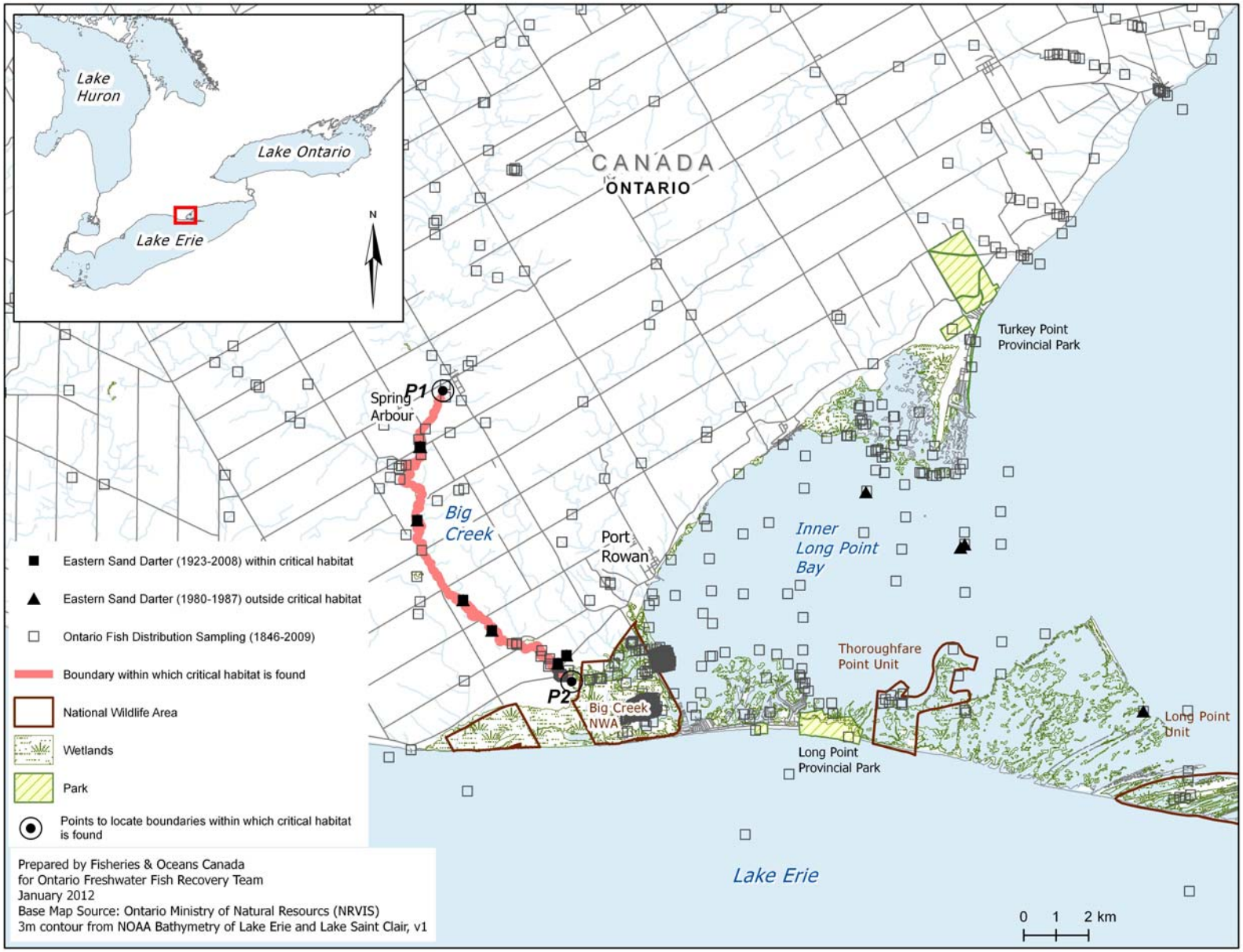

Figure 7. Area within which critical habitat is found for the Eastern Sand Darter in Big Creek.

Long Point Bay (Lake Erie) - The area within which critical habitat is found in Long Point Bay includes the contiguous waters of the Inner Bay and the tip, from the shore down to the 3 m contour (Figure 8). The 3 m contour was used as occupied habitats were found only within this area. This represents a total area of approximately 167 km^2. Critical habitat extends up to the high water mark elevation for Lake Erie at 174.62 m above sea level (International Great Lakes Datum 1985).

