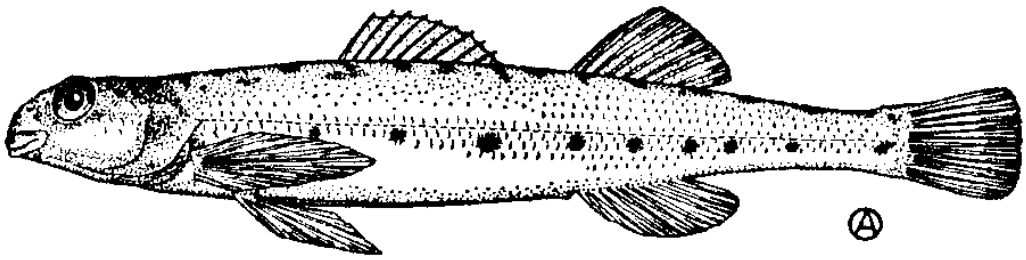
COSEWIC
Assessment and Status Report

on the

Eastern Sand Darter
Ammocrypta pellucida

Ontario populations
Quebec populations

in Canada



THREATENED
2009

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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Previous report(s):

COSEWIC. 2000. COSEWIC assessment and update status report on the Eastern Sand Darter *Ammocrypta pellucida* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. v + 20 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Holm, E. and N.E. Mandrak. 1994. COSEWIC status report on the Eastern Sand Darter *Ammocrypta pellucida* in Canada. Committee on the Status of Endangered Wildlife in Canada. 17 pp.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le dard de sable (*Ammocrypta pellucida*), populations de l'Ontario et populations du Québec, au Canada.

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Eastern Sand Darter — Drawing by Anker Odum reproduced from Scott and Crossman (1973) with permission of W.B. Scott.

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COSEWIC
Assessment Summary

Assessment Summary – November 2009

Common name
Eastern Sand Darter - Ontario populations

Scientific name
Ammocrypta pellucida

Status
Threatened

Reason for designation
This species prefers sand bottom areas of lakes and streams in which it burrows. There is continuing decline in the already small and fragmented populations; 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.

Occurrence
Ontario

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.

Assessment Summary – November 2009

Common name
Eastern Sand Darter - Quebec populations

Scientific name
Ammocrypta pellucida

Status
Threatened

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

Occurrence
Quebec

Status history
The species was considered a single unit and designated Threatened in April 1994 and November 2000. When the species was split into separate units in November 2009, the "Quebec populations" unit was designated Threatened.

COSEWIC
Executive Summary

Eastern Sand Darter
Ammocrypta pellucida

Ontario populations
Quebec populations

Species information

The Eastern Sand Darter is one of six members of the genus *Ammocrypta* and the only one found in Canada. It reaches a maximum total length of 81 mm. The Eastern Sand Darter can easily be distinguished from other Canadian darters by its translucent colouration and slender, elongate body form.

Distribution

The Eastern Sand Darter occurs in the Ohio River basin (Ohio, Indiana, Illinois, Kentucky, West Virginia, Pennsylvania), a portion of the lower Great Lakes drainage (Lake Huron, Lake St. Clair and Lake Erie drainages in Michigan, Ohio, New York, Pennsylvania, and Ontario), and farther east in the St. Lawrence River and Lac Champlain drainages (Québec, Vermont, New York). In Ontario, populations have been found in seven southwestern Ontario watersheds as well as lakes Erie and St. Clair. In Québec, populations are known from the St. Lawrence River and several of its tributaries. Populations have been lost from several watersheds in Canada. Two designatable units (Ontario and Québec populations) are considered based on the large range disjunction (~500 km) between populations in Ontario and Québec.

Habitat

The preferred habitat of the Eastern Sand Darter is sand-bottomed areas in streams and rivers, and sandy shoals in lakes. Spawning has not been observed in nature but, in the laboratory, Eastern Sand Darter spawned on a mixed sand and gravel substrate. Eastern Sand Darter habitats in Canada have been extensively impacted by land clearing, intensive agriculture, urban development, impoundments and stream channel modifications.

Biology

The Eastern Sand Darter is relatively short-lived, reaching a maximum age of 4 years. Fish of both sexes mature in the spring following their first growing season at age 1, but some females may not spawn until their second year. Eastern Sand Darter spawn in late spring and summer at water temperatures between 14.4 and 25.5 ^{o}C. Spawning is intermittent and females may lay eggs several times during the protracted spawning season. The slightly adhesive eggs are likely laid in sand and gravel substrates. Hatching occurs in 4 to 5 days at 20.5 to 23 ^{o}C and larvae become benthic soon after emerging. Fossorial (burying) behaviour is well-developed in the species. Eastern Sand Darter are benthic insectivores that feed primarily on the larvae of midges (Chironomidae). Movements of the species are unknown, but it is expected to have limited dispersal abilities.

Population sizes and trends

In Ontario, Eastern Sand Darter populations have probably been extirpated from three of seven river systems. Available information suggests populations have declined in lakes Erie and St. Clair, and in Big Creek. The Thames River probably supports the largest population of this species in Canada. In Québec, trends in Eastern Sand Darter populations are largely unknown due to a lack of recent sampling in several river systems. It is likely that the species has been extirpated from three drainages. The Eastern Sand Darter has recently been collected from four historically occupied watersheds. Four new sites have been discovered since the status of this species was last assessed. Three of these sites are from drainages with previous records. There is no recent information available to assess trends for five historically occupied watersheds.

Limiting factors and threats

There are several significant threats to Eastern Sand Darter populations in Canada. Siltation from a variety of sources appears to be the leading cause of habitat loss. Additional threats include pollution associated with intensive agriculture and urban development, impoundments, channel alterations, and potentially predation and competition from the introduced Round Goby.

Special significance of the species

The Eastern Sand Darter is one of the few Canadian freshwater fishes that primarily exploits sandy habitats and related resources. Its fossorial behaviour is unusual for an adult freshwater fish in Canada. In addition to contributing to the biodiversity of aquatic ecosystems, this species is an indicator of ecosystem health in an area of Canada that has dense human populations and intensive agricultural and urban development.

Existing protection or other status designations

The Eastern Sand Darter is listed as Threatened under Schedule 1 of the federal *Species at Risk Act*, and under Ontario's *Endangered Species Act, 2007*. It was listed as threatened under Québec's *Act Respecting Threatened or Vulnerable Species* in October 2009. These listings prohibit harvest or capture without specific authorization, but do not yet provide habitat protection. The species is ranked as globally Vulnerable (G3) by NatureServe and the IUCN, and is listed as a species at risk in 9 of 11 North American jurisdictions in which it occurs.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2009)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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Eastern Sand Darter

Ammocrypta pellucida

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SPECIES INFORMATION

Name and classification

Class:	Actinopterygii
Order:	Perciformes
Family:	Percidae
Genus:	*Ammocrypta*
Species*:	*Ammocrypta pellucida* (Agassiz, 1863)
Common Name:	English* Eastern Sand Darter
	French* Dard de sable

* from Nelson *et al.* (2004)

Ammocrypta is one of four recognized genera of darters (Family Percidae: Tribe Etheostomatini). There has been considerable debate in recent years regarding the generic placement of the sand darters, which have long been recognized in the genus *Ammocrypta*. Simons (1991; 1992) proposed that *Ammocrypta* be downgraded to the subgenus level and that six species within the subgenus, including *A. pellucida*, be placed in the genus *Etheostoma*. His study indicated that the genus *Ammocrypta* is not monophyletic and, when reduced to a monophyletic group (by removing the Crystal Darter, now recognized in its own genus as *Crystallaria asprella*), *Ammocrypta* exhibits a similar amount of character variation as the *Etheostoma* subgenera *Boleosoma* and *Ioa* (Simons 1991; 1992). Shaw *et al.* (1999) and Wood and Raley (2000) supported the placement of *Ammocrypta* as a subgenus of *Etheostoma*. However, Near *et al.* (2000) suggested that *Ammocrypta* should stand as a genus and this position was supported by Nelson *et al.* (2004) in the latest American Fisheries Society publication on common and scientific names of North American fishes.

No subspecies of the Eastern Sand Darter are currently recognized (Williams 1975).

Morphological description

Species in the genus *Ammocrypta* are generally distinguished from other darters by translucent and slender, elongate bodies, which are usually incompletely scaled. The Eastern Sand Darter (Figures 1, 2 and 7) differs from the other five species of the genus in the following characteristics. It is pale white, yellowish or silvery coloured with a series of 10-14 lateral dark spots usually located entirely below the lateral line scale row. These spots are slightly smaller than the pupil, and are frequently rounded anteriorly and oblong posteriorly. The median fins are not pigmented. The Eastern Sand Darter is one of the most elongate species of *Ammocrypta*, with body depth entering into standard length usually 8-9 times. There are usually 10-12 transverse scale rows on each side, 4-7 of these below the lateral line, and 9-11 (usually 10) preopercular-mandibular canal pores (this canal is part of the lateral line system on the head). The pelvic rays of adult males are darkly pigmented and have small tubercles. Average adult size ranges from 46-71 mm total length (TL), and the maximum recorded size is 81 mm

TL (from Scott and Crossman 1973; Williams 1975; Trautman 1981). Simon *et al.* (1992) described larval characteristics of five sand darter species, including the Eastern Sand Darter. Williams (1975) examined morphological variation across the range of this species and found that, although the species is highly variable, there were no clinal or geographic trends.

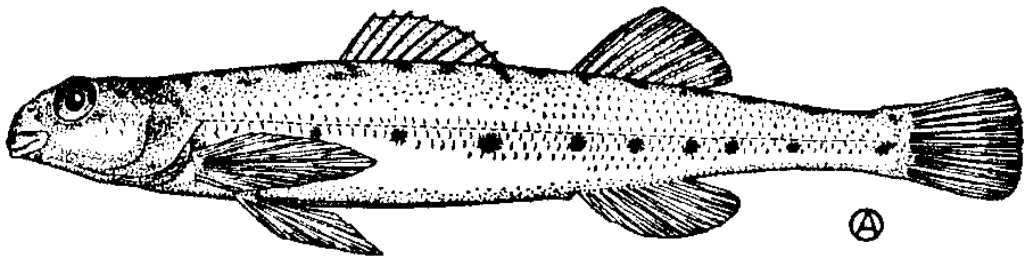

Figure 1. Eastern Sand Darter, *Ammocrypta pellucida* (drawing by Anker Odum reproduced from Scott and Crossman (1973) with permission of W. B. Scott).

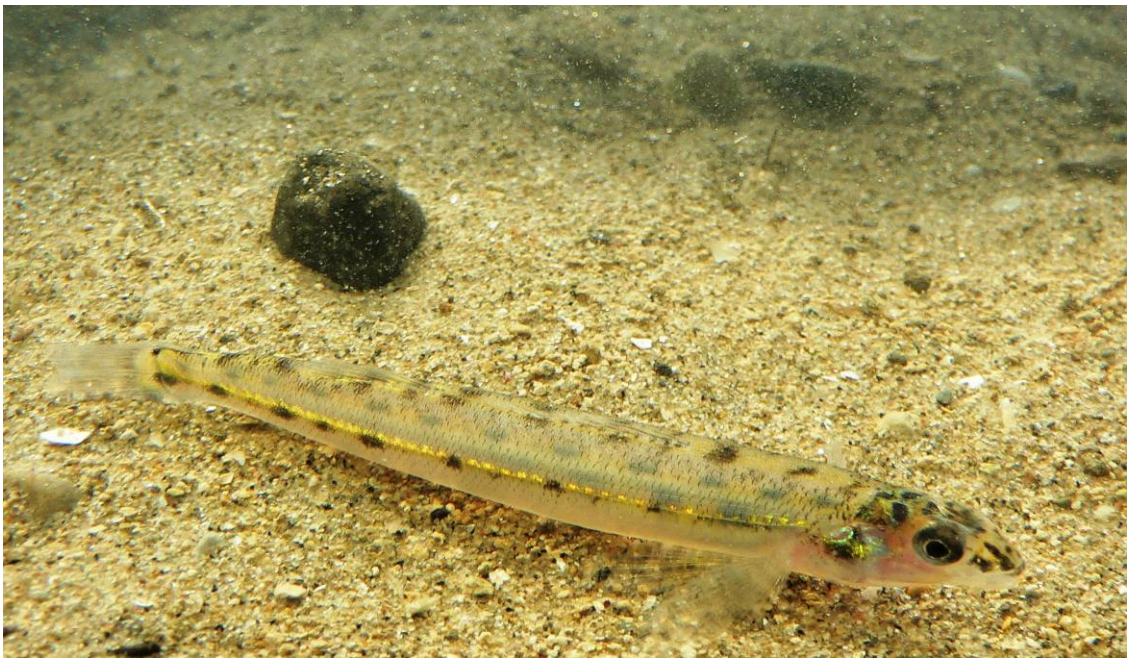

Figure 2. Eastern Sand Darter, *Ammocrypta pellucida*, from the Grand River, Ontario, July 2007 (photo: Alan Dextrase, Ontario Ministry of Natural Resources, Peterborough, Ontario).

