Photo: Doug Watkinson

River Darter (Great Lakes – Upper St. Lawrence populations)

(Percina shumardi) in Ontario

Ontario Recovery Strategy Series

2018

Natural. Valued. Protected.

Ministry of Natural Resources and Forestry

Ontario

About the Ontario Recovery Strategy Series

This series presents the collection of recovery strategies that are prepared or adopted as advice to the Province of Ontario on the recommended approach to recover species at risk. The Province ensures the preparation of recovery strategies to meet its commitments to recover species at risk under the *Endangered Species Act 2007* (ESA) and the Accord for the Protection of Species at Risk in Canada.

What is recovery?

Recovery of species at risk is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

What is a recovery strategy?

Under the ESA a recovery strategy provides the best available scientific knowledge on what is required to achieve recovery of a species. A recovery strategy outlines the habitat needs and the threats to the survival and recovery of the species. It also makes recommendations on the objectives for protection and recovery, the approaches to achieve those objectives, and the area that should be considered in the development of a habitat regulation. Sections 11 to 15 of the ESA outline the required content and timelines for developing recovery strategies published in this series.

Recovery strategies are required to be prepared for endangered and threatened species within one or two years respectively of the species being added to the Species at Risk in Ontario list. Recovery strategies are required to be prepared for extirpated species only if reintroduction is considered feasible.

What's next?

Nine months after the completion of a recovery strategy a government response statement will be published which summarizes the actions that the Government of Ontario intends to take in response to the strategy. The implementation of recovery strategies depends on the continued cooperation and actions of government agencies, individuals, communities, land users, and conservationists.

For more information

To learn more about species at risk recovery in Ontario, please visit the Ministry of Natural Resources and Forestry Species at Risk webpage at: **www.ontario.ca/speciesatrisk**

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Declaration

The recovery strategy for the River Darter was developed in accordance with the requirements of the *Endangered Species Act, 2007* (ESA). This recovery strategy has been prepared as advice to the Government of Ontario, other responsible jurisdictions and the many different constituencies that may be involved in recovering the species.

The recovery strategy does not necessarily represent the views of all of the individuals who provided advice or contributed to its preparation, or the official positions of the organizations with which the individuals are associated.

The goals, objectives and recovery approaches identified in the strategy are based on the best available knowledge and are subject to revision as new information becomes available. Implementation of this strategy is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy.

Responsible jurisdictions

Ontario Ministry of Natural Resources and Forestry
Environment and Climate Change Canada – Canadian Wildlife Service, Ontario
Fisheries and Oceans Canada

Executive summary

The River Darter is a small (<94 mm), elongate fish in the perch family. The Great Lakes – Upper St. Lawrence populations have a highly localized, disjunct distribution in the Lake St. Clair drainage of southwestern Ontario. These populations have been assessed by the Committee on the Status of Species at Risk in Ontario (COSSARO) and are listed as Endangered under Ontario's *Endangered Species Act, 2007* (*ESA*). In this area, the species is rare and has only been collected 29 times in small and large rivers, and Lake St. Clair since first discovered in southwestern Ontario in 1973. As a result, its abundance and specific habitat preferences are unknown. The main threats to these populations are likely physical and chemical habitat alterations and invasive species.

The recommended recovery goal for the River Darter (Great Lakes – Upper St. Lawrence populations) is to recover or maintain self-sustaining, viable populations at historical and current sites, respectively, across the historical range. Based on the limited number of individuals caught since 1973, the species is likely currently in low abundance and may require population enhancement and/or reintroduction to maintain self-sustaining, viable populations.

The objectives for achieving this goal are:

1. Determine current distribution and long-term population abundance trends.
2. Determine habitat requirements for all life stages and long-term habitat trends.
3. Evaluate and minimize threats to the species and its habitat.
4. Determine necessity and feasibility of population enhancement and reintroduction.
5. Enhance recovery efforts through coordination with aquatic and terrestrial species and ecosystem recovery teams and other appropriate groups.
6. Improve overall awareness of River Darter and the role of healthy aquatic ecosystems, and their importance to humans.