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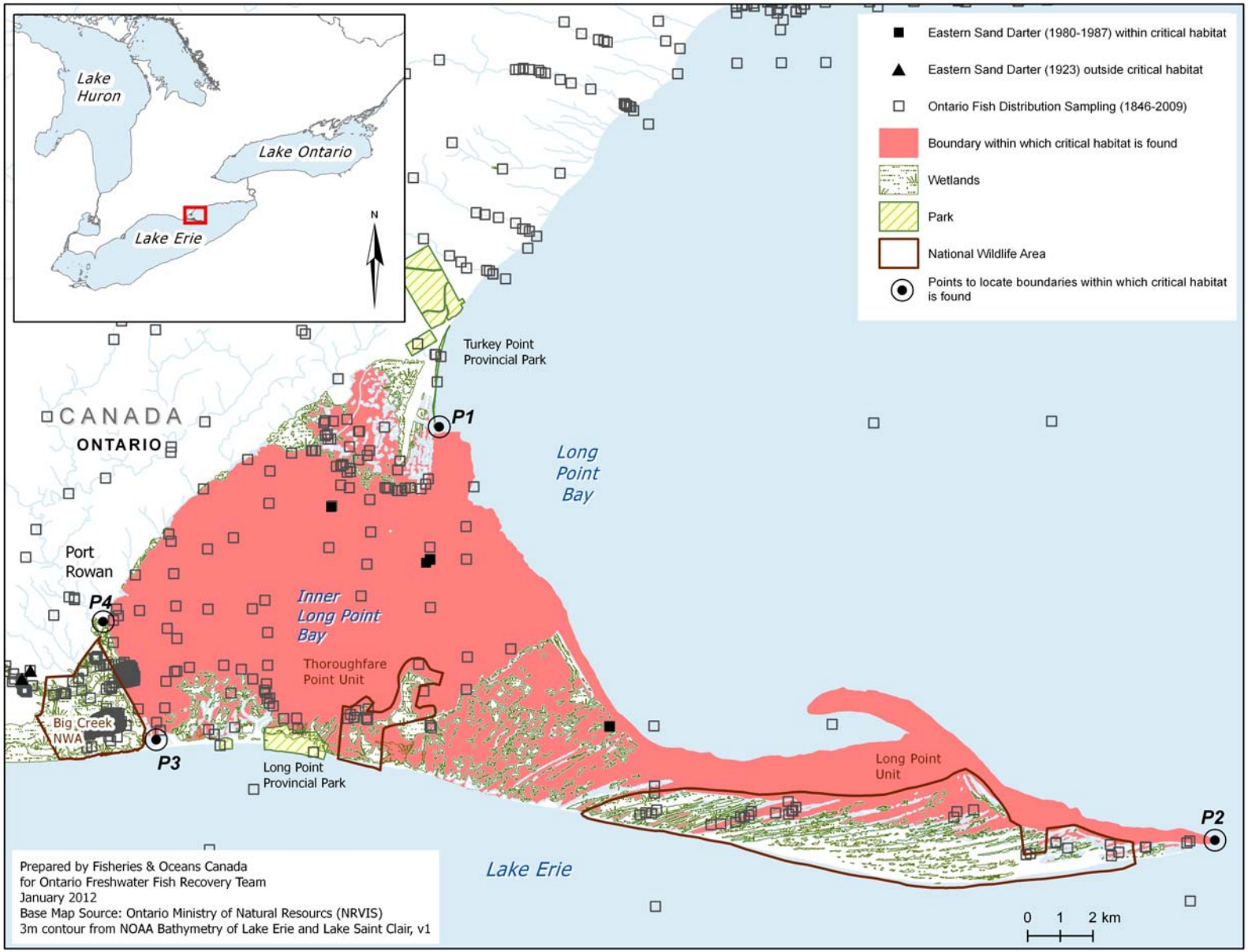

Figure 8. Area within which critical habitat is found for the Eastern Sand Darter in Long Point Bay (Lake Erie).

These identifications of critical habitat ensure that currently occupied habitat within the Sydenham, Thames, and Grand rivers, Big Creek (Norfolk County), and Long Point Bay is protected, until such time as critical habitat for the species is further refined according to the schedule of studies (Section 2.7.5 Schedule of studies to identify critical habitat). The schedule of studies outlines activities necessary to refine the current critical habitat descriptions at confirmed extant locations, but will also apply to new locations should new locations with established populations be confirmed. Critical habitat descriptions will be refined as additional information becomes available to support or inform the population and distribution objectives.

2.7.4.1 Population viability

The minimum area for population viability (MAPV) for each life stage of the Eastern Sand Darter was estimated for Canadian populations (Table 12). The MAPV is defined as the amount of exclusive and suitable habitat required for a demographically sustainable recovery target based on the concept of a MVP (Finch et al. 2011). The estimated MVP for adult Eastern Sand Darter is 52 822, given a 10% chance of a catastrophic event occurring per generation. The corresponding MAPV has been estimated to be 0.037 km^2 in rivers, and 0.213 km^2 in lakes. For more information on the MVP and MAPV and associated methodology refer to Finch et al. (2011).

The MAPV is a quantitative metric of critical habitat that can assist with the recovery and management of species at risk (Finch et al. 2011). MAPV values are somewhat conservative in that they represent the sum of habitat needs calculated for all life stages of the Eastern Sand Darter; these numbers do not take into account the potential for overlap in the habitat of the various life stages and may overestimate the area required to support an MVP. However, since many of these populations occur in areas of degraded habitat (MAPV assumes habitat quality is optimal), areas larger than the MAPV may be required to support an MVP. In addition, for many populations, it is likely that only a portion of the habitat within that identified as the area within which critical habitat is found would meet the functional requirements of the species' various life stages.