The Eastern Sand Darter is the only species of *Ammocrypta* found in Canada and it can easily be distinguished from other Canadian darters by its translucent colouration, its slender, elongate body form, and the large separation between its spiny and soft dorsal fins. Young-of-the-year Eastern Sand Darter are similarly distinctive and are unlikely to be confused with other Canadian darters.

Genetic description

The Eastern Sand Darter has been included in molecular analyses (allozymes and mitochondrial DNA) as part of larger studies examining the phylogeny of *Ammocrypta* and other darters (Wood and Mayden 1997; Shaw *et al.* 1999; Near *et al.* 2000; Wood and Raley 2000), but geographic genetic variation within Eastern Sand Darter has not been specifically examined. Studies on the conservation genetics of Canadian Eastern Sand Darter populations are being initiated at the University of Windsor (D. Heath, University of Windsor, pers. comm.).

Designatable units

All Canadian populations are found within the Great Lakes-Upper St. Lawrence Freshwater Ecological Area. There are no known phenotypic or genotypic distinctions between the populations within this area, and both parts of the Canadian range may have been from a Mississippian glacial refugium (Williams 1975; Mandrak 1990). However, the Ontario populations are separated from those in Québec by a range disjunction of over 500 km. The hiatus in the range of the species may be due to the lack of suitable habitat or historical, but undocumented, population losses in the intervening area. However, the latter is unlikely as it has never been reported from the north shore of Lake Ontario, or in the St. Lawrence River above Lake of Two Mountains (Scott and Crossman 1998). Its presence in the Lake Champlain drainage suggests the two parts of the Canadian range may have had separate colonization histories, via a second colonization route from Lake Champlain. Other species, such as the Channel Darter (*Percina copelandi*) show a similar distribution (Lee *et al.* 1980; Scott and Crossman 1998).

The large range disjunction of more than 500 km in Canada with no possibility of exchange between them justifies the recognition of two designatable units (COSEWIC 2009: Appendix F5). Therefore, information in this report and technical summaries are presented to allow assessment of the Ontario and Québec populations as separate designatable units.

DISTRIBUTION

Global range

The Eastern Sand Darter has been found in the Ohio River basin in Ohio, Indiana, Illinois, Kentucky, West Virginia, and Pennsylvania (Figure 3). It has been recorded from the Lake Huron, Lake St. Clair and Lake Erie drainages in Michigan, Ohio, New York, Pennsylvania and Ontario. It has not been recorded in the Lake Ontario drainage, but occurs farther east in the St. Lawrence River and Lac Champlain drainages of Québec, Vermont and New York (Figure 3). Recent reductions in distribution have been documented in Kentucky (Kuehne and Barbour 1983), Illinois (Smith 1971), Ohio (Trautman 1981), Michigan (Smith *et al.* 1981; Derosier 2004), and Pennsylvania (Cooper 1983). Since 1970, the Eastern Sand Darter has been recorded at new localities in New York (Smith 1985; Daniels *et al.* 2006), Ontario, and Québec (Holm and Mandrak 1996).

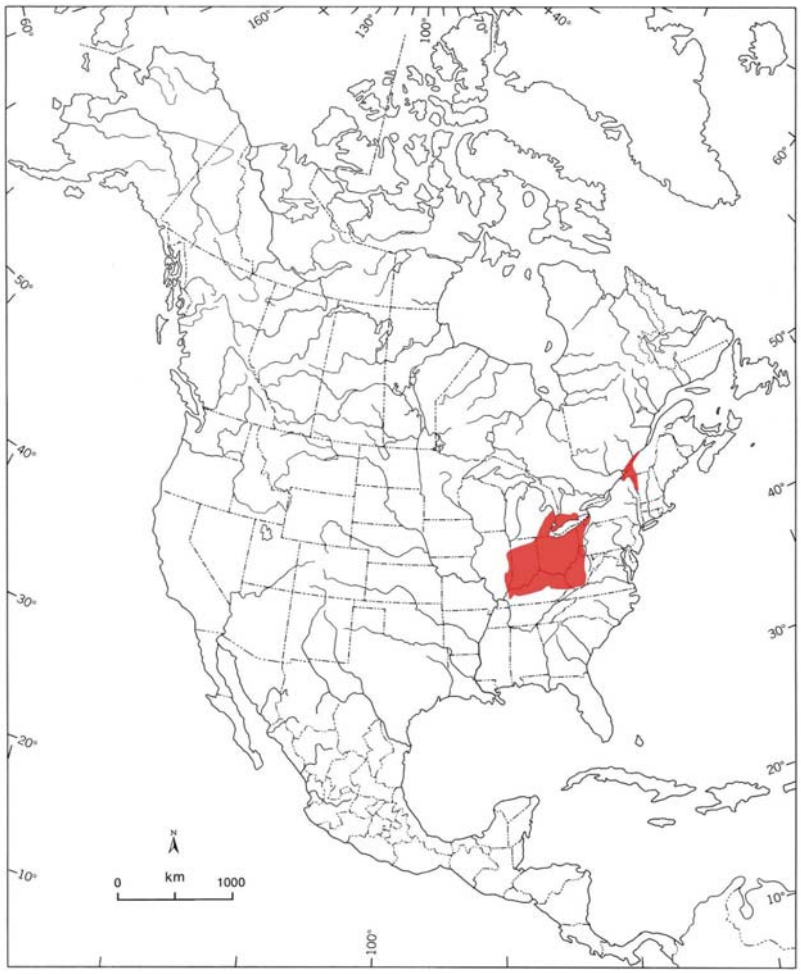

Figure 3. Global range of the Eastern Sand Darter, *Ammocrypta pellucida* (modified from Page and Burr 1991).

Canadian range

In Ontario, the Eastern Sand Darter occurs in the southwestern part of the province in lakes Erie and St. Clair, and in several of their tributary streams (Figure 4). In Lake Erie, recent collections have occurred at Rondeau Bay and Long Point Bay, but it has not been observed at Pelee Island since originally being collected there in 1953. The Eastern Sand Darter has not been observed in two streams tributary to Lake Erie in more than 50 years (Catfish Creek and Big Otter Creek [Elgin County]) and is presumed extirpated from these locations. In Big Creek (Norfolk County), the continued presence of Eastern Sand Darter was confirmed in 2008, despite its not being collected in this watershed since 1955. The Eastern Sand Darter is patchily distributed along an 80 km stretch of the lower Grand River, where its presence was first detected in 1987. In the Lake St. Clair watershed, the species is present along the south shore of Lake St. Clair, throughout a 145 km stretch of the lower Thames River and a 30 km stretch of the lower East Sydenham River. The Eastern Sand Darter was known historically from the Ausable River in the Lake Huron drainage, but has not been observed since 1928 and is presumed extirpated from this watershed.

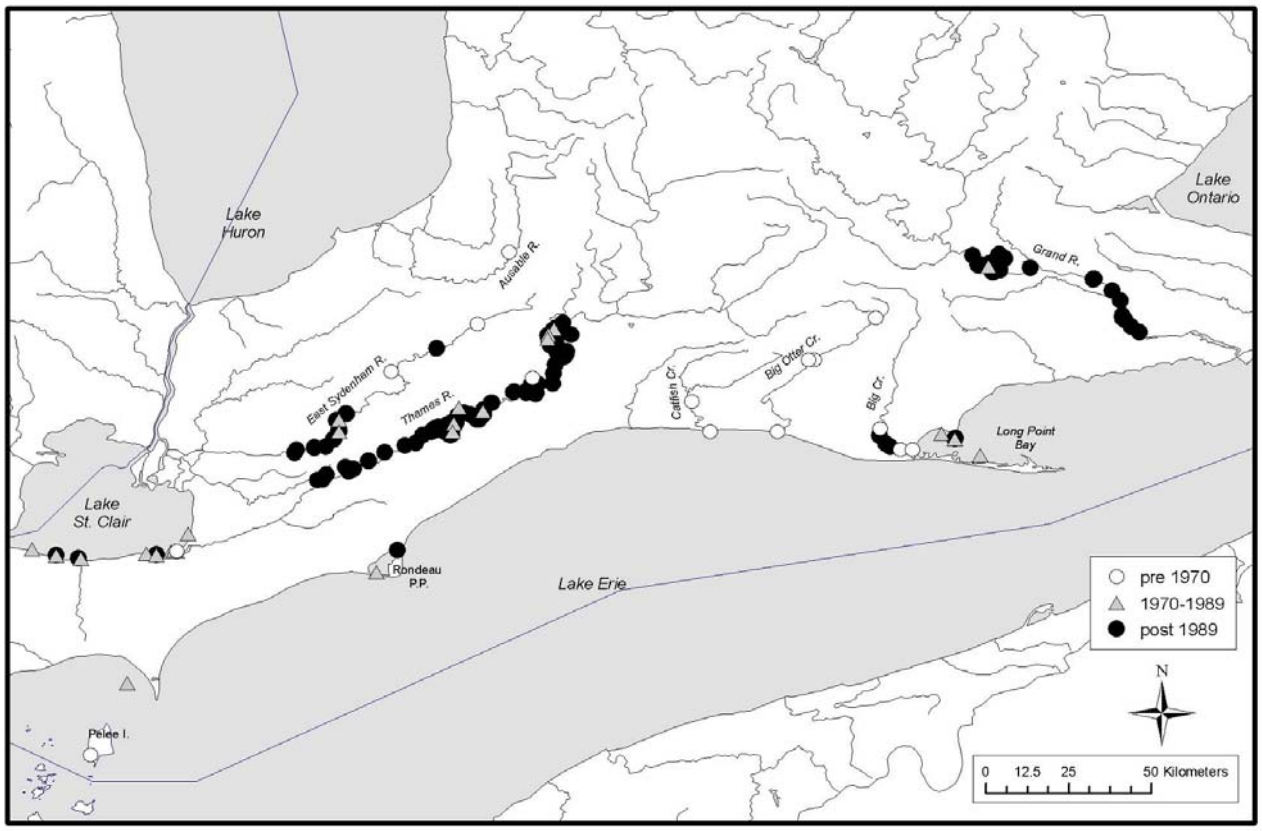

Figure 4. Ontario range of the Eastern Sand Darter, *Ammocrypta pellucida*.

In Québec, the Eastern Sand Darter occurs in the St. Lawrence River and in several of its larger tributary streams from Lac des Deux Montagnes near Montréal downstream to Leclercville (Figure 5). In the St. Lawrence River, the Eastern Sand Darter has been recently confirmed extant on the north shore near Saint-Sulpice, in Rivière des Mille Îles (connecting channel between Lac des Deux Montagnes and the St. Lawrence River), as well as in Lac Saint-Pierre and its archipelago, but has not been recently collected from Lac des Deux Montagnes where it was present in the 1940s. Recent captures of Eastern Sand Darter have occurred in four St. Lawrence drainages: Rivière L'Assomption and its tributary Rivière Ouareau (new location), Rivière Richelieu and Missisquoi Bay of Lac Champlain (headwater lake of the Rivière Richelieu, new location), Rivière à la Truite of the Châteauguay drainage, and Rivière aux Saumons (new location). There have been no recent observations of the Eastern Sand Darter in the Rivière Châteauguay, Rivière Yamaska, and Rivière Saint-François despite recent sampling. There are no recent records from the Rivière Yamachiche, Rivière Gentilly, Rivière Bécancour, Rivière aux Orignaux, and Petite Rivière du Chêne. However, sampling effort has not been sufficient to determine if the species is still present in these systems.