Approaches to achieving protection and recovery include: addressing knowledge gaps through research; inventory; monitoring and assessment; education and outreach; and, stewardship. Local First Nations should be engaged as the potential exists for the species to be present on their land.

As the River Darter has a limited distribution in the Canadian Great Lakes basin, it is recommended that the habitat regulation include those areas where the species was historically or is currently found. As the specific habitat requirements of River Darter in the Great Lakes basin are unknown and, thus, a knowledge gap and recovery objective, the features of its habitat cannot be described at this time. Given that habitat is an extensive knowledge gap, the habitat regulation should be re-evaluated once the recovery objective of identifying the habitat requirements of the River Darter is addressed.

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1.0 Background information

1.1 Species assessment and classification

Table 1. Species assessment and classification of the River Darter (*Percina shumardi*), Great Lakes – Upper St. Lawrence populations. The glossary provides definitions for the abbreviations within, and for other technical terms in this document.

Assessment	Status
SARO List Classification	Endangered
SARO List History	Endangered (2017)
COSEWIC Assessment History	River Darter (Great Lakes – Upper St. Lawrence populations): Endangered (2016) River Darter: Not at Risk (1989)
SARA Schedule 1	No schedule, no status.
Conservation Status Rankings	GRANK: G5TNR NRANK: NNR SRANK: SNR

1.2 Species description and biology

Species description

River Darter is a small, elongated fish in the perch family (Percidae) that can grow, in Canada, to a maximum of 94 mm total length (TL) (Watkinson unpub. data). In Ontario, the average length is 50 mm TL (Holm et al. 2009). The large eyes are placed close together and high on the head (Kuehne and Barbour 1983), which has a short, rounded snout with a moderate-sized, terminal mouth (Scott and Crossman 1973, Stewart and Watkinson 2004). The spiny and soft dorsal fins are separated. Scales are ctenoid, and there are 46 to 62 lateral-line scales (Holm et al. 2009). While the breast is usually scaleless, scales are usually found on the cheeks and gill cover (Scott and Crossman 1973, Becker 1983). River Darter colouration varies from light brown to dark olive. Seven to eight faint saddles on the back and 8 to 15 indistinct lateral blotches or short vertical bars on the sides are present (Kuehne and Barbour 1983, Holm et al. 2009). Distinct bars drop from below the eyes, and small, well-defined caudal spots may also be present (Scott and Crossman 1973). Breeding males are generally darker (Scott and Crossman 1973, Smith 1979) and may develop nuptial tubercles on the caudal, anal

and pelvic fins, as well as on the vent and on the head under the eye and jaw (Kuehne and Barbour 1983). The enlarged anal fin of spawning males reaches almost to the caudal fin (Scott and Crossman 1973). Characteristics that distinguish the River Darter from the Channel Darter (*Percina copelandi*) and Blackside Darter (*Percina maculata*), which have overlapping distributions in southwestern Ontario (Holm et al. 2009), include a well-marked dark spot on the upper anterior and lower posterior corners of the spiny dorsal fin (Stewart and Watkinson 2004, Holm et al. 2009).

Species biology

There is no information on the age and maturity of Great Lakes – Upper St. Lawrence populations. River Darter collected from Manitoba and northwestern Ontario reached a maximum age of four years and were sexually mature at age one. In the United States, individuals can mature as early as age one and reach a maximum age of three (Thomas 1970) or four (Smith 1979), with a generation time of two years.