Comparisons were made between the extent of critical habitat identified for each population relative to the estimated MAPV (refer to Table 12). The critical habitats identified inside the segments are the areas that meet the functional habitat requirements outlined in Table 10. Consequently, the area data provided are only cartographic estimations of the total watercourse segment and are not the actual area of available critical habitat. Further studies will be required to assess the area of critical habitat available on an annual basis, for each identified river segment. Future studies may also help quantify the amount and quality of habitat that meets the functions, features, attributes within geospatial areas for all populations. Such information, along with the verification of the MAPV model, will allow greater certainty for the determination of population viability. As such, the results in Table 12 are preliminary and should be interpreted with caution.

Table 12. Comparison of the area within which critical habitat is found for each Eastern Sand Darter population, relative to the estimated minimum area for population viability (MAPV)[10].

Population[11]	Area within which critical habitat is found	MAPV area	MAPV achieved?
Sydenham River	4.9 km^2 (154 km of river)	0.037 km^2	Yes
Thames River	3.1 km^2 (148 km of river)	0.037 km^2	Yes
Grand River	11.9 km^2 (107 km of river)	0.037 km^2	Yes
Big Creek	0.3 km^2 (18 km of river)	0.037 km^2	Yes
Long Point Bay	167 km^2	0.213 km^2	Yes

2.7.5 Schedule of studies to identify critical habitat

This recovery strategy includes an identification of critical habitat to the extent possible, based on the best available information. Further studies are required to refine critical habitat identified for the Eastern Sand Darter to support the population and distribution objectives for the species. The activities in Table 13 are not exhaustive and it is likely that the process of investigating these actions will lead to the discovery of further knowledge gaps that need to be addressed.

Table 13. Schedule of studies to identify critical habitat.

Description of activity	Rationale	Approximate timeline
Conduct studies to determine the habitat requirements for all life stages.	There is little known about YOY and juvenile habitat requirements, and spawning has never been observed in the wild. Determining habitat requirements for each life stage will ensure that all types of critical habitat for this species will be identified.	2011-2014
Survey and map habitat quality and quantity within historical and current sites, as well as sites adjacent to currently occupied habitat.	Strengthen confidence in data used to determine if sites meet the criteria to identify critical habitat; monitor current sites for changes in habitat that may result in changes to critical habitat identification; surveying adjacent habitat ensures accuracy of area of occurrence, on which critical habitat is being partly defined.	2011-2014

[10] The MAPV estimation is based on modeling approaches described above. This table is preliminary as further studies are needed to quantify the amount and quality of habitat within the currently identified critical habitat area.

[11] Note that some locations may contain more than one population (e.g., some of the larger areas such as Long Point Bay). In such cases, the MAPV would be applied to each individual population.

Description of activity	Rationale	Approximate timeline
Conduct additional species surveys to fill in distribution gaps, and to aid in determining population connectivity.	Additional populations and corresponding critical habitat may be required to meet the population and distribution objectives.	2011-2014
Create a population-habitat supply model for each life stage.	Will aid in developing recovery targets and determining the amount of critical habitat required by each life stage to meet these targets.	2014-2016
Based on information gathered, review population and distribution goals. Determine amount and configuration of critical habitat required to achieve goal if adequate information exists. Validate model.	Once the information above is gathered, recovery targets should be reviewed to ensure that they are still achievable and logical. Determining the amount and configuration of critical habitat based on recovery targets will be required for the action plan.	2014-2016

Activities identified in this schedule of studies will be carried out through collaboration between DFO, relevant ecosystem recovery teams, and other relevant groups and land managers.

2.7.6 Examples of activities likely to result in the destruction of critical habitat

The critical habitat for the Eastern Sand Darter will be legally protected through the application of subsection 58(1) of SARA, which prohibits the destruction of any part of the critical habitat of aquatic species listed as Endangered or Threatened, and any part of the critical habitat of aquatic species listed as Extirpated if a recovery strategy has recommended their reintroduction into the wild in Canada.

Activities that ultimately increase siltation/turbidity levels and/or result in the decrease of water quality or cause direct habitat modification can negatively impact Eastern Sand Darter habitat. Without appropriate mitigation, direct destruction of habitat may result from work or activities such as those identified in Table 14.

The activities described in this table are neither exhaustive nor exclusive and have been guided by the threats described in Section 1.5 (Threats). The inclusion of an activity does not result in its automatic prohibition since it is destruction of critical habitat that is prohibited. Furthermore, the exclusion of an activity does not preclude, or fetter the department's ability to regulate it pursuant to SARA. Since habitat use is often temporal in nature, every activity is assessed on a case-by-case basis and site-specific mitigation is applied where it is reliable and available. In every case, where information is available, thresholds and limits are associated with attributes to better inform

management and regulatory decision-making. However, in many cases the knowledge of a species and its critical habitat may be lacking and in particular, information associated with a species' or habitats thresholds of tolerance to disturbance from human activities, is lacking and must be acquired.