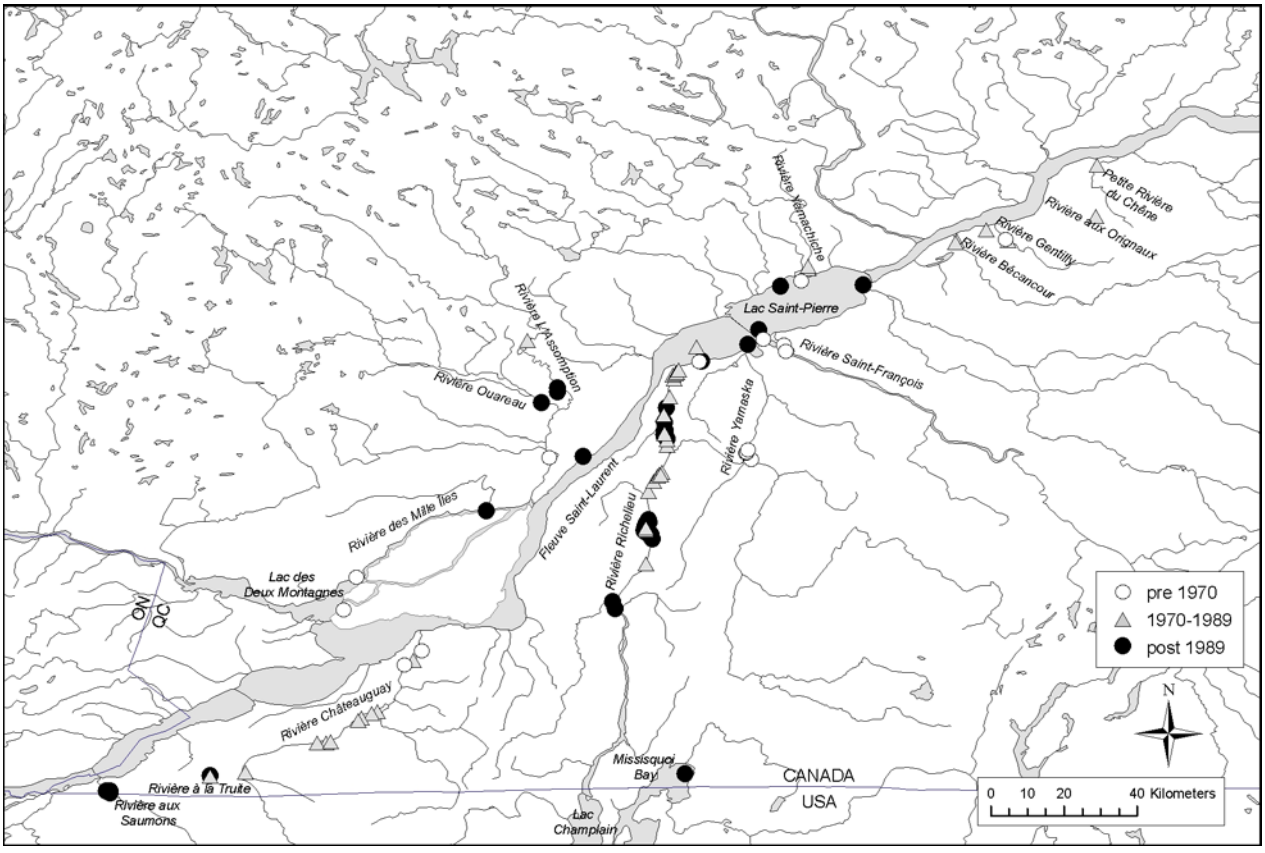

Figure 5. Québec range of the Eastern Sand Darter, *Ammocrypta pellucida*.

The current extent of occurrence of the Eastern Sand Darter in Canada is approximately 20,764 km^2 (Ontario – 10,840 km^2, Québec – 9,924 km^2; estimated from Figures 4 and 5, respectively, excluding intervening area). The historical extent of occurrence was 33,832 km^2 (Ontario – 19,534 km^2, Québec – 14,298 km^2; estimated from Figures 4 and 5, respectively, excluding intervening area). This represents a 39% decline in the Canadian extent of occurrence (45% decline in Ontario, 32% decline in Québec). The current area of occupancy is estimated at 797 km^2 based on a 1 km^2 grid (Ontario – 304 km^2, Québec – 493 km^2; estimated from Figures 4 and 5, respectively) and 1,240 km^2 based on a 2 km^2 grid (Ontario – 556 km^2, Québec – 684 km^2; estimated from Figures 4 and 5, respectively). Because the species generally occupies narrow (30-100 m wide), riverine habitats, use of the 1 km^2 grid is probably most appropriate for assessment purposes. Current biological area of occupancy is estimated at 366 km^2 (Ontario – 21 km^2, Québec – 345 km^2; based on stream widths and occupied river length, as well as occupied lacustrine areas). Calculations of extent of occurrence and area of occupancy included five streams in the eastern part of the Québec range where there has not been recent sampling, but where the species was present in the 1980s. The Eastern Sand Darter is known to be extant at 17 locations in Canada (seven in Ontario and 10 in Québec). Given the lack of recent sampling in portions of the Québec range, it is quite possible that the species may still be extant in the five streams without recent sampling data. Individual streams and tributaries that would not be affected by a common and fast acting threat (e.g., siltation or pollution events) are considered to be separate locations as are areas of occurrence within lacustrine habitats.

HABITAT

Habitat requirements

The preferred habitat of the Eastern Sand Darter is sand-bottomed areas in streams and rivers, and sandy shoals in lakes (Scott and Crossman 1973). They are most abundant in sandy portions of medium to large size streams with moderate current that maintain a silt-free condition without washing away sand (Trautman 1981). Eastern Sand Darter are typically found on sand substrates in the depositional areas downstream of bends in the river (Daniels 1993; Facey 1998). Although the Eastern Sand Darter has been collected over bottoms of mud, silt, rubble and gravel (Vladykov 1942; Holm and Mandrak 1996) its preference for sand habitats has been demonstrated both in the field and in the laboratory (Daniels 1993; Facey and O'Brien 2004). According to Daniels (1993), few temperate stream fishes are as strongly associated with a particular habitat variable as is the Eastern Sand Darter. Based on sampling of 131 sites in randomly selected reaches of the Thames River in 2006, the Eastern Sand Darter was most likely to be found at sites dominated by sand (0.06-2.0 mm) or fine gravel (2.0–8.0 mm), and was absent from sites dominated by silt (<0.06 mm) or cobble (>64.0 mm) (Figure 6, A. Dextrase, unpublished data). Poos *et al*. (2008) found that at the reach level, occurrence of the Eastern Sand Darter in the Sydenham River, Ontario was positively correlated with clean coarse substrates and negatively correlated with silt, but there was no association with percent sand.

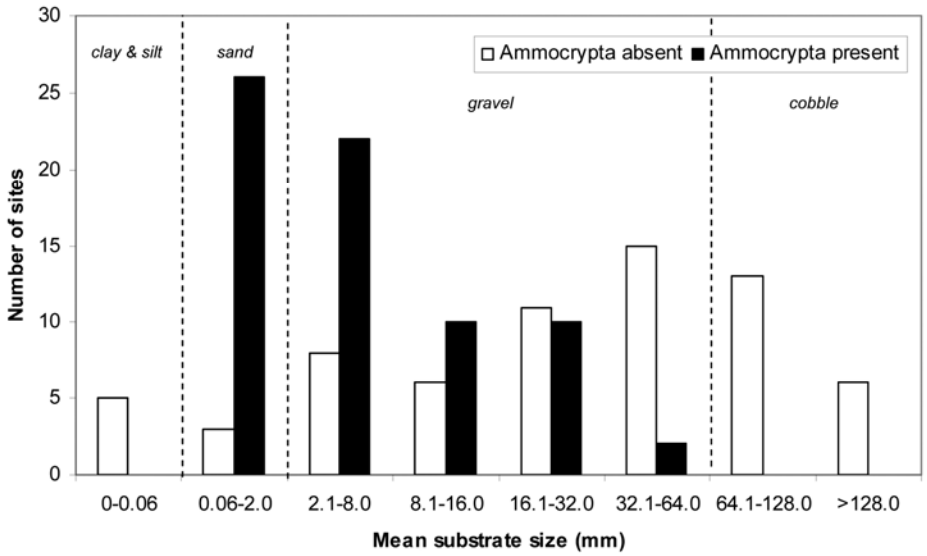

Figure 6. Occupancy of Eastern Sand Darter (*Ammocrypta pellucida*) and mean substrate size at 10 x 10 m sites in randomly selected reaches in the Thames River (*n* = 131, A. Dextrase, unpublished data).

The Eastern Sand Darter has been found in waters that are clear, tea-coloured and highly turbid (Secchi depth ≥7 cm), but a negative association with high turbidity has been demonstrated (Poos *et al*. 2008). Daniels (1993) found that most Eastern Sand Darter in the Mettawee River, New York, were captured at water velocities of less than 20 cm/s^{-1}. Poos *et al.* (2008) found a positive association between presence of the Eastern Sand Darter and flow in the Sydenham River, Ontario. In the Grand and Thames rivers, Ontario, flow does not seem to be important in determining occupancy, but moderate flow or wave action can assist in maintaining silt-free sand and gravel bars that the species prefers (A. Dextrase, unpublished data). Sites dominated by aquatic macrophytes are unlikely to be occupied (Facey 1998; A. Dextrase, unpublished data). The habitat at most recent capture sites in Québec has been dominated by sand, with little flow, limited or no aquatic macrophytes and shallow depths (<1.5 m), but the substrate at the 2001 St. Lawrence River site near Saint-Sulpice was dominated by clay (Gaudreau 2005). Although most authors report Eastern Sand Darter as occupying shallow habitats < 1.5 m, this may be an artefact of sampling in wadeable habitats. An Eastern Sand Darter was captured by trawling in Lake Erie in 14.6 m of water (Scott and Crossman 1973), and individuals have been caught in trawls in the Grand and Thames rivers at depths of 2 to 3 m (A. Dextrase, unpublished data).

Spawning of Eastern Sand Darter has not been observed in the wild but, in the laboratory, eggs were buried in a mixed sand and gravel substrate (Johnston 1989). In the Tippecanoe River, Indiana, post yolk-sac larvae were collected from near-shore margins in slow water downstream of riffle habitats (Simon and Wallus 2006). Recently transformed juveniles (total length 18-23 mm) have been caught in the same habitats as adults in the Thames River (A. Dextrase, unpublished data). Simon and Wallus (2006) reported that early juveniles are more tolerant of silt margins than adults, occurring in areas adjacent to coarse sand and gravel riffles. However, distribution in these habitats may be related to current and predator avoidance as opposed to silt tolerance. Drake *et al.* (2008) found that first year growth in the Thames River was lower for fish found in silt habitats than for those in sand-dominated habitats. In the Saint-Marc-sur-Richelieu sector of the Rivière Richelieu, Québec, the Eastern Sand Darter is most often observed during the fall period in areas with a sandy bottom exposed to a slow current, with sparse vegetation cover dominated by Wild Celery (*Vallisneria americana*) and Grassleaf Mud-plantain (*Heteranthera dubia*) (N. Vachon, MRNF, Longueuil, QC, pers. comm.).

There is little information available on seasonal changes in habitat use. Faber (2006) collected Eastern Sand Darter in wadeable habitats of a 1.2 km stretch of the Little Muskingum River, Ohio, throughout the year (with lower catches in winter). Eastern Sand Darter were found in similar habitats throughout the summer season (May to September) in the Grand and Thames rivers, Ontario (A. Dextrase, unpublished data). In the Richelieu River, in May and June 2007, more than 235 Eastern Sand Darter were collected with 82 seine hauls during a particularly high spring flood period, while, in the same sector, none were caught in 40 seine hauls in September (N. Vachon, MRNF, Longueuil, QC, unpublished data,).

Habitat trends

In Ontario rivers, increased siltation associated with intensive agriculture is thought to have negatively impacted the clean sand habitats preferred by Eastern Sand Darter (Holm and Mandrak 1996). Excessive nutrient enrichment and turbidity have been identified as issues for most of these watersheds (Staton *et al.* 2003; Portt *et al.* 2004; TRRT 2004; Edwards *et al*. 2007). Most of the occupied watersheds have impoundments and are subject to extensive agricultural drainage (open and tile drains). The hydrology of the Ausable River has been particularly affected by channel realignments (Nelson *et al.* 2003). Dams within the occupied range of Eastern Sand Darter on the Grand River have rendered upstream habitat unsuitable for several km and likely interfere with sediment transport (A. Dextrase, unpublished data; Portt *et al.* 2004). In addition to agricultural influences, there are large and growing urban centres upstream of the occupied ranges on the Grand and Thames rivers. Although efforts to improve water quality in the Grand River have met with success (Plummer *et al.* 2005) stresses on the watershed are expected to increase due to the growing human population (Edwards *et al.* 2007). Stewardship and other recovery actions to improve watershed health are ongoing in the Ausable, Sydenham, Thames and Grand River watersheds as part of watershed-based ecosystem recovery strategies for these systems.