Photoperiod and temperature determine the reproductive cycle of River Darter (Hubbs 1985). There is no information on reproduction specific to the Great Lakes – Upper St. Lawrence populations. In other Canadian populations (Saskatchewan - Nelson River populations and Southern Hudson Bay - James Bay populations), spawning occurs from May to early July (Balesic 1971) while, in Louisiana at the southern extent of its range, spawning occurs from January to April (Hubbs 1985). River Darter predominantly spawns in rivers, but ripe individuals have been collected in lakes, suggesting that spawning can occur in a lake environment as well (Balesic 1971). In Canada, ripe (spawning ready) River Darter were collected in the Assiniboine River between June 22 and 24 at a water temperature of 24°C (Watkinson unpub. data). Males will typically be the first to move to spawning sites (Holm et al. 2009). During spawning, females will partially bury themselves in sand or gravel while the male rests on top, holding the female with his pelvic fins (Dalton 1990). While the pair vibrates, eggs are singly deposited, then fertilized. Spawning occurs several times over several weeks with different partners (Holm et al. 2009). Balon (1975) categorized River Darter breeding behaviour as non-guarding, brood-hiding lithophilic – eggs are typically deposited in substrate and not guarded. Balesic (1971) noted that the eggs were adhesive and hatched nine days after fertilization in 19 to 21°C water and that larvae were 5 to 6.5 mm long and swimming within several hours of hatching. There is no parental guarding of eggs and young (Dalton 1990). River Darter has been known to hybridize with Logperch (*Percina caprodes*) (Trautman 1981).River Darter feeds primarily during daylight hours (Thomas 1970), consuming a wide variety of food items (Balesic 1971). There is no information on feeding and diet specific to the Great Lakes – Upper St. Lawrence populations. Stomach contents of fish from Illinois and Manitoba included dipterans, trichopterans, ephemeropterans, crustaceans and fish eggs (Thomas 1970, Balesic 1971). Fish from Manitoba also consumed corixids and fishes (Balesic 1971). Gastropods may be an important component of River Darter diet in Alabama, Tennessee and Manitoba (Balesic 1971, Starnes 1977, Haag and Warren 2006). River Darter collected from northwestern Ontario and southeastern Manitoba indicated

consumed dipterans, trichopterans, ephemeropterans, crustaceans and gastropods (Pratt et al. 2015a, 2015b, 2016). The study took place in June, September and October, and dominance of prey items varied between sites and seasons, likely reflecting differences in prey availability.

While there is little information available regarding River Darter physiology and adaptability, Cavadias (1986) studied swim-bladder lift in the field and laboratory. Results of the study found that River Darter would adjust swim-bladder lift based on the amount of current to which they were exposed, reducing lift in higher current, and increasing it in lower current.

Seasonal variation in abundance of River Darter in rivers can occur, with upstream spawning migrations into rivers occurring in May to July in Manitoba (Balesic 1971). Balesic (1971) also found that downstream dispersal may occur in rivers as the surface-water velocities would typically be greater than the larvae's swimming speed, as indicated by laboratory observations of larval River Darter swimming position near the top of the water column (Balesic 1971).

1.3 Distribution, abundance and population trends

Of the darter species, River Darter, along with Logperch and Johnny Darter (*Etheostoma nigrum*), has one of the largest latitudinal distributions (Page and Burr 2011). Its distribution extends north from the Texas coast on the Gulf of Mexico to the Nelson River near Hudson Bay in northern Manitoba (Scott and Crossman 1973, Stewart and Watkinson 2004, Page and Burr 2011) and east from the Saskatchewan River in Saskatchewan to the Lake St. Clair watershed in Ontario (COSEWIC 2016).