Table 14. Human activities likely to result in the destruction of critical habitat for Eastern Sand Darter.
(The affect pathway for each activity is provided as well as the potential links to the biophysical functions, features, and attributes of critical habitat.)

Activity	Affect-pathway	Function affected	Feature affected	Attribute affected
Habitat modifications: Dredging Grading Excavation Placement of material or structures in water (e.g., groynes, piers, infilling, partial infills, jetties) Shoreline hardening	Changes in bathymetry and shoreline morphology caused by dredging and nearshore grading and excavation can remove (or cover) preferred substrates, change water depths, and change flow patterns, potentially affecting nutrient levels and water temperatures. Placing material or structures in water reduces habitat availability (e.g., the footprint of the infill or structure is lost). Placing of fill can cover preferred substrates. Changing shoreline morphology can result in altered flow patterns, change sediment depositional areas, reduce oxygenation of substrates, cause erosion, and alter turbidity levels. These changes can promote aquatic plant growth and cause changes to nutrient levels. Hardening of shorelines can reduce organic inputs into the water and alter water temperatures potentially affecting the availability of prey for this species.	Spawning Nursery Feeding Cover (fossorial behaviour)	Reaches of streams and rivers with sand substrates. Sandy shoals, bars and beaches in lakes. Shallow pools and bays.	• Moderate current or wave action (e.g., depositional areas) • Sand and/or gravel with minimal fines • Well-oxygenated substrates • Warm water temperatures • Shallow water (< 3 m)

Activity	Affect-pathway	Function affected	Feature affected	Attribute affected
Habitat modifications: Water extraction Change in timing, duration and frequency of flow	Water extraction can affect surface water levels and flow and groundwater inputs into streams and rivers, affecting habitat availability, the oxygenation of substrates, and prey abundance. Altered flow patterns can affect sediment deposition (e.g., changing preferred substrates), oxygenation of substrates, and prey abundance.	All (same as above)	Reaches of streams and rivers with sand substrates.	• Moderate current (e.g., depositional areas) • Sand and/or gravel with minimal fines • Well-oxygenated substrates • Warm water temperatures
Habitat modifications: Unfettered livestock access to waterbodies Grazing of livestock and ploughing to water's edge	Resulting damage to shorelines, banks, and watercourse bottoms from unfettered access by livestock can cause increased erosion and sedimentation, affecting substrate oxygenation and water temperatures. Such access can also increase organic nutrient inputs into the water, causing nutrient loading and potentially promoting algal blooms, and decreasing prey abundance.	All (same as above)	Reaches of streams and rivers with sand substrates.	• Sand and/or gravel with minimal fines • Well-oxygenated substrates • Warm water temperatures
Toxic compounds: Over application or misuse of herbicides and pesticides Release of urban and industrial pollution into habitat	Introduction of toxic compounds into habitat used by this species can change water chemistry affecting habitat availability or use and cause increased aquatic plant growth, affecting spawning and recruitment success.	Spawning Nursery Feeding	All (same as above)	• Well-oxygenated substrates • Warm water temperatures

Activity	Affect-pathway	Function affected	Feature affected	Attribute affected
Nutrient loadings: Over-application of fertilizer and improper nutrient management (e.g., organic debris management, wastewater management, animal waste, septic systems and municipal sewage)	Improper nutrient management can cause nutrient loading of nearby waterbodies. Elevated nutrient levels can cause increased aquatic plant growth, changing water temperatures, and slowly change preferred flows and substrates. Oxygen levels in substrates can also be negatively affected.	Spawning Nursery Feeding Cover (fossorial behaviour	All (same as above)	• Moderate current or wave action (e.g., depositional areas) • Sand and/or gravel with minimal fines • Well-oxygenated substrates • Warm water temperatures
Siltation and turbidity: Altered flow regimes causing erosion and changing sediment transport (e.g., tiling of agricultural drainage systems, removal of riparian zones) Work in or around water with improper sediment and erosion control (e.g., overland runoff from ploughed fields, use of industrial equipment, cleaning or maintenance of bridges or other structures)	Improper sediment and erosion control or mitigation can cause increased turbidity levels, changing preferred substrates and their oxygen levels, potentially reducing feeding success or prey availability, impacting the growth of aquatic vegetation, and possibly excluding fish from habitat due to physiological impacts of sediment in the water (e.g., gill irritation). Also see: Habitat modifications - change in timing, duration and frequency of flow.	All (same as above)	All (same as above)	• Sand and/or gravel with minimal fines • Well-oxygenated substrates • Warm water temperatures
Riparian vegetation removal: Mechanical removal	Removal of riparian vegetation can cause erosion and increase turbidity, ultimately affecting preferred substrates and oxygenation of substrates. Water temperatures can also be negatively affected by removal of riparian vegetation, and water velocities can be increased during high-water events.	All (same as above)	All (same as above)	• Moderate current or wave action (e.g., depositional areas) • Sand and/or gravel with minimal fines • Well-oxygenated substrates • Warm water temperatures

2.8 Activities permitted by the recovery strategy

As set out in subsection 83(4) of SARA, a person can engage in an otherwise prohibited activity if the activity is permitted by a recovery strategy and the person is authorized

under an Act of Parliament to engage in that activity. Section 83(4) can be used as an exemption to allow activities, which have been determined to not jeopardize the survival or recovery of the species.