Near-shore habitats in lakes Erie and St. Clair have changed considerably over the last half a century. Eutrophication of Lake Erie resulted in extensive oxygen depletion and changes to the benthic community over the period 1955 to 1980 (Koonce *et al*. 1996). Water quality has now improved, but shoreline habitat has been extensively modified by erosion control structures that have altered near-shore sediment transport. Habitat in Lake St. Clair changed dramatically after the invasion of Zebra Mussel (*Dreissena polymorpha*) in the late 1980s when water clarity and the abundance of aquatic macrophytes increased significantly (Griffiths 1993). This may have been detrimental to habitat for Eastern Sand Darter in the lake.

In Québec, the Eastern Sand Darter inhabits rivers in areas that have been subject to intensive urban and agricultural development. Similar to Ontario rivers, these watersheds are subject to siltation, high turbidity and excessive nutrient inputs (Edwards *et al*. 2007; Équipe de Rétablissement des Cyprinidés et des Petits Percidés du Québec 2008). The species occurs or used to occur in four of Québec's most polluted rivers (L'Assomption, Richelieu, Saint-François, and Yamaska rivers) that have high turbidity and high concentrations of nutrients, pesticides, suspended solids, and organic matter (Edwards *et al*. 2007). Commercial shipping and dredging activities have contributed to erosion and siltation in Lac Saint-Pierre. Eastern Sand Darter habitat is negatively impacted by dams and artificial irregularities of water flow in Rivière Ouareau, while dams contribute to increase sedimentation in Rivière Yamaska (Gaudreau 2005).

Habitat protection/ownership

The habitat of the Eastern Sand Darter is subject to the general habitat protection provisions of the federal *Fisheries Act*. Although the Eastern Sand Darter is listed as Threatened under Schedule 1 of the federal *Species at Risk Act*, critical habitat for the species has yet to be identified and, therefore, is not protected under this Act. In Ontario, the species is listed as Threatened under the *Endangered Species Act, 2007*, but its habitat will not be protected until 2013 unless a specific habitat regulation is made at an earlier date. In Québec, the Eastern Sand Darter was listed as threatened in October 2009 under the *Act Respecting Threatened or Vulnerable Species*, but does not receive specific habitat protection under this Act. A provincial recovery plan recently published by the Québec government includes an action plan that identifies four measures for the protection of Eastern Sand Darter habitat (Équipe de Rétablissement des Cyprinidés et des Petits Percidés du Québec 2008).

In Ontario, adjacent lands receive policy level protection through the fish habitat provisions of the Provincial Policy Statement (PPS) under the provincial *Planning Act*. The PPS prohibits development or site alteration on adjacent lands (within 30 m of fish habitat) unless it can be shown through an Environmental Impact Study that the fish habitat in question will not be negatively impacted. Municipal planning decisions must be consistent with the PPS. The provincial *Lakes and Rivers Improvement Act* may also indirectly protect Eastern Sand Darter habitat when applications for the construction or maintenance of dams and dredging activities are reviewed. Aspects of the provincial *Nutrient Management Act, Environmental Protection Act, Water Resources Act,* and *Source Water Protection Act* may also provide indirect protection for the habitat of Eastern Sand Darter.

In Québec, general habitat protection is provided to fishes under the *Conservation and Development of Wildlife Act* and the *Environmental Quality Act*. Indirect protection is also afforded through Policy on the Protection of Stream Banks, Littoral Areas and Floodplains; as well as a regulation framework dealing with municipal and urban planning. In addition, as of 1 April 2005, under agricultural and farming regulations pursuant to the Law on Environmental Quality, farm animals are not to be permitted free access to streams.

The beds of the rivers inhabited by Eastern Sand Darter are largely owned by the Crown, but the majority of adjacent lands are privately owned and in agricultural production. On the Grand River, Thames River, and St. Lawrence River and its tributaries, there are significant portions of adjacent lands in urban areas. Only a very small percentage of Eastern Sand Darter habitat (< 1%) is within protected areas (Rondeau Provincial Park and Komoka Provincial Park in Ontario), although there are some adjacent conservation lands. The Eastern Sand Darter is present in the Refuge Faunique Pierre-Étienne-Fortin, a protected area created in 2002 in the Chambly Rapids of the Rivière Richelieu to protect the spawning habitat of several rare species, including the Copper Redhorse (*Moxostoma hubbsi*), the River Redhorse (*M. carinatum*) and the Channel Darter. A similar protected area is also being planned around Jeannotte and aux Cerf islands, in the Saint-Marc-sur-Richelieu sector of the Rivière Richelieu, recently acquired by Nature Conservancy Canada.

BIOLOGY

As a globally rare species, there have been few studies specifically examining the biology of Eastern Sand Darter. Most life history studies have been conducted in the Ohio River drainage of the US, but there are some recent studies from southwestern Ontario rivers.

Life cycle and reproduction

The Eastern Sand Darter is relatively short-lived, reaching a maximum age of 4 years in the Thames River, Ontario (Drake *et al.* 2008), although most adults are 1 and 2 years old (Finch *et al.* 2008). Studies of populations from two Ohio streams found a maximum age of 2-3 years (Spreitzer 1979; Faber 2006). Reported sex ratios (female:male) are 1.16:1 for the Little Muskingum River, Ohio (Faber 2006), and 1:1 for Salt Creek, Ohio (Spreitzer 1979).

Eastern Sand Darter grow quickly and achieve most of their total growth during their first growing season (Drake *et al.* 2008). Fish of both sexes mature in the spring following their first growing season at age 1 (Spreitzer 1979), but some females may not reproduce until their second year (Faber 2006). Given that fish mature at age 1, and that few live beyond age 3, generation time is estimated at 2 years.

Fecundity is low but comparable to many darter species. In Salt Creek, Ohio, the total number of eggs for ova-bearing females ranged from 22 to 829 (mean = 343) and the number of mature ova in fecund females (clutch size) ranged from 30 to 170 (mean = 71) (Spreitzer 1979). Clutch size ranged from 16-97 eggs (mean = 56) for the population in the Little Muskingum River, Ohio (Faber 2006). The average clutch size for 10 females from the Thames River, Ontario, was similar at 66 eggs (Finch 2008). Larger females had larger clutch sizes in the two Ohio populations.

The Eastern Sand Darter is an intermittent spawner and females may lay eggs several times during the protracted spawning season (Johnston 1989; Simon and Wallus 2006). A range of spawning periods has been reported for American Eastern Sand Darter populations spanning the months of April to August at water temperatures ranging from 14.4 to 25.5 ^{o}C (Williams 1975; Spreitzer 1979; Johnston 1989; Facey 1998; Faber 2006; Simon and Wallus 2006). The Eastern Sand Darter has been observed to spawn in the laboratory at water temperatures between 20.5°C and 23°C (Johnston 1989). Examination of the gonads of 17 specimens from several watersheds in the Royal Ontario Museum (ROM) collection indicated that spawning probably occurs between late June and late July in Ontario (Holm and Mandrak 1996). Analysis of daily growth increments on otoliths of young-of-the-year Eastern Sand Darter from the Thames River, Ontario, suggests that emergence occurred between early May and late June (Finch 2008). Spreitzer (1979) suggested that the spawning season was synchronized with low silt levels in the habitat.

Actual observations of the spawning act have only been made in the laboratory (Johnston 1989). During spawning, the male mounts the female, and eggs are deposited when the pair have vibrated and buried their tails and caudal peduncles in the substrate. "Sneaker males" (males that quickly sneak in and fertilize eggs of a female spawning with another male) often joined mating pairs (Johnston 1989). Eggs were buried individually in the substrate. Spawning activity was observed during day and night. A well-oxygenated substrate such as unsilted sand is likely required for high egg survivorship.

Fertilized eggs are slightly adhesive and average 1.4 mm in diameter (Johnston 1989). Hatching occurs in 4 to 5 days at 20.5 to 23 ^{o}C (Simon *et al.* 1992). Newly hatched larvae are 5.5 to 5.7 mm long (total length) and remain in the substrate for a short period until exogenous feeding commences (Simon *et al.* 1992; Simon and Wallus 2006). Post yolk-sac larvae from the Tippecanoe River, Ohio, were found in pelagic drift samples during dusk and night periods, but became benthic at total lengths greater than 7.4 mm (Simon and Wallus 2006). Larvae transform into juveniles at a total length of 18 mm (Simon and Wallus 2006). In the Thames River, Ontario, juvenile fish large enough to be captured in a 3 mm mesh seine net were first detected on July 5 (A. Dextrase, unpublished data), but the smallest juvenile (total length = 18 mm) was seen at the end of July lending support to the protracted spawning period. The juvenile stage is relatively short-lived as most fish mature the spring following hatching, although some females may not mature until their second year.

Fossorial (burying) behaviour is well-developed within the sand darter genus *Ammocrypta* (Figure 7). Daniels (1989) provided evidence indicating that burying is an adaptation to maintain position on relatively homogenous sand beds, particularly during periods of extremely high or low flow. His experiments suggested that Eastern Sand Darter does not bury to avoid predators or to ambush prey. Similar experimental work by Simon (1991) supported the hypothesis that burying is a resting response used during occupation of homogeneous sand habitats. Low oxygen levels in silted substrate may discourage complete burial, or reduce the length of burial time. This may have a negative survival effect by increasing the amount of energy expended to maintain position in its habitat. Despite the two experimental studies, Eastern Sand Darter in the wild have been observed to quickly dart under the sand upon being approached by juvenile Smallmouth Bass (*Micropterus dolomieu*) suggesting that fossorial behaviour may be used in some instances to escape predation (A. Dextrase, unpublished data).

Figure 7. Eastern Sand Darter, *Ammocrypta pellucida*, from the Grand River, Ontario displaying fossorial behaviour (photo: Alan Dextrase, Ontario Ministry of Natural Resources, Peterborough, Ontario).

Feeding/nutrition

The diet of the Eastern Sand Darter has been reported to be limited to midge larvae (Chironomidae), black fly larvae (Simuliidae) and possibly entomostracan crustaceans by its small mouth size and restricted habitat (Turner 1922; Scott and Crossman 1973; Smith 1979; Cooper 1983). In Salt Creek, Ohio, midge larvae comprised an average of 94.4% of the diet of the Eastern Sand Darter. Aquatic worms (Oligochaeta) and water fleas (Cladocera) comprised significant, but smaller, proportions in June and November, respectively (Spreitzer 1979). In the Little Muskingum River, Ohio, midge larvae comprised 93% of the diet over all seasons, but several other aquatic invertebrate taxa were consumed including biting midges (Ceratopogonidae), fingernail clams (Sphaeriidae), and seed shrimp (Ostracoda) (Faber 2006). Midge larvae comprised 50% of the summer diet of Eastern Sand Darter in the Thames River, Ontario, while ostracods comprised 30% (M. Finch, University of Waterloo, Waterloo, Ontario, pers. comm.). Eastern Sand Darter feed by ambushing benthic invertebrate prey using quick lunges of 0.5 to 1.0 cm and then retreating to their pre-strike position (Spreitzer 1979; A. Dextrase, unpublished data). Incidentally ingested sand is expelled through the mouth.

Predation

There are several potential predators of Eastern Sand Darter, but actual predation has rarely been recorded. Potential fish predators include Channel Catfish (*Ictalurus punctatus*), Stonecat (*Noturus flavus*), Smallmouth Bass and Rock Bass (*Ambloplites rupestris*) that commonly co-occur with Eastern Sand Darter. Eastern Sand Darter have been found in the stomach contents of Stonecat from the Thames River (M. Finch, University of Waterloo, Waterloo, Ontario, pers. comm.). Piscivorous birds, such as Belted Kingfisher (*Ceryle alcyon*) and Great Blue Heron (*Ardea herodias*), are also potential predators. The fossorial behaviour and cryptic colouration of the Eastern Sand Darter probably provide some protection from predation, and predation has not been linked to declines or been identified as a threat in Eastern Sand Darter populations.

Dispersal/migration

As a small fish without a swim bladder, the Eastern Sand Darter appears well-adapted to a sedentary benthic life style. However, the movements of this species are virtually unknown. Most darters are sedentary, and migrations are rare (Page 1983). However, Johnston (1989) suggested male Eastern Sand Darter may have congregated in an area sampled in the Tippecanoe River, Indiana, in July 1987. Spreitzer (1979) provided evidence that some individuals may migrate to feed when local chironomid population levels are low. Larval Eastern Sand Darter have the capacity to drift downstream for a short period of time before they become benthic (Simon and Wallus 2006). The distances associated with this downstream drift are unknown. Despite the fact that there are no data on dispersal distances for this species, its small size and benthic life style suggest that most populations are probably isolated from each other. It is unlikely that areas currently occupied by small populations would be re-colonized if the populations were to become extirpated.