The River Darter has only been collected in the Canadian Great Lakes basin since 1973 (COSEWIC 2016), long after aquatic ecosystems had been impacted by numerous threats, and the distribution and abundance of its original populations are unknown. In the Canadian Great Lakes basin (Figure 1), River Darter has only been caught in Lake St. Clair (14 collections, 1973 - 2013) and its tributaries: Bear Creek (one collection, 1997); Thames River (four collections, 1991 - 2016) and its tributary, Raleigh Plains Drain (one collection, 1989); and, the Sydenham River (nine collections, 1975 - 2012) (COSEWIC 2016; this document) despite extensive sampling with appropriate gear (Edwards and Mandrak 2006, Mandrak et al. 2006, Marson et al. 2009, COSEWIC 2016). Since the publication of the most recent COSEWIC (2016) report, two additional collections were made in the Thames River, one in each of 2015 and 2016. Based on the lack of records in the last 20 years, Raleigh Plains Drain should be considered a historical site. In the last 20 years, the western Lake St. Clair and Raleigh Plains Drain records have been lost and Bear Creek records gained. As a result, the Index of Area of Occupancy has changed little between historical and current time periods. As River Darter continues to be rare in the Great Lakes basin (Pratt et al. 2015a, 2015b, 2016), estimates of changes and fluctuations in population size and density cannot be made.

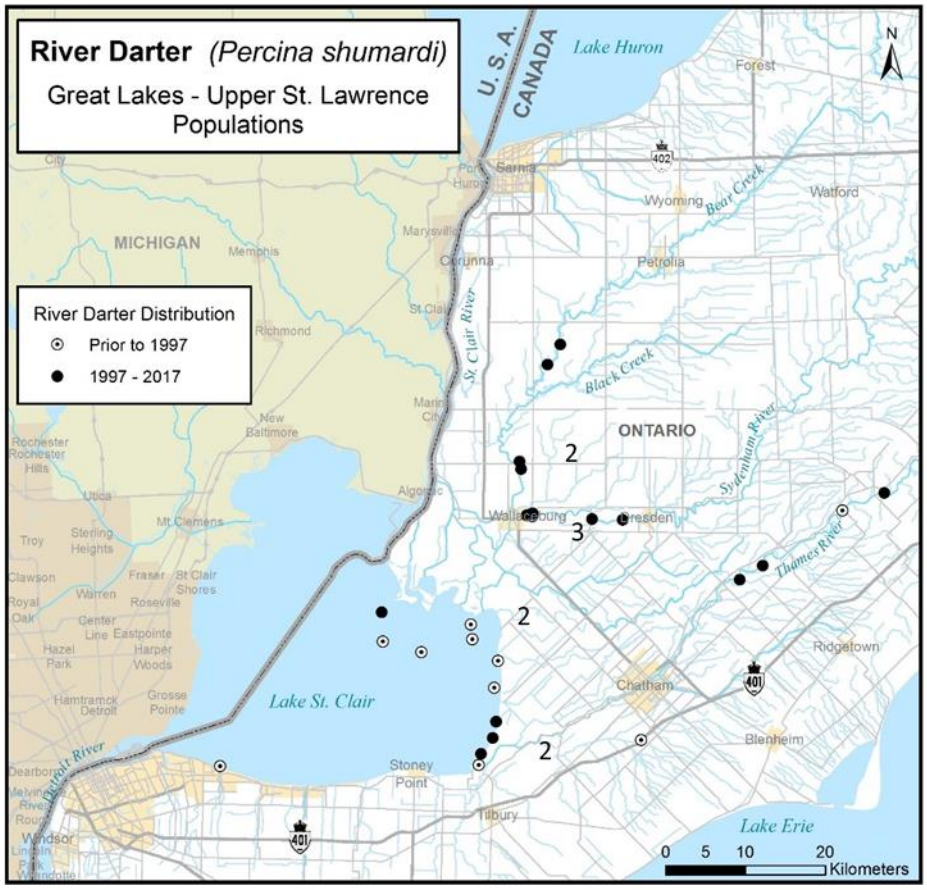

Figure 1. Historical (pre-1997) and current (1997-present) distribution of the Great Lakes – Upper St. Lawrence Populations of River Darter.