Continuation of limited commercial baitfish harvesting
Commercial baitfish harvesting is regulated by the Province of Ontario through the Ontario Fishery Regulations of the *Fisheries Act*. Eastern Sand Darter is not a legal baitfish. As outlined in Section 1.5 (Threats) under incidental harvest, commercial baitfish harvesting activities are unlikely to affect Eastern Sand Darter populations and have been determined to be eligible for an exemption as per s83(4). The management of Eastern Sand Darter recovery could include limited fishing mortality as the threat to Eastern Sand Darter by baitfish harvest is low. Although exempt from SARA, provincial legislation still applies. Baitfish harvesters must also comply with conditions of their baitfish licence.

Under s. 83(4) of SARA, this recovery strategy allows bait harvesters to engage in the activities of commercial and sportfishing for baitfish that incidentally kill, harm, harass, capture or take Eastern Sand Darter, subject to the following two conditions:

1. The fishing activities are conducted under licenses issued under the *Ontario Fishery Regulations, 2007*.

2. All Eastern Sand Darter caught are to be released immediately and returned to the place from where taken in a manner that causes them the least harm.

2.9 Existing and recommended approaches to habitat protection

When the *Canadian Environmental Assessment Act, 2012* (CEAA 2012) applies and a species at risk has been identified as a valued ecosystem component within the scope of the review pursuant to that Act, the environmental assessment will take into account, any change that might be caused to aquatic species as defined in s.2(1) of SARA. Furthermore, under s.79 of SARA, during an environmental assessment of a project under CEAA (2012), the competent minister must be notified if the project will affect a listed wildlife species or its critical habitat. Once identified, SARA includes provisions to prevent the destruction of critical habitat of the Eastern Sand Darter.

Provincially, the Eastern Sand Darter is currently listed as Threatened under Ontario's *Endangered Species Act, 2007*. The species was reassessed and listed as Threatened in 2010 and the habitat of the Eastern Sand Darter is also protected. Protection is also afforded under the *Planning Act*. Planning authorities are required to be "consistent with" the provincial Policy Statement under Section 3 of Ontario's *Planning Act*, which prohibits development and site alteration in the habitat of Endangered and Threatened species. The *Conservation Authority Act* requires review of projects that could result in the development, interference with wetlands, and alterations to shorelines and watercourses. A majority of the land adjacent to the rivers inhabited by the Eastern

Sand Darter is privately owned; however, the river bottom is generally owned by the Crown. Under the *Public Lands Act*, a permit may be required for work in the water and along the shore.

The recovery team will continue to review priorities and direct efforts to improve and protect habitat through the recommended recovery approaches.

2.10 Effects on other species

Eastern Sand Darter habitat is shared by many other species, including multiple species at risk. These include not only aquatic species but also a number of amphibians, turtles, and birds. Specifically, 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. Some of the proposed recovery activities will benefit the environment in general and are expected to positively affect other sympatric native species. There could be consequences to those species whose requirements may differ from those of Eastern Sand Darter. Consequently, it is important that habitat management activities for the Eastern Sand Darter be considered from an ecosystem perspective through the development, with input from responsible jurisdictions, of multi-species plans, ecosystem-based recovery programs or area management plans that take into account the needs of multiple species, including other species at risk.

Many of the stewardship and habitat improvement activities to benefit the Eastern Sand Darter may be implemented through existing ecosystem-based recovery programs that have already taken into account the needs of other species at risk.

2.11 Recommended approach for recovery implementation

The recovery team recommends a dual approach to recovery implementation that combines an ecosystem-based approach with a single-species focus. This will be accomplished by working closely with existing ecosystem recovery teams to combine efficiencies and share knowledge on recovery initiatives. There are currently four aquatic ecosystem-based recovery strategies (Thames River, Sydenham River, Grand River, and Essex-Erie region) being implemented that address several populations of Eastern Sand Darter. Eastern Sand Darter populations that occur outside the boundaries of existing ecosystem-based recovery programs can use a single-species approach to recovery that will facilitate implementation of recovery actions within these watersheds through partnerships with local watershed management and stewardship agencies. If ecosystem-based recovery initiatives are developed in the future for these watersheds, the present single-species strategy will provide a strong foundation to build upon.