Physiology

There are no published studies on the physiology or environmental tolerances of the Eastern Sand Darter.

Interspecific interactions

The fish species most commonly associated with Eastern Sand Darter in the Thames River, Ontario, were Spotfin Shiner (*Cyprinella spiloptera*), Bluntnose Minnow (*Pimephales notatus*), Emerald Shiner (*Notropis atherinoides*), Mimic Shiner (*Notropis volucellus*) and Blackside Darter (*Percina maculata*) (in order of association strength) (A. Dextrase, unpublished data). Abundance of Eastern Sand Darter was positively correlated with the abundance of several species. The strongest correlations (in order of strength of the correlation) were with Bluntnose Minnow, Mimic Shiner, and Logperch (*Percina caprodes*). Johnny Darter (*Etheostoma nigrum*) was the most abundant darter species found at sites with Eastern Sand Darter. These associations include many of the same species that were found to be associated with Eastern Sand Darter in Ohio (Spreitzer 1979; Faber 2006) and New York (Daniels 1993). These relationships are likely an indication of the widespread nature of the associated species, most of which tend to be more habitat generalists than the Eastern Sand Darter (Daniels 1993).

The Eastern Sand Darter co-occurs with several species that have been designated as species at risk by COSEWIC. These include fishes (Silver Shiner [*Notropis photogenis*], Spotted Sucker [*Minytrema melanops*], River Redhorse, Black Redhorse [*Moxostoma duquesnei*], Copper Redhorse, Northern Madtom [*Noturus stigmosus*], and Channel Darter), mussels (Northern Riffleshell [*Epioblasma torulosa rangiana*], Snuffbox [*Epioblasma triquetra*], Rayed Bean [*Villosa fabalis*], Mudpuppy Mussel [*Simpsonaias ambigua*], Mapleleaf [*Quadrula quadrula*], Round Hickorynut [*Obovaria subrotunda*], and Round Pigtoe [*Pleurobema sintoxia*]), and turtles (Spiny Softshell [*Apalone spinifera*], and Map Turtle [*Graptemys geographica*]).

Adaptability

The Eastern Sand Darter appears to have limited adaptability. The species has strict habitat requirements (i.e., clean sand substrates) and has declined throughout much of its range where habitat alteration has occurred (Grandmaison *et al.* 2004). The Eastern Sand Darter likely has limited dispersal capability and populations are fragmented within Canada. This makes natural recolonization of formerly occupied habitats unlikely when isolated populations are extirpated. However, Daniels (1993) suggested that Eastern Sand Darter may have colonized the Metawee River, New York, after improvement of habitat conditions following reforestation of riparian slopes.

POPULATION SIZES AND TRENDS

Search effort

Several recent surveys in Canada have specifically targeted Eastern Sand Darter or areas where several fish species at risk (including Eastern Sand Darter) are known to occur. Many Eastern Sand Darter records are from general stream inventory work or surveys for other purposes. Throughout most of the Eastern Sand Darter's Canadian range, pre-1970 sampling effort was sparse and was conducted with seine nets and traps.

In the 1970s, the Ontario Ministry of Natural Resources (OMNR) conducted stream surveys that included systematic fish sampling using a variety of gear types (including backpack electrofishing) throughout most streams and their major tributaries within the Ontario range of the Eastern Sand Darter. The OMNR conducted a standard near-shore seining program along the south shore of Lake St. Clair from 1979-1981 and from 1990-1996. Index trawling transects have been conducted by OMNR in Long Point Bay since 1972. Over the past 10 years, specific surveys have been conducted using a variety of gear types by Fisheries and Oceans Canada (DFO), OMNR, the Royal Ontario Museum and Conservation Authorities, targeting historical locations and potential habitats for species at risk in the Ausable River, Bayfield River, Big Creek, Big Otter Creek, Catfish Creek, Detroit River, Grand River, St. Clair River, Sydenham River, and Thames River watersheds. Similar surveys have also been conducted on beaches along the north shore of Lake Erie. Since 2004, intensive systematic sampling of all Ontario stream habitats that are occupied, or were formerly occupied, by Eastern Sand Darter has been conducted by graduate students, DFO and Conservation Authorities.

In Québec, targeted surveys for species at risk (including Eastern Sand Darter) were conducted in the Châteauguay River and Des Outaouais rivers in 2006, and in the l'Achigan, l'Assomption and Ouareau rivers in 2002. Survey work was also conducted in several Québec rivers in fall of 2005 and the summer of 2007 as part of a project assessing the impacts of the baitfish industry on species at risk. Since 1997 in the Rivière Richelieu, 40 seine stations have been sampled almost annually (with the exception of 2000, 2002 and 2005) to monitor Copper Redhorse recruitment (Vachon 2007); this program also offers the opportunity to monitor other rare fish species in the Richelieu River. In 1995, a large-scale, standardized monitoring program was initiated in the Québec freshwater portion of the St. Lawrence River, covering five fluvial reaches between Lac Saint-François and Québec City. The first sampling cycle was completed between 1995 and 1997, the second cycle between 2002 and 2006 and a third cycle was initiated in 2006. During each cycle, more than 235 stations are sampled using beach seines (every 1 to 2 km along the shore).

In addition to the surveys described above, Eastern Sand Darter records have been contributed by agency staff, consultants and students who have conducted sampling for other purposes. Many of the surveys described above are limited to presence/absence information, but information on relative abundance is available for several rivers. There are few sampling locations where similar gear and effort have been used through time to allow detailed analyses of population trends.

Abundance

Studies have not been specifically conducted to estimate population sizes of Eastern Sand Darter in Canada. Information on relative abundance is available from several locations. Populations at specific sites can fluctuate widely (Facey 1998), so data from multiple sites and years are much more valuable for assessing trends.

Ontario populations

Lake Huron drainage

Ausable River

The Ausable River is the only Canadian location within the Lake Huron watershed where the Eastern Sand Darter has been recorded. A single adult was collected in 1928 at Ailsa Craig (Hubbs and Brown 1929). No individuals have been collected since, despite sampling at this site in 1936 and 1982, and in 1974 at five sites within 5 km of the capture site (Holm and Mandrak 1996). Eastern Sand Darter were also not found in the Ausable River during targeted sampling for species at risk in the watershed in 2004 (Stewart and Veliz 2004), nor in targeted sampling in 2007 at sites in the watershed that had the highest predicted habitat value for the species (A. Dextrase, unpublished data). It is presumed extirpated from this watershed.

Lake Huron

Although there are no records, it is possible that populations of Eastern Sand Darter exist in areas of sandy habitat in southern Lake Huron. These areas have not been sampled to the same extent with trawls and seines as near-shore areas in Lake Erie and Lake St. Clair (Holm and Mandrak 1996).

Lake St. Clair drainage

Sydenham River

The Eastern Sand Darter was collected in the East Sydenham River at Strathroy in 1927, Alvinston in 1929, and downstream at the mouth of one of its tributaries, Fansher Creek, in 1972 (Holm and Mandrak 1996). Its continued presence near Fansher Creek has been confirmed through repeated collections in 1989, 1991, 1997,1999 and 2002. Eight collections, made by the ROM at seven sites with sandy bottoms between Strathroy and Alvinston in 1991, failed to capture the Eastern Sand Darter (Holm and Mandrak 1996). Eastern Sand Darter were captured at one site sampled in this area in 2002 (Poos 2004). The Eastern Sand Darter ranked 27th in abundance and 37th in encounter frequency of the 52 fish species found during systematic sampling of the Sydenham River watershed in 1997 (Holm and Boehm 1998). It was captured at three of 23 sites with an average of nine individuals per capture site. More recently, Poos (2004) conducted systematic sampling in 2002 and 2003 at 100 sites (including 25 sites that were sampled in both years) and captured Eastern Sand Darter at 14 of these sites. The Eastern Sand Darter ranked 37th among 68 fishes in terms of abundance and encounter frequency, with an average of six individuals per occupied site (M. Poos, University of Toronto, Toronto, Ontario, unpublished data). Recent sampling has confirmed that the Eastern Sand Darter is extant at historical collection sites in the lower section of the East Sydenham River, and at one site upstream of this area, but there have been no recent records upstream at the historical locations near Strathroy and Alvinston (Figure 4).

Thames River

Forty-eight specimens were collected in the Thames River "at Muncey" in 1923 (Hubbs and Brown 1929). Although it was not captured "near Muncey" in 1941 sampling, it was recorded during sampling downstream from Muncey in the Thames River between Wardsville and the Moravian Indian Reserve in 1958 (ROM Accession 482). The Eastern Sand Darter was collected at four other sites both upstream and downstream of Muncey in the 1970s. ROM surveys in 1989-1991 found Eastern Sand Darter at most locations in the Thames River where they had been captured in the past including the upstream and downstream extremes (Holm and Mandrak 1996). Sampling in 2006 and 2007 captured Eastern Sand Darter in 26 of 30 randomly selected reaches in a 145 km stretch between London and Chatham (A. Dextrase, unpublished data). The Eastern Sand Darter was the 4th most frequently encountered species occurring at 66 of the 131 sample sites, and ranked 7th in abundance out of 48 species, with a mean of 8 individuals/occupied site (10 x 10 m) (A. Dextrase, unpublished data). Given the length of occupied river and the amount of suitable habitat, the Thames River probably has the largest population of Eastern Sand Darter in Canada with thousands of adults.

Lake St. Clair

A near-shore seining program was conducted along the south shore of Lake St. Clair by the OMNR from 1979 to 1981, and from 1990 to 1996 (M. Belore, OMNR, Wheatley, Ontario, pers. comm.). Fifty Eastern Sand Darter were captured at seven different sites from 1979 to 1981, but only five were captured at three different locations in three of seven years during the 1990-1996 sampling period. This coincides with the changed habitat conditions associated with the Zebra Mussel invasion (see Habitat Trends above) and the invasion of Round Goby (*Neogobius melanostomus*) into the lake (see Limiting Factors and Threats below). The Eastern Sand Darter was also collected in Mitchell's Bay in the eastern part of the lake by an OMNR small trawl study conducted between 1983 and 1985 (Holm and Mandrak 1996). The results of the study show an overall decline in numbers of captured specimens (1983: 97 specimens, 0.6 specimens/tow; 1984: 66, 0.4; 1985: 26, 0.2) (Holm and Mandrak 1996).

Lake Erie drainage

Catfish Creek

The Eastern Sand Darter was collected in Catfish Creek in 1922 and 1941 (Hubbs and Brown 1929; Holm and Mandrak 1996). Since 1973, eight sampling attempts have failed to capture specimens. Sampling effort included systematic stream surveys by OMNR in 1973, Canadian Museum of Nature surveys in 1975, sampling by Wilfrid Laurier University in 1983, repeated surveys by the ROM in 1980, 1989, 1990, 1997, sampling by DFO in 2002, and surveys by Trent University in 2008 (Holm and Boehm 1998; A. Dextrase, unpublished data). Many of these surveys included the historical capture locations. Therefore, it is probable that Eastern Sand Darter is extirpated from this watershed.

Big Otter Creek

The Eastern Sand Darter was collected in Big Otter Creek in 1923 and 1955 (Hubbs and Brown 1929; Holm and Mandrak 1996). Since 1973, 11 sampling attempts in Big Otter Creek have failed to capture specimens. These sampling attempts included backpack electrofishing at numerous sites throughout the watershed in 2002 and 2003 (D. DePasquale, pers. comm.) and seining at 14 sites within historically occupied reaches and randomly selected reaches in 2008 (A. Dextrase, unpublished data). Therefore, it is probable that Eastern Sand Darter no longer occurs in this watershed.

Big Creek

The Eastern Sand Darter was collected in Big Creek in 1923 and 1955 (Hubbs and Brown 1929; Holm and Mandrak 1996). Between 1973 and 2004, six sampling attempts failed to capture specimens. However, a total of three adult Eastern Sand Darter was captured from three different sites in 2008, confirming the continued presence of the species in the watershed (J. Stackhouse, DFO, Burlington, Ontario, pers. comm.; A. Dextrase, unpublished data). Big Creek has a deep, swift-flowing, entrenched channel with plentiful coarse woody debris making it difficult to sample effectively.