1.4 Habitat needs

River Darter is a benthic species mainly collected from medium- to large- sized rivers or from nearshore areas of lakes (Balesic 1971, Stewart and Watkinson 2004), although it has been found in small rivers (i.e. Bear Creek, Raleigh Plains Drain) in the Lake St. Clair drainage. It is associated with moderate currents and deeper water over a variety of substrates (Thomas 1970, Pfleiger 1971, Scott and Crossman 1973, Becker 1983, Kuehne and Barbour 1983). Given the paucity of records and habitat data, little is known specifically about its habitat in the Canadian Great Lakes basin. It has been collected in the clear waters of Lake St. Clair over sand substrates in less than 3 m of water, and in large (i.e. Sydenham, Thames) and small highly turbid rivers. These systems are found in an area of southwestern Ontario highly modified by agriculture and the current riverine habitats likely do not reflect the habitat present prior to European colonization. Fisheries and Oceans Canada (DFO) collected 11 River Darter and measured habitat between 2012 and 2016 at one site on the Sydenham River and three sites on the Thames River (Table 2). Habitat was variable between these locations. The most consistent habitat variables were large stream width (mean=45.67±1.13 m), high turbidity (≥61.8 Nephelometric Turbidity Unit (NTU)), little channel cover (≤5%), and the lack of aquatic vegetation (dominant aquatic vegetation characterized as “none; open water”). Such habitat is widely present in the Sydenham and Thames rivers within and beyond the sites occupied by River Darter.

Sampling conducted with Missouri and mini-Missouri trawls (Herzog et al. 2005, 2009) in the Assiniboine River, Manitoba found River Darter to be the third most common species collected (Watkinson unpub. data). It was most frequently collected in moderate water velocities (0.4 - 0.85 m/s) and depths (0.8 - 1.8 m). River Darter catches were highest over gravel and cobble substrates. Sampling conducted with a mini-Missouri trawl, predominantly in lakes of northwestern Ontario, collected River Darter over gravel and cobble substrates at a mean depth of 3.7 m. The deepest documented record of a River Darter was in Lake Winnipeg at 15 m (a single specimen collected with a beam trawl) (Watkinson unpub. data).

Clean gravel and cobble substrates may be important for spawning and feeding (COSEWIC 2016). Adults and juveniles are often collected together when sampling. Being tolerant of turbid waters (Balesic 1971, Pfleiger 1971, Cooper 1983, Sanders and Yoder 1989), it can be the most common darter in turbid rivers (Cooper 1983, Kuehne and Barbour 1983, Watkinson unpub. data). In the middle reaches of the Assiniboine River, Manitoba, with Secchi readings of ~0.7 m (moderate turbidity levels), River Darter abundance is highest (Watkinson unpub. data). Information is not available on the site fidelity or home-range size of River Darter, although site fidelity in darters is likely high given their small size and limited dispersal ability.

Table 2. Summary of the habitat variables measured where 11 River Darter were caught by Fisheries and Oceans Canada at one site in the Sydenham River and at three sites in the Thames River, 2012-2016.