2.12 Statement on action plans

Action plans are documents that describe the activities designed to achieve the recovery goals and objectives identified in recovery strategies. Under SARA, an action plan provides the detailed recovery planning that supports the strategic direction set out in the recovery strategy for the species. The plan outlines what needs to be done to achieve the recovery goals and objectives identified in the recovery strategy, including the measures to be taken to address the threats and monitor the recovery of the species, as well as the measures to protect critical habitat. Action plans offer an opportunity to involve many interests in working together to find creative solutions to recovery challenges. As such, they may also include recommendations on individuals and groups that should be involved in carrying out the proposed activities.

One or more actions plans relating to this recovery strategy for Ontario populations will be produced within five years of the final recovery strategy being posted to the SARA registry. These may include multi-species or ecosystem-based action plans.

3 REFERENCES

ARRT (Ausable River Recovery Team). 2005. Recovery strategy for species at risk in the Ausable River: an ecosystem approach, 2005-2010. Draft 5 June 2005. xi + 128 pp.

Baker, K. 2005. Nine year study of the invasion of western Lake Erie by the Round Goby (*Neogobius melanostomus*): changes in goby and darter abundance. Ohio Journal of Science 105: A-31.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. (2nd edition). U.S. Environmental Protection Agency. Office of Water, Washington, D.C. EPA 841-B-99-002.

Bernatchez, L. and M. Giroux. 2000. Les poissons d'eau douce du Québec et leur répartition dans l'Est du Canada. Broquet, Boucherville, Québec.

Bouvier, L.D. and N.E. Mandrak. 2010. Information in support of a recovery potential assessment of Eastern Sand Darter (*Ammocrypta pellucida*) in Ontario. DFO Canadian Science Advisory Secretariat Research Document 2010/093. vi + 43 pp.

Clarke, A.H. 1981. The freshwater molluscs of Canada. National Museums of Canada, Ottawa, Canada. 446 pp.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2000. COSEWIC status report on the Eastern Sand Darter (*Ammocrypta pellucida*) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 17 pp. + an addendum.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2009. COSEWIC assessment and status report on the Eastern Sand Darter *Ammocrypta pellucida*, Ontario populations and Quebec populations, in Canada. vii + 49 pp.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2011. COSEWIC's assessment process and criteria, November 2011. (Accessed: August 7, 2012).

Daniels, R.A. 1989. Significance of burying in *Ammocrypta pellucida*. Copeia 1898: 29-34.

Daniels, R.A. 1993. Habitat of the Eastern Sand Darter, *Ammocrypta pellucida*. Journal of Freshwater Ecology 8(4): 287-295.

Dextrase, A.J., S.K. Staton, and J.L. Metcalfe-Smith. 2003. National recovery strategy for species at risk in the Sydenham River: an ecosystem approach. National Recovery

Plan No. 25. Recovery of Nationally Endangered Wildlife (RENEW). Ottawa, Ontario. 73 pp.

Drake, D.A.R., M. Power, M.A. Koops, S.E. Doka, and N.E. Mandrak. 2008. Environmental factors affecting growth of Eastern Sand Darter (*Ammocrypta pellucida*). Canadian Journal of Zoology 86: 714-722.

Edsall, T.A. and M.N. Charlton. 1997. Nearshore waters of the Great Lakes. State of the Great Lakes ecosystem conference 1996. Background Paper. 162 pp.

EERT (Essex-Erie Recovery Team). 2008. Recovery strategy for fish species at risk in the Essex-Erie region: an ecosystem approach. Prepared for the Department of Fisheries and Oceans. July 2008 – Draft.

Etnier, D.A. and W.C. Starnes. 1993. The fishes of Tennessee. University of Tennessee Press, Knoxville. 681 pp.

Facey, D.E. 1995. The status of the Eastern Sand Darter (*Ammocrypta pellucida*) in Vermont. Unpublished report to The Nature Conservancy.

Facey, D.E. 1998. The status of the Eastern Sand Darter, *Ammocrypta pellucida*, in Vermont. Canadian Field-Naturalist 112: 596-601.

Facey, D.E. and S.M. O'Brien. 2004. Influence of sediment size and substrate composition on habitat selection and distribution of eastern sand darters (*Ammocrypta pellucida)* in the Poultney River. Pages 291-298 *in* T. Manley, P. Manley, and T. Mihuc, editors. Lake Champlain: Partnerships and Research in the New Millennium. Kluwer Academic Press.

FAPAQ (Société de la faune et des parcs du Québec). 2002. Rapport sur les impacts de la production porcine sur la faune et ses habitats. Vice-présidence au développement et à l'aménagement de la faune, Québec.

Finch, M.R. 2009. Life history and population dynamics of Eastern Sand Darter (*Ammocrypta pellucida*) in the lower Thames River, Ontario. University of Waterloo, Waterloo, Ontario, Canada.