Grand River

The Eastern Sand Darter was first captured in the Grand River at Brantford in 1987 (Holm and Mandrak 1996). Targeted sampling for Eastern Sand Darter in the lower river by Holm (2001) and Dextrase (unpublished data), along with incidental captures associated with other surveys have extended its known range from Brantford to 3.5 km downstream of the town of Cayuga (~ 85 river km). Within this area, its distribution is somewhat patchy. In sampling done in 2006 and 2007, the Eastern Sand Darter was found in 13 of 31 randomly selected reaches. The Eastern Sand Darter was the 13th most frequently encountered species occurring at 34 of the 151 sample sites, and ranked 13th in abundance out of 51 species with a mean of 13 individuals/occupied site (10 x 10 m) (A. Dextrase, unpublished data). The Grand River was sampled in the vicinity of Brantford between 1966 and 1976. However, the site of the 1987 capture was not sampled during this period and there is no evidence in records available that it was sampled prior to 1966 (Holm and Mandrak 1996). Prior to 1990, fish sampling in the lower portion of the main stem of the Grand River (Brantford to Dunnville) was sparse when compared to upstream areas where wadeable sampling is more easily conducted. The Grand River population is more than 50 km from the nearest known native populations in Long Point Bay and Big Creek, and there is a barrier at Dunnville that would prevent natural movements upstream in the Grand River. This population may be the result of an unauthorized introduction, or a recently discovered native population. Given the distribution of the species in Ontario, and the limited sampling in the lower Grand River prior to the first discovery of the species, it seems probable that the Eastern Sand Darter is native to the Grand River watershed.

Lake Erie

The Eastern Sand Darter was first collected in the Canadian waters of Lake Erie at Pelee Island in 1953 (Holm and Mandrak 1996). Additional specimens were collected from Rondeau Bay in 1975, from Long Point Bay in multiple years since 1979, and from the western basin near Point Pelee in 1984 and 1985. OMNR index netting trawls in Long Point Bay conducted since 1972, captured specimens every year between 1979 and 1987, except 1983. Neither sampling techniques nor personnel had changed in the OMNR index netting program in Long Point Bay (Holm and Mandrak 1996). Therefore, the appearance of specimens in Long Point Bay only after 1978 was not the result of changes in sampling techniques and may represent the establishment of a new population or recovery of a reduced population following water quality improvements (see Habitat Trends section above). Despite the apparent recovery, between 1987 and 2005, only a single Eastern Sand Darter was captured in 1996. Reid and Mandrak (2008) did not capture any Eastern Sand Darter during summer and fall seining at 34 sand and gravel beach sites along the north shore of Lake Erie and Pelee Island in 2005 and 2006. In 2005, a single adult Eastern Sand Darter was captured in Rondeau Provincial Park during a weekly seining program in the Park, confirming its continued presence in Rondeau Bay (S. Dobbyn, OMNR, London, Ontario, pers. comm.).

Québec populations

St. Lawrence River drainage

Lac des Deux Montagnes

The Eastern Sand Darter was collected in Lac des Deux Montagnes at L'Anse à l'Orme in 1941 and at Sainte-Marthe-sur-le-Lac in 1946 (Gaudreau 2005). Mongeau and Massé (1976) and Mongeau *et al.* (1980) did not report its capture in their studies of the waters around Montréal between 1964 and 1977. A sampling attempt in 1990 by the ROM on a shallow, sandy beach at the 1941 site, L'Anse à l'Orme, failed to capture any *Ammocrypta* (Holm and Mandrak 1996). Between 1949 and 1951, Lac des Deux Montagnes fish communities had been decimated following prolonged winter periods of anoxia caused by the discharge of untreated domestic sewage and pulp mill effluents in Rivière des Outaouais (Mongeau *et al.* 1976). Two Eastern Sand Darter were captured in 2008 in Rivière des Mille Îles, an outflow of Lac des Deux Montagnes, at the mouth of Rivière Mascouche (S. Garceau, MRNF, Longueuil, QC, pers. comm.).

Fleuve Saint-Laurent

The Eastern Sand Darter was not recorded in a 1973 survey of 325 sampling stations in the St. Lawrence River between Montréal and Sorel (Massé and Mongeau 1976). A single specimen was captured along the north shore of the river at Saint-Sulpice in 2001 as part of the Réseau de Suivi Ichtyologique's (RSI) systematic survey (Gaudreau 2005; MRNF 2008). The Eastern Sand Darter was captured in 1944 in the Lac Saint-Pierre archipelago (Saint-Anne de Sorel) by Cuerrier *et al.* (1946). It has recently been captured on the north shore (two stations in 2002) and south shore (two stations in 2002 and 1 in 2007) of Lac Saint-Pierre during RSI surveys (MRNF 2008), but was not captured during surveys conducted in 1974, 1995 and 1997 (Gaudreau 2005). The species has been captured since 1944 at four different locations in the Lac Saint-Pierre Archipelago, which is located immediately upstream of Lac Saint-Pierre. In 2002 and 2007, RSI surveys captured specimens near l'île du Moine, and in 2003, specimens were captured near the 1944 site of Sainte-Anne-de-Sorel (Gaudreau 2005; MRNF 2008).

Rivière aux Saumons

In 2007, a new population was discovered in Rivière aux Saumons west of Lac Saint-François (D. Hatin, pers. comm., MRNF, Longueuil, QC, pers. comm.). More than 320 individuals were captured from 40% of 102 sites sampled over a 6 km section of the river between the New York border and Lac Saint-François (D. Hatin, MRNF, Longueuil, QC, pers. comm.). The species is known from the upstream portion of this drainage in New York (Grandmaison *et al.* 2004).

Rivière Châteauguay

The Eastern Sand Darter was collected at 12 sites on Rivière Châteauguay between 1941 and 1976. Vladykov (1942) reported the capture of three specimens in June 1941 from Rivière Châteauguay near Sainte-Philomène village (now Mercier). Cuerrier *et al.* (1946) later documented the capture in August 1943 of about 180 specimens at a site near the city of Châteauguay. A fish survey of the Rivière Châteauguay, where the main course of the river was sampled at approximately 0.32 km intervals from the mouth to the headwaters, was conducted by Ministère du Loisir, de la Chasse et de la Pêche (MLCP) - Montréal during 1975 and 1976 (Mongeau *et al.* 1979). The Eastern Sand Darter was collected at 10 of 287 sampling stations distributed along approximately 55 km of the main course of the river and at one site in one of its tributaries, Rivière à la Truite. It ranked 31st out of 53 species in frequency of occurrence in the collections. However, it was not recorded from the city of Châteauguay where it had been previously reported as abundant (Cuerrier *et al.* 1946). The Eastern Sand Darter was not detected during a 1993 survey of the river (La Violette and Richard 1996 cited in Gaudreau 2005). A 2006 survey targeting Channel Darter in the Châteauguay watershed captured a single Eastern Sand Darter specimen in the Rivière à la Truite confirming its continued presence in this system (Garceau *et al.* 2007). None were captured at 24 additional sites sampled throughout the watershed.

Rivière L'Assomption

Fourteen specimens were collected at L'Assomption on Rivière L'Assomption in 1969. No specimens were captured at, or near, this site nor at any of the other 15 sites sampled between the mouth of the river and Sainte-Mélanie during electrofishing surveys in 1990. At the original collection site, the water was described as very turbid and the substrate consisted of 100% clay in 1990 (St-Onge 1992). Holm and Mandrak (1996) concluded that the Eastern Sand Darter was probably extirpated from Rivière L'Assomption. However, in 2002 specimens were captured during surveys for rare fishes conducted in Rivière L'Assomption near Joliette, confirming the species' continued presence in the river (Gaudreau 2005).

Rivière Ouareau

Surveys of the Rivière Ouareau in 1990 were conducted between its confluence with the Rivière L'Assomption upstream to Chertsey, but no Eastern Sand Darter were captured. Rare fish surveys in 2002 and 2003 captured specimens near Crabtree (Gaudreau 2005).

Rivière Richelieu

In 1970, Eastern Sand Darter was collected at 19 of 159 sampling stations in a 60 km stretch of the main channel of Rivière Richelieu from McMasterville to its mouth. It ranked 30th out of 60 species in frequency of occurrence in the collections (Mongeau 1979a). In 1974, four specimens were collected at one site less than 2 km from the mouth of Rivière Richelieu (Massé and Mongeau 1974). A single specimen was captured from the Chambly basin in 1993, but no specimens were captured between Lacolle and the mouth of the river in a 1995 survey (Gaudreau 2005). Specimens have recently been collected in the Chambly Rapids (2003) (Gaudreau 2005; Boucher 2006). Between 1997 and 2008, more than 400 Eastern Sand Darter were captured just upstream of Saint-Marc-sur-Richelieu and downstream of Saint-Ours in eight of nine years of the fall seining program for young-of-the-year copper redhorse. In the Saint-Marc sector, 23 Eastern Sand Darter were captured between May and August in 1997 and 1998, and more than 235 were captured in late May and early June in 2007 (Vachon 1999, 2007; N. Vachon, MRNF, Longueuil, QC, unpublished data). A single specimen was captured in 2003 from Missisquoi Bay of Lac Champlain in the Richelieu drainage (Gaudreau 2005). The Eastern Sand Darter occurs in several tributaries of the lake in Vermont and New York (Grandmaison *et al.* 2004).

Rivière Yamaska

In Rivière Yamaska, the Eastern Sand Darter was captured in 1967 at four of 120 sampling stations within a 5 km stretch of the river between the mouth and the Saint-Hugues rapids. It ranked 37th out of 59 species in frequency of occurrence in the collections (Mongeau 1979b). No specimens were captured during sampling conducted between the mouth of the river and Lac Brome in 1995 and 2003 (Gaudreau 2005).

Rivière Saint-François

Cuerrier *et al.* (1946) reported that the Eastern Sand Darter was particularly abundant in Rivière Saint-François in the Lac Saint-Pierre region. However, it has not been captured in this river since 1944, despite sampling by MLCP - Montréal between 1965 and 1975 (Mongeau and Legendre 1976), and by Ministère de l'Environnement du Québec in 1991 (Audet and St-Onge 1992), and in 2002 (Gaudreau 2005). Sampling at three locations in 2003 also failed to capture any specimens (Gaudreau 2005).

Rivière Yamachiche

The Eastern Sand Darter was captured from three sites in Rivière Yamachiche near the mouth in 1944 and 1972 (Holm and Mandrak 1996). Due to the lack of recent sampling, it is not possible to determine the current status of the Eastern Sand Darter in Rivière Yamachiche.

Rivière Bécancour

A single specimen was captured from Rivière Bécancour in 1981 (Holm and Mandrak 1996). Due to the lack of recent sampling, it is not possible to determine the current status of the Eastern Sand Darter in Rivière Bécancour.

Rivière Gentilly

The Eastern Sand Darter was collected from Rivière Gentilly at one site in 1941 and at two sites in 1982 (Holm and Mandrak 1996). Due to the lack of recent sampling, it is not possible to determine the current status of the Eastern Sand Darter in Rivière Gentilly.

Rivière aux Orignaux

A single specimen was captured from Rivière aux Orignaux in 1982 (MacFarlane and Durocher 1984). Due to the lack of recent sampling, it is not possible to determine the current status of the Eastern Sand Darter in Rivière aux Orignaux.

Petite Rivière du Chêne

A single specimen was captured from Petite Rivière du Chêne in 1982 (MacFarlane and Durocher 1984). Due to the lack of recent sampling, it is not possible to determine the current status of the Eastern Sand Darter in Petite Rivière du Chêne.

Fluctuations and trends

In Ontario, Eastern Sand Darter populations have probably been extirpated from three river systems: the Ausable River (last seen in 1928); Big Otter Creek (last seen in 1955); and, Catfish Creek (last seen in 1941). Populations are extant in four river systems (Big Creek, Grand River, Sydenham River, Thames River). Because of the lack of consistent sampling programs through time, it is not possible to identify fluctuations or trends with confidence. It is likely that the population in Big Creek has declined given the difficulty in detecting the species over the last couple of decades. Trends are unknown for the other three river systems, but it is clear that the population in the Thames River is fairly abundant over a large stretch of the lower river, and probably represents the largest population of this species in Canada. Although little can be said with certainty regarding population trends in Lakes Erie and St. Clair, available data suggest that populations in both lakes may have declined in recent years.

In Québec, trends in Eastern Sand Darter populations are largely unknown due to a lack of recent sampling in several river systems. It is likely that the species has been extirpated from Lac des Deux Montagnes (last seen in 1946), Rivière Saint-François (last seen in 1944), and Rivière Yamaska (last seen in 1967). The lack of records despite recent sampling in Rivière Châteauguay suggests that the Eastern Sand Darter may have declined in this river. The continued presence of Eastern Sand Darter has recently been confirmed in Lac Saint-Pierre and its archipelago, St. Lawrence River at Saint-Sulpice and Rivière des Mille Îles, Rivière à la Truite of the Châteauguay drainage, Rivière L'Assomption, and Rivière Richelieu. New locations have recently been discovered in Rivière Ouareau of the L'Assomption drainage, Missisquoi Bay of Lac Champlain in the Richelieu drainage, and Rivière aux Saumons. It is not possible to assess trends in five Québec rivers due to lack of recent sampling (Rivière Yamachiche, Rivière Bécancour, Rivière Gentilly, Rivière aux Orignaux, Petite Rivière du Chêne).