Date of Capture	**20-Sep-12**	**20-Sep-12**	**25-Jun-14**	**18-Jun-15**	**19-Jun-15**	**21-Jul-16**	**Mean**	**Std**	**Min**	**Max**
Waterbody Name	Sydenham River	Sydenham River	Thames River	Thames River	Thames River	Thames River				
Latitude	42.59811	42.59819	42.60976	42.53209	42.51767	42.51743				
Longitude	-82.35909	-82.35969	-81.8195	-82.00846	-82.04396	-82.04417				
Number of River Darter Caught	1	1	1	1	1	6				
Water Temperature	19.6	19.6	23.5	22.8	21.3	26.5	22.2	2.6	19.6	26.5
Conductivity (µs)	522.0	522.0	686.5	327.0	657.6	677.5	565.4	138.8	327.0	686.5
Dissolved Oxygen	6.15	6.15	7.77	Unavailable	7.56	7.4	7.01	0.79	6.15	7.77
pH	8.54	8.54	9.05	Unavailable	8.25	8.87	8.65	0.31	8.25	9.05
Secchi Tube (m)	0.14	0.14	0.6	0.12	0.14	0.07	0.20	0.20	0.07	0.60
Turbidity (NTU)	61.8	61.8	151.8	Unavailable	81.27	78.01	86.94	37.36	61.80	151.80
Stream Width (m)	45.5	45.5	46.0	45.5	44.0	47.5	45.67	1.13	44.00	47.50
Bank Slope (%)	5	5	80	55	45	60	41.67	2.64	5.00	80.00
Channel Cover (%)	5	5	0	0	0	5	2.50	2.64	0.00	5.00
Average Stream Depth (m)	3.53	3.53	1.10	1.50	2.70	1.53	2.32	0.99	1.10	3.53
Average Water Velocity (m/sec)	0.02	0.02	0.52	0.98	0.74	0.20	0.41	0.36	0.02	0.98
Floodplain Use	Residential	Residential	Agricultural	Shrubs/ woodland	Shrubs/ woodland	Shrubs/ woodland				
Dominant Substrate	Clay	Clay	Gravel	Cobble	Cobble	Gravel				
Dominant Aquatic Vegetation	Open Water	Open Water	Open Water	Open Water	Open Water	Open Water				
Dominant Riparian Vegetation	Herbaceous	Herbaceous	Deciduous	Deciduous	Herbaceous	Herbaceous				

1.5 Threats to survival and recovery

Great Lakes – Upper St. Lawrence populations of River Darter are found in an area of the highest human impacts on freshwater ecosystems in the country (Chu et al. 2015). These populations may be impacted by physical and chemical alterations, household, urban, industrial, or agricultural activities, sediment loading, and invasive species (COSEWIC 2016). Our knowledge of the magnitude and extent of these threats on River Darter populations is limited. River Darter abundance in the Great Lakes basin may never have been high (Pratt et al. 2015a, 2015b, 2016).

Physical alterations

Physical habitat alterations may negatively be impacting Great Lakes – Upper St. Lawrence populations of River Darter. As a result of agricultural practices and urbanization, there have been significant physical changes in the Sydenham and Thames river watersheds (Staton et al. 2003, TRRT 2004). Prior to European settlement, the Sydenham River watershed contained 70% forest and 30% wetland (Staton et al. 2003). Currently, most wetlands are now drained and, by 1983, only 12% of the watershed was forested (Staton et al. 2003).

The hardening of shorelines, including Lake St. Clair, has been suggested as a threat for at-risk fish species (EERT 2008). Degradation and/or loss of gravel and cobble substrates in rivers and the exposed shorelines of lakes is a possible threat to the habitat of the River Darter, similar to other darter species (Grandmaison et al. 2004, Bouvier and Mandrak 2010, DFO 2011). Bank hardening is extensive along large portions of the south shore of Lake St. Clair. However, the extent to which this impacts River Darter is currently unknown.

Dredging occurs in Lake St. Clair and occasionally its tributaries. Considering that River Darter deposit eggs into the substrate during spawning (Simon 1999), dredging can be inferred as a potential threat to spawning sites (Freedman 2010). Freedman (2010) found that dredged sites had an overall reduction in the numbers and diversity of small fishes likely because of decreased food availability or forage efficiency and impacts resulting from sedimentation. Overall, this ongoing threat to the Great Lakes – Upper St. Lawrence populations is considered to be small in spatial scope and moderate-high severity (COSEWIC 2016) with medium certainty.