Finch, M., L.A. Vélez-Espino, S.E. Doka, M. Power, and M.A. Koops. 2011. Recovery potential modelling of Eastern Sand Darter (*Ammocrypta pellucida*) in Canada. DFO Canadian Science Advisory Secretariat Research Document 2011/020. vi + 34 pp.

French, J.R.P. and D.J. Jude. 2001. Diets and diet overlap of non-indigenous gobies and small native fishes co-habiting the St. Clair River, Michigan. Journal of Great Lakes Research 27: 300-311.

Gaudreau, N. 2005. Rapport sur la situation du dard de sable (*Ammocrypta pellucida*) au Québec. Ministère des Ressources naturelles et de la Faune. Direction du développement de la faune. 26 pp.

Gimenez Dixon, M. 1996. *Etheostoma pellucidum*. In: IUCN 2006. 2006 IUCN Red List of Threatened Species. Version 2010.2 (Accessed: 17 March 2010).

Grandmaison, D., J. Mayasich, and D. Etnier. 2004. Eastern Sand Darter status assessment. Prepared for: U.S. Fish and Wildlife Service, Region 3. Fort Snelling, MN 55111. NRRI Technical Report No. NRRI/TR-2003/40. 39 pp. + figures.

Holm, E. and N.E. Mandrak. 1996. The status of the Eastern Sand Darter, *Ammocrypta pellucida*, in Canada. Canadian Field-Naturalist 110(3): 462-469.

Illinois Department of Natural Resources. 2010. Endangered species protection board. Effective October 30, 2009 (Accessed: March 17, 2010).

Janssen, J. and D.J. Jude. 2001. Recruitment failure of mottled sculpin, *Cottus bairdii*, in Calumet Harbour, southern Lake Michigan, induced by the newly introduced round goby, *Neogobius melanostomus*. Journal of Great Lakes Research 27: 319-328.

Jelks, H.L., S.J. Walsh, N.M. Burkhead, S. Contreras-Balderas, E. Díaz-Pardo, D.A. Hendrickson, J. Lyons, N.E. Mandrak, F. McCormick, J.S. Nelson, S.P. Platania, B.A. Porter, C.B. Renaud, J.J. Schmitter-Soto, E.B. Taylor, and M.L. Warren Jr. 2008. Conservation status of imperiled North American freshwater and diadromous fishes. Fisheries 33(8): 372-407.

Johnston, C.E. 1989. Spawning in the Eastern Sand Darter, *Ammocrypta pellucida* (Pisces: Percidae), with comments on the phylogeny of *Ammocrypta* and related taxa. Transactions of the Illinois Academy of Sciences 82(3-4): 163-168.

Koonce, J.F., W.-D.N. Busch, and T. Czapla. 1996. Restoration of Lake Erie: contribution of water quality and natural resource management. Canadian Journal of Fisheries and Aquatic Sciences 53(Supplement 1): 105-112.

Kuehne, R.A. and R.W. Barbour. 1983. The American darters. The University Press of Kentucky. Lexington, Kentucky. 177 pp.

Michigan Department of Natural Resources. 2010. Effective April 9, 2009. (Accessed: March 17, 2010).

NatureServe. 2012. NatureServe explorer: an online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. (Accessed: July 20, 2012).

Near, T.J., J.C. Porterfield, and L.M. Page. 2000. Evolution of Cytochrome b and the molecular systematics of *Ammocrypta* (Percidae: Etheostomatinae). Copeia 2000(3): 701-711.

Nelson, M. 2006. Towards a recovery strategy for fishes at risk of the Essex-Erie region: synthesis of background Information. Prepared for the Essex-Erie Recovery Team. Draft 4 - September 2006.

New York Sate Department of Environmental Conservation. 2010. Eastern Sand Darter. (Accessed: March 17, 2010).

O'Brien, S.M. and D. Facey. 2008. Habitat use by the Eastern Sand Darter, *Ammocrypta pellucida*, in two Lake Champlain tributaries. Canadian Field Naturalist. 122: 239-246.

Ohio Department of Natural Resources. 2010. Ohio's species of concern. Updated January 2009 (Accessed: March 17, 2010).

OMNR (Ontario Ministry of Natural Resources). 2010a. Recreational Fishing License Information. (Accessed: March 17, 2010).

OMNR (Ontario Ministry of Natural Resources). 2010b. Species at risk - deciduous forest. (Accessed: August 7, 2012).

Page, L.M. 1983. Handbook of darters. TFH Publications, Neptune City, New Jersey. 271 pp.

Page, L.M. and B.M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin Company, Boston. 432 pp.

Page, L.M. and M.E. Retzer. 2002. The status of Illinois' rarest fishes and crustaceans. Transactions of the Illinois Academy of Sciences 95: 311-326.

Poly, W.J. 2003. Design and evaluation of a translocation strategy for the fringed darter (*Etheostoma crossopterum*) in Illinois. Biological Conservation 113: 13-22.