Rescue effect

The Eastern Sand Darter is extant in the waterways of five states adjacent to Canadian populations. However, the species is rare, and is listed as a species at risk in all of these jurisdictions (Endangered – Pennsylvania; Threatened - Michigan, New York, and Vermont; Species of Concern – Ohio) (Grandmaison *et al.* 2004). The Eastern Sand Darter has recently been collected from the Michigan waters of Lake St. Clair, but there is no information regarding population status in the American waters of the Lake (Grandmaison *et al*. 2004). It is possible that populations in Michigan could colonize Canadian waters of the lake if suitable habitat were available. Eastern Sand Darter were collected from the Pennsylvania and New York waters of Lake Erie in the 1990s (Grandmaison *et al.* 2004) and may still be present in the Ohio waters of the lake. There are no records from the Michigan waters of Lake Erie (Bailey *et al*. 2004). Fish from the American waters of eastern Lake Erie would need to traverse a considerable distance of unsuitable habitat to colonize areas in the Canadian waters of Lake Erie, so rescue from these populations seems unlikely. The Eastern Sand Darter occurs in five tributaries to Lac Champlain in Vermont and New York, but has not been captured from

the lake itself in the United States (Daniels 1993; Facey 1998; Grandmaison *et al.* 2004). Although it seems unlikely, it is possible that these populations could serve as a source of rescue for downstream populations in the Richelieu system of Québec. The population in Rivière aux Saumons could potentially be rescued from upstream populations in New York. Rescue would be contingent on suitable habitat being present in Canadian waters. Overall, rescue appears unlikely given the rarity of bordering American populations, and the limited dispersal abilities and strict habitat requirements of this species.

LIMITING FACTORS AND THREATS

Siltation, impoundments, stream flow modifications, pollution, and exotic species are factors attributed to the decline of the Eastern Sand Darter in the United States (Smith 1971; Barnes 1979; Trautman 1981; Burr and Warren 1986; Grandmaison *et al*. 2004). These threats are also applicable to Canadian populations.

Siltation appears to be the leading cause of significant loss of habitat in Canada (Holm and Mandrak 1996). Silt reduces the available substrate oxygen necessary for fossorial behaviour and egg survivorship. It has caused the decline and extirpation of the Eastern Sand Darter in some rivers where it was formerly abundant (Kuehne and Barbour 1983; Holm and Mandrak 1996). Berkman and Rabeni (1987) found that the feeding guilds most impacted by siltation in Missouri streams were benthic feeders. Most watersheds supporting Eastern Sand Darter in Canada have been largely cleared of their forest cover, are subject to intensive agriculture (row crop or livestock) and tile drainage, and have had channel alterations. Many rivers also have large urban developments on their banks and within their catchments. All of these factors contribute to the input of sediment into streams and associated siltation. The draft recovery strategy for Eastern Sand Darter ranks siltation as a high severity threat for all riverine populations in Ontario (Edwards *et al*. 2007). Activities that can increase siltation (e.g., agricultural pollution, loss of riparian cover, wave action from commercial shipping) are also identified as important threats for the watersheds in Québec that support the species.

Pollution from industrial activity, urban centres and intensive agriculture is a pervasive threat for most Eastern Sand Darter populations in Canada. Contaminants associated with industrial activity, and urban and agricultural runoff have the potential to kill Eastern Sand Darter outright, or to affect their invertebrate food supply. Poor water quality near urban areas such as Montréal and Châteauguay, Québec, may have caused its decline or extirpation in those areas (Scott and Crossman 1973). Pollution from urban centres has been identified as an important threat in seven of 16 Québec drainages (Lac des Deux Montagnes, Fleuve Saint-Laurent [Montréal to Sorel], Rivière Châteauguay, Rivière Richelieu, Rivière Yamaska, Rivière Saint-François, Rivière Gentilly), and as a potential threat to Eastern Sand Darter populations in the Grand and Thames rivers in Ontario (Edwards *et al.* 2007). The impacts of chronic levels of contaminant inputs that currently exist have not been assessed, but are unlikely to be

positive. Barbour *et al.* (1999) considered the Eastern Sand Darter to be pollution intolerant. Nutrient inputs associated principally with agricultural activities have been identified as primary threats limiting aquatic species at risk in the Ausable, Sydenham and Thames river watersheds in Ontario (Nelson *et al.* 2003; Staton *et al.* 2003; Taylor *et al.* 2004), and agricultural pollution has been ranked as a high severity threat for 11 of 16 Québec drainages where the Eastern Sand Darter occurs or used to occur (Edwards *et al*. 2007). Expanding, intensive corn and soybean culture, often associated with the hog industry, is a particular concern in many of the Québec watersheds. Poos *et al.* (2008) found a negative association between the occurrence of Eastern Sand Darter and nitrate levels in the Sydenham River, Ontario. Excessive nutrient inputs promote the growth of macrophytes and algae which can directly impact habitat and reduce dissolved oxygen levels. The impacts of pesticide use on Eastern Sand Darter populations are also of concern, but specific impacts have not been evaluated. In addition to the chronic effects of low level contaminant exposure, episodes of acute exposure also occur. At least four separate chemical or fertilizer spills have occurred within the Ausable, Grand, Sydenham and Thames river watersheds in the last 10 years that have resulted in fish kills (A. Dextrase, unpublished data). Although the impacts of these spills are localized and short-lived, they can be significant. There are no records of these spills directly affecting areas inhabited by Eastern Sand Darter.

Impoundments exist within the range of Eastern Sand Darter in several river systems in Canada. Impoundments can destroy habitat by flooding upstream riffles and promoting siltation, and by reducing flows downstream (Grandmaison *et al.* 2004; Edwards *et al.* 2007). Dams can also fragment populations by limiting gene flow and reducing the likelihood of recolonization when small isolated populations are extirpated by other factors (Grandmaison *et al.* 2004). In the Grand River, Ontario, where there are two mainstem dams within the occupied range, the occupancy of reaches by Eastern Sand Darter is positively correlated to the distance upstream from the dams (A. Dextrase, unpublished data). The impounded areas upstream from each dam have minimal flow, extensive aquatic macrophytes and fine sediment, rendering them unsuitable for Eastern Sand Darter. Dams have been identified as a significant threat for three Ontario populations (Grand River, Sydenham River, Thames River) and several Québec populations (Fleuve Saint-Laurent [Montréal to Sorel], Rivière Châteauguay, Rivière à la Truite, Rivière Ouareau, Rivière Richelieu, and Rivière Yamaska) (Edwards *et al.* 2007; Équipe de Rétablissement des Cyprinidés et des Petits Percidés du Québec 2008).

Stream channel alteration and associated changes to flow regimes are a significant threat to Eastern Sand Darter populations in both Ontario and Québec (Edwards *et al.* 2007; Équipe de Rétablissement des Cyprinidés et des Petits Percidés du Québec 2008). Channel straightening and widening, and the construction of tile drains have been conducted in many areas for flood control and improving drainage for agricultural production. These modifications increase peak flows, decrease low flows, can lead to increased erosion, and interfere with natural sediment deposition processes that nourish sand bars (Paine and Watt 1994; Helfman 2007). Hydrological alterations have been identified as a significant threat to Eastern Sand Darter populations in four Québec

rivers (Rivière Châteauguay, Rivière à la Truite, Rivière L'Assomption, Rivière Yamaska) and three Ontario rivers (Ausable River, Sydenham River, Thames River) (Edwards *et al*. 2007). The Ausable River was particularly affected by the construction of a new channel in 1873 that bypassed a large section of the lower river (ARRT 2005). In lakes Erie and St. Clair, near-shore sediment transport has been altered by shoreline protection structures, but the impacts on Eastern Sand Darter populations are difficult to assess. Low water levels in the St. Lawrence River are a particular concern for Eastern Sand Darter populations inhabiting the river (Gaudreau 2005; Équipe de Rétablissement des Cyprinidés et des Petits Percidés du Québec 2008). Recent climate trends and human channel alterations (e.g., dredging for shipping, water control structures) have concentrated the flow in the deep channel, and reduced flows in shallow habitats inhabited by the Eastern Sand Darter. A modelling exercise suggested that Eastern Sand Darter populations in the St. Lawrence River are sensitive to alterations in water levels and flows (Giguère *et al.* 2005).

The introduced Round Goby is a potential threat to most Eastern Sand Darter populations in Ontario and Québec. It was first found in North America in the St. Clair River in 1990 (Jude *et al.* 1992), has since spread to each of the Great Lakes and the St. Lawrence River system, and has become locally abundant in some areas. Predation and competition from the Round Goby has been implicated in declines of Mottled Sculpin (*Cottus bairdii*) and, possibly, Logperch populations in the St. Clair River (French and Jude 2001), and several darter species in lakes Erie and St. Clair (Thomas and Haas 2004; Baker 2005; Reid and Mandrak 2008). Impacts to Eastern Sand Darter populations have not been specifically studied, but are not expected to be positive. Over the last 5 years, the Round Goby has invaded at least six of the seven Ontario river systems historically occupied by Eastern Sand Darter, and the ranges of the two species now overlap in the four systems with extant Eastern Sand Darter populations. The Round Goby was first discovered in the St. Lawrence River near Québec in 1998, but is now widespread in the river where it occurs from Lac Saint-François to the limits of brackish waters, downstream of Québec City (P. Dumont, unpublished data). Presumably tributary streams to the St. Lawrence River with Eastern Sand Darter populations are vulnerable to invasion by the Round Goby. Introduced Zebra Mussels may have negatively affected habitat in Lake St. Clair, but it is not known if there have been impacts to Eastern Sand Darter in other habitats that have been invaded (Lake Erie, Thames River, St. Lawrence River).

Incidental harvest of Eastern Sand Darter in commercial bait fisheries is a potential threat although the species is not a legal baitfish under Ontario fishing regulations and harvest is prohibited under SARA (Edwards *et al.* 2007). Surveys of Québec commercial bait fish operations in the fall of 2005 and the summer of 2007 did not find any Eastern Sand Darter, although captures were made during scientific survey work nearby employing gear similar to the type used by the industry (Boucher *et al.* 2006; Garceau *et al.* 2008). Québec has prohibited commercial bait fishing in areas with Eastern Sand Darter populations. The potential impacts of incidental harvest in Ontario are unknown, but a similar study is currently being conducted in Ontario through the University of Toronto. A 1988 survey of the tanks of four Toronto baitfish dealers by Litvak and Mandrak (1993) did not find Eastern Sand Darter, but two more common darter species were found in the tanks (Blackside Darter and Johnny Darter).

The use of the biological insecticide *Bacillus thuringiensis israelensis* to control blackflies in Québec rivers has the potential to indirectly affect Eastern Sand Darter by reducing the abundance of their insect food supply. This bacterium has been shown to reduce the abundance of chironomids in a Minnesota wetland (Liber *et al.* 1998) and has been used extensively for blackfly control in some Québec rivers including the Rivière Saint-François (S. Nadeau, Fisheries and Oceans Canada, Ottawa, Ontario pers. comm.). The impacts of these pesticide applications are unknown, but are cause for concern.

ABORIGINAL TRADITIONAL KNOWLEDGE AND COMMUNITY KNOWLEDGE

At the time of writing, there was no Aboriginal Traditional Knowledge (Goulet, pers. comm. 2009) or Community Knowledge (Timm, pers. comm. 2009) available on the Eastern Sand Darter.

SPECIAL SIGNIFICANCE OF THE SPECIES

The Eastern Sand Darter is the only member of the genus *Ammocrypta* found in Canada, and is one of the few Canadian freshwater fishes that primarily exploits sandy habitats and related resources. Its fossorial behaviour is unusual for an adult freshwater fish in Canada. Although the Eastern Sand Darter is of limited value in terms of human use of the resource, it may be an important prey item for other species where it is abundant. The Eastern Sand Darter may serve as a host for the glochidia larvae of the endangered Round Hickorynut (COSEWIC 2003). In addition to contributing to the biodiversity of aquatic ecosystems, this species is an indicator of ecosystem health in an area of Canada that has dense human populations and intensive agricultural and urban development.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Eastern Sand Darter is listed as Threatened under Schedule 1 of the federal *Species at Risk Act*, and under Ontario's *Endangered Species Act, 2007*. These listings prohibit harvest or capture without specific authorization, but do not yet provide habitat protection. In Québec, the Eastern Sand Darter was listed as threatened under the *Act Respecting Threatened or Vulnerable Species* in October 2009. The Eastern Sand Darter is ranked as 'at risk' in Canada and Ontario, and as 'may be at risk' in Québec by the General Status of Wild Species in Canada (CESCC 2006).