Poos. M.S., A.J. Dextrase, A.N. Schwalb, and J.D. Ackerman. 2010. Secondary invasion of the round goby into high diversity Great Lakes tributaries and species at risk hotspots: potential new concerns for endangered freshwater species. Biological Invasions 12: 1269-1284.

Poos, M.S., N.E. Mandrak, and R.L. McLaughlin. 2008. A practical framework for selecting among single-species, community-, and ecosystem-based recovery plans. Canadian Journal of Fisheries and Aquatic Sciences 65: 2656-2665.

Portt, C., G. Coker, and K. Barret. 2007. Recovery strategy for fish species at risk in the Grand River in Canada [Proposed]. *In Species at Risk Act* Recovery Strategy Series. Ottawa: Fisheries and Oceans Canada. 104 pp.

Reid, S.M. and N.E. Mandrak. 2008. Historical changes in the distribution of threatened Channel Darter (*Percina copelandi*) in Lake Erie with general observations on the beach fish assemblage. Journal of Great Lakes Research 34: 324-333.

Scott, W.B. 1955. Freshwater fishes of eastern Canada. University of Toronto Press. 91 pp.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Environment Canada. Fisheries and Marine Service. Ottawa, Ontario. Bulletin 184. 1026 pp.

Shute, J.R., P.L. Rakes, and P.W. Shute. 2005. Reintroduction of four imperiled fishes in Abrams Creek, Tennessee. Southeastern Naturalist 4: 93-110.

Simon, T.P. and R. Wallus. 2006. Reproductive biology and early life history of fishes in the Ohio River: Percidae – perch, pikeperch and darters, Volume 4. CRC Press, Boca Raton, Florida, USA.

Sloss, B.L., N. Billington, and B.M. Burr. 2004. A molecular phylogeny of the Percidae (Teleostei: Perciformes) based on mitochondrial DNA sequence. Molecular Phylogenetics and Evolution 32: 545-562.

Song, C.B., T.J. Near, and L.M. Page. 1998. Phylogenetic relationships among percid fishes as inferred from mitochondrial cytochrome b DNA sequence data. Molecular Phylogenetics and Evolution 10: 343-353.

Spreitzer, A.E. 1979. The life history, external morphology, and osteology of the Eastern Sand Darter, *Ammocrypta pellucida* (Putnam, 1863), an endangered Ohio species (Pisces: Percidae). Unpublished M.S. Thesis, Ohio State University. Columbus, Ohio.

Stanfield, L. and R. Kuyvenhoven. 2005. Protocol for applications used in the Aquatic Landscape Inventory software application for delineating, characterizing and classifying valley segments within the Great Lakes basin. Ontario Ministry of Natural Resources Report, July 27, 2005.

State of Pennsylvania. 2005. Pennsylvania Code. Chapter 75. Endangered Species. Updated July 10, 2009. (Accessed: March 17, 2010).

Staton, S.K., A. Dextrase, J.L. Metcalfe-Smith, J. Di Maio, M. Nelson, J. Parish, B. Kilgour, and E. Holm. 2003. Status and trends of Ontario's Sydenham River ecosystem in relation to aquatic species at risk. Environmental Monitoring and Assessment 88: 283-310.

Taylor, I., B. Cudmore, C. MacCrimmon, S. Madzia, and S. Hohn. 2004. The Thames River watershed: synthesis report (draft). Prepared for the Thames River Recovery Team. 74 pp.

Thomas, M.V. and R.C. Haas. 2004. Status of the Lake St. Clair fish community and sport fishery 1996-2001. Michigan Department of Natural Resources. Fisheries Research Report 2067.

Trautman, M.B. 1981. The fishes of Ohio with illustrated keys. Revised Edition. Ohio State University Press. 782 pp.

TRRT (Thames River Recovery Team). 2004. Recovery strategy for the Thames River aquatic ecosystem: 2005-2010. December 2004-draft. 145 pp.

van Meter, H.D. and M.B. Trautman. 1970. An annotated list of the fishes of Lake Erie and its tributary waters exclusive of the Detroit River. Ohio Journal of Science 70: 65-78.

Vermont Fish and Wildlife Department. 2010. Effective February 3, 2008. (Accessed: March 17, 2010).

Welsh, S.A. and S.A. Perry. 1997. Influence of spatial scale on estimates of substrate use by benthic darters. North American Journal of Fisheries Management 18(4): 954-959.

Williams, J.D. 1975. Systematics of the percid fishes of the subgenus *Ammocrypta*, genus *Ammocrypta*, with descriptions of two new species. Bulletin of the Alabama Museum of Natural History 1: 1-56.

LIST OF PERSONAL COMMUNICATIONS

Dextrase, Alan. 2010. Ontario Ministry of Natural Resources.

Drake, Andrew. 2010. University of Toronto.

Fisher, B. 2005. Non-game Aquatic Biologist, Indiana Department of Natural Resources. Electronic mail to K. Vlasman, Subject: Eastern Sand Darter.

Mandrak, Nicholas. 2010. Fisheries and Oceans Canada.

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