The Eastern Sand Darter is listed as Vulnerable by the World Conservation Union (IUCN) (Giminez Dixon 1996) and by the American Fisheries Society (Jelks *et al.* 2008). Its global NatureServe rank also reflects this Vulnerable status (G3), and subnational ranks are between S1 and S2 in eight of the 11 jurisdictions in which it occurs (Table 1) (NatureServe 2008). The subnational rank for this species in Ontario and Québec is S2. The Eastern Sand Darter is most secure in Kentucky where it is ranked S4S5. It is listed as Endangered in one state (Pennsylvania), Threatened in four states (Illinois, Michigan, New York, Vermont), and as a Species of Concern in two states (Indiana, Ohio) (Grandmaison *et al.* 2004).

Table 1. Global, national and subnational heritage ranks for the Eastern Sand Darter (*Ammocrypta pellucida*) (NatureServe 2008).

Rank level	Rank	Jurisdictions
Global	G3	
National	N3	United States, Canada
Subnational	S4S5	Kentucky
	S3	Ohio
	S2S3	West Virginia
	S2	Indiana, New York, Ontario, Quebec
	S1S2	Michigan
	S1	Illinois, Pennsylvania, Vermont

A recovery strategy has been prepared for Eastern Sand Darter in Québec (Équipe de Rétablissement des Cyprinidés et des Petits Percidés du Québec 2008) and a draft national recovery strategy has also been prepared (Edwards *et al.* 2007). In Ontario, watershed-based ecosystem recovery strategies that include the Eastern Sand Darter have been prepared for the Ausable, Grand, Sydenham, and Thames river watersheds and Lake Erie. Several recovery actions associated with these strategies have been initiated, including stewardship initiatives to improve riparian and watershed health, the identification of important habitats, and research to address information gaps.

TECHNICAL SUMMARY 1 – DU 1 ONTARIO POPULATIONS

Ammocrypta pellucida - Ontario Populations
Eastern Sand Darter *dard de sable*
Range of Occurrence: Ontario

Demographic Information

Generation time (average age of parents in the population	2 yrs
Inferred continuing decline in number of mature individuals.	Yes
Estimated percent of continuing decline in total number of mature individuals within 5 years.	Unknown
Observed, estimated, inferred, or suspected percent reduction in total number of mature individuals over the last 10 years.	Unknown
Projected or suspected percent reduction in total number of mature individuals over the next 10 years.	Unknown
Observed, estimated, inferred, or suspected percent reduction in total number of mature individuals over any 10 year period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Some are
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated Extent of Occurrence (EO)	Current 10,840 km² Historic 19,534 km^2
Area of Occupancy (AO) Index of area of occupancy (IAO) 1 X 1 km grid (most suitable because of narrow linear habitats) 2 X 2 km grid	21 km² 304 km² 556 km²
Is the total population severely fragmented?	Yes
Number of locations	7
Observed continuing decline in extent of occurrence	45%
Is there an inferred continuing decline in index of area of occupancy?	Yes
Observed continuing decline in number of populations	Yes – at least 4 are presumed to have been extirpated
Observed continuing decline in number of locations	Yes
Is there an observed continuing decline in area, extent and quality of habitat?	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals in Each Population

Population	N Mature Individuals
Ausable River (0 – Presumed Extirpated) Sydenham River (unknown) Thames River (unknown, but large) Lake St. Clair (unknown, declining?) Catfish Creek (0 – Presumed Extirpated) Big Otter Creek (0 – Presumed Extirpated) Big Creek (unknown, but small) Grand River (unknown) Lake Erie – Long Point Bay (unknown, declining?) Lake Erie – Rondeau Bay (unknown) Lake Erie – Pelee Island (0? – Possibly Extirpated)	
Total	Unknown, but probably more than 10,000
Number of locations	7

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not Applicable

Threats (actual or imminent threats to populations or habitats)

Siltation of sand and fine gravel habitats from urban and agricultural development
Pollution from industrial activity, urban centres, and intensive agriculture
Impoundments
Stream channel alterations
Potential predation and competition from introduced Round Goby
Potential impacts from incidental harvest in commercial bait fisheries

Rescue Effect (immigration from an outside source)

Status of outside population(s)?
USA:
Michigan (S1S2), Ohio (S3). Pennsylvania (S1), New York (S2), Vermont (S1) – considered a rare species in adjacent U.S. jurisdictions. It is listed as a species at risk in all five adjacent states
CANADA:
Québec (S2) – rare and disjunct from Ontario populations

Is immigration known or possible?	Unlikely
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Unlikely

Current Status

COSEWIC:Threatened, November 2000, November 2009
SARA: Threatened – Schedule 1
ONTARIO: Threatened (ESA 2007)
QUÉBEC: Threatened (*Act Respecting Threatened or Vulnerable Species*)
GENERAL STATUS – CANADA: At Risk
GENERAL STATUS – ONTARIO: At Risk
GENERAL STATUS – QUÉBEC: May be at Risk

Status and Reasons for Designation

COSEWIC-approved Status:	**Alpha-numeric code:**
Threatened	B2ab(i,iii,iv,v)
Reasons 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.	

Applicability of Criteria

Criterion A (Declining Total Population): Not applicable, number of mature individuals unknown and % decline unknown.
Criterion B (Small Distribution, and Decline or Fluctuation): Meets Threatened B2ab(i, iii,iv,v). The area of occupancy (304 km^2) is below the threshold of 2000 km^2, there are less than 10 populations, and continuing decline has been observed in the EO, quality and quantity of habitat, number of locations, and number of mature individuals.
Criterion C (Small Total Population Size and Decline): Not applicable, the number of mature individuals probably exceeds 10,000.
Criterion D (Very Small Population or Restricted Distribution): Not applicable, number of individuals, IAO and number of locations exceed the threshold values.
Criterion E (Quantitative Analysis): Not applicable, no data.

TECHNICAL SUMMARY 2 – DU 2 QUEBEC POPULATIONS

Ammocrypta pellucida – Québec Populations
Eastern Sand Darter *dard de sable*
Range of Occurrence in Canada: Québec

Demographic Information

Generation time (average age of parents in the population	2 yrs
Inferred continuing decline in number of mature individuals.	Yes
Estimated percent of continuing decline in total number of mature individuals within 5 years.	Unknown
Observed, estimated, inferred, or suspected percent reduction in total number of mature individuals over the last 10 years.	Unknown
Projected or suspected percent reduction in total number of mature individuals over the next 10 years.	Unknown
Observed, estimated, inferred, or suspected percent reduction in total number of mature individuals over any 10 year period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Some are
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated Extent of Occurrence (EO)	Current 14,298 km² Historic 9924 km^2
Area of Occupancy (AO) Index of area of occupancy (IAO) 1 X 1 km grid (most suitable because of narrow linear habitats) 2 X 2 km grid	345 km² 493 km² 684 km²
Is the total population severely fragmented?	Yes
Number of locations	10 (may be as high as 15, but lack of sampling in 5 watersheds)
Observed continuing decline in extent of occurrence	32%
Is there an inferred continuing decline in index of area of occupancy?	Yes
Observed continuing decline in number of populations	Yes – at least 3 have probably been extirpated, and the fate of 5 others is uncertain
Observed continuing decline in number of locations	Yes
Is there an observed continuing decline in area, extent and quality of habitat?	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals in Each Population

Population	N Mature Individuals
Fleuve Saint-Laurent (unknown) Rivière des Mille Îles (unknown) Lac St. Pierre and Archipelago (unknown) Lac des Deux Montagnes (0 – probably extirpated) Rivière aux Saumons (unknown – new location) Rivière Châteauguay (declining and may be extirpated) Rivière à la Truite (unknown – new location) Rivière L'Assomption (unknown – new location) Rivière Ouareau (unknown – new location) Rivière Richelieu (may be large – new location) Lac Champlain Missisquoi Bay (unknown) Rivière Yamaska (0 - may be extirpated) Rivière Saint-François (0 – may be extirpated) Rivière Yamachiche (unknown – but no recent sampling) Rivière Bécancour (unknown – but no recent sampling) Rivière Gentilly (unknown – but no recent sampling) Rivière aux Orignaux (unknown – but no recent smapling) Petite Rivière du Chêne (unknown – but no recent sampling)	
Total	Unknown, but probably more than 10,000
Number of locations 10 (possibly 15)	

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not Applicable – no data

Threats (actual or imminent threats to populations or habitats)

Siltation of sand and fine gravel habitats from urban and agricultural development and commercial shipping in the St. Lawrence River
Pollution from industrial activity, urban centres, and intensive agriculture
Impoundments
Stream channel alterations
Potential predation and competition from introduced Round Goby
Potential impacts from incidental harvest in commercial bait fisheries

Rescue Effect (immigration from an outside source)

Status of outside population(s)?
USA:
Michigan (S1S2), Ohio (S3). Pennsylvania (S1), New York (S2), Vermont (S1) – considered a rare species in adjacent U.S. jurisdictions. It is listed as a species at risk in all five adjacent states
CANADA:
Ontario (S2) – species is rare and disjunct from Québec populations

Is immigration known or possible?	Unlikely
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Unlikely

Current Status

COSEWIC:Threatened (November 2009) SARA: Threatened – Schedule 1 ONTARIO: Threatened (ESA 2007) QUÉBEC: Threatened (*Act Respecting Threatened or Vulnerable Species*) GENERAL STATUS – CANADA: At Risk GENERAL STATUS – ONTARIO: At Risk GENERAL STATUS – QUÉBEC: May be at Risk

Status and Reasons for Designation

COSEWIC-approved Status:	**Alpha-numeric code:**
Threatened	B1ab(i,ii,iii,iv,v) + 2ab(i,ii,iii,iv,v)
Reasons for Designation: This species prefers sand bottom areas of lakes and streams in which it burrows. There is continuing decline in the already small and fragmented populations; three (of 18) have probably been extirpated, and the fate of five others is unknown due to lack of recent sampling. The extent of occurrence of this species in Québec is approximately two-thirds of what it was in the 1970s, despite records at five new sites in two locations. There is continuing habitat loss and degradation from historic and ongoing urban and agricultural development, stream channelization and competition with invasive alien species.	

Applicability of Criteria

Criterion A (Declining Total Population): Not applicable, number of mature individuals unknown and % decline unknown.
Criterion B (Small Distribution, and Decline or Fluctuation): Meets Threatened B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v). The extent of occurrence (9924 km²) and index of area of occupancy (493 km²) are below the threshold values (20,000 km² and 2000 km² respectively), the extant populations are severely fragmented, continuing decline has been observed in the extent of occurrence, area of occupancy, quality and quantity of habitat, and decline in the number of mature individuals is inferred from population losses.
Criterion C (Small Total Population Size and Decline): Not applicable, the number of mature individuals probably exceeds 10,000.
Criterion D (Very Small Population or Restricted Distribution): Not applicable, number of individuals, IAO, and number of locations exceed the threshold values.
Criterion E (Quantitative Analysis): Not applicable – no data.

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Nicholas E. Mandrak is a Research Scientist with the Canada Department of Fisheries and Oceans in Burlington, Ontario. His research interests are the biodiversity, biogeography and conservation of Canadian freshwater fishes. Nick has co-authored 26 COSEWIC reports.

Pierre Dumont is a fisheries biologist, who has worked in Québec freshwater ecosystems since early 1970s, when he was involved in the impact studies of the James Bay hydropower development. He has worked for the Québec government since 1978 in the St. Lawrence River lowlands. Pierre is mainly involved in scientific studies on the status and management of Lake Sturgeon, Yellow Perch and American Eel, on the long term monitoring of fish communities along the St. Lawrence River, on fish habitat improvement and on the restoration of the Copper Redhorse. He has also been involved in the restoration program for the European Sturgeon since 1998, when he had the chance to work at the Cemagref (Bordeaux, France) for one year. He acts as co-director of graduate students in four Quebec universities. Pierre has contributed to the writing of five COSEWIC status reports.

COLLECTIONS EXAMINED

Accession number UMMZ 85543 collected from the Ausable River in 1928 was examined and confirmed by Douglas Nelson from the University of Michigan Museum of Zoology.