Dams likely have a limited effect on the Great Lakes-St. Lawrence population of River Darter (COSEWIC 2016). All known locations of River Darter are below the lowermost dams in the Sydenham and Thames rivers, except for the Darcy McKeough Dam and Diversion Channel in the Sydenham River. This dam remains open at all times and does not obstruct flow except when downstream flooding in Wallaceburg is imminent, at which time the gates are closed and floodwaters diverted directly to the St. Clair River (Parish Geomorphic 2000). As of 2000, the diversion had been used six times for a few

days each since its construction in 1984 (Parrish 2000). Dams in the North Sydenham River drainage at Brigden on Bear Creek and Wilkesport on Black Creek, and at Dresden on the Sydenham River, may prevent the upstream dispersal of River Darter, but the species is not known to have been present above these dams. River Darter was documented to disperse upstream after a dam removal in the Cahaba River, Alabama (Bennett et al. 2015).The lowest dam in the Thames River (Springbank Dam in London) is several hundred kilometers of the nearest River Darter record.Chemical habitat alterations

Southwestern Ontario is a hotspot for toxic spill events (e.g., manure, chemicals, petroleum products, etc.). Agricultural growth has contributed to an increase risk of manure spills; during the period from 1988-1998, 214 manure spills were reported in southwestern Ontario, resulting in 42 known fish kills (Environmental Commissioner of Ontario 2002). Urban development has contributed to increased discharge of a variety of contaminants, including salt, pesticides, heavy metals, hydrocarbons, and fertilizers, all of which can enter the watercourse with runoff.

Excessive nutrient enrichment from agricultural activities is a problem in the Lake St. Clair watershed (Staton et al. 2003; TRRT 2004). The Sydenham and Thames rivers continue to be below standards set by the provincial government for acceptable levels of key parameters such as total phosphorus and *E. coli*, which could impact fishes via their influence on dissolved oxygen levels (TRRT 2004; SCRCA 2008).

Declines in closely related darter species, Channel Darter (*Percina copelandi*) and Logperch (*Percina caprodes*), have been linked to eutrophication (Reid and Mandrak 2008) and reduced oxygen conditions (Clady 1977), respectively.

Sediment loading

Sediment loading occurs throughout much of the Great Lakes basin where River Darter occurs. Sediment loading affects inland watercourses, coastal wetlands, and nearshore habitats by decreasing water clarity, increasing the proportion of fine substrates, (e.g. silt), and may have a role in the selective transport of pollutants and nutrients including phosphorus. It may impact both the species and its habitat. Sediment loading increases turbidity that affects a species' vision and may inhibit respiration. Turbidity is high in the Sydenham and Thames watersheds (>60 NTU) in 2012 and 2016 DFO samples), probably a result of agricultural runoff facilitated by the widespread use of tile drainage (Staton et al. 2003).

Siltation can potentially impact the habitat and, hence, abundance of benthic prey for River Darter (Holm and Mandrak 1996), as well as smother their eggs laid in the substrate (Finch 2009). The impacts of high sediment loads on the River Darter in Canada are not known. The species is likely more tolerant of high levels of suspended solids (i.e., turbidity) (Pflieger 1975, Trautman 1981) given that it occurs in turbid systems throughout its range. Overall, this ongoing threat to the Great Lakes – Upper

St. Lawrence populations of River Darter is considered to be pervasive in spatial scope and moderate severity (COSEWIC 2016) with high certainty. Roseman et al. (2009) indicated that six species, including River Darter, have declined appreciably due to loss of clear-water stream habitat in the Lake Huron basin.

Invasive species

Impacts of invasive dreissenid mussels on the benthic fauna of Lake St. Clair have been documented (Griffiths 1993), but impacts specific to River Darter through the reduction of turbidity, benthic prey, or benthic space, but have not been studied. Other impacts may occur from invasive species by direct competition for space and habitat, competition for food, and restructuring of aquatic food webs (Thomas and Haas 2004, Poos et al. 2010, Burkett and Jude 2015). At least 182 exotic species have invaded the Great Lakes basin since 1840 (Ricciardi 2006) and some of these species may affect River Darter populations to some extent. The Round Goby (*Neogobius melanostomus*), whose distribution overlaps with River Darter in Lake St. Clair, Thames River, and the Sydenham River, has been implicated in the decline of other benthic species, including darters, and may negatively impact the River Darter through direct competition for food resources as the two species share a number of prey items (Balesic 1971, French and Jude 2001, Burkett and Jude 2015) and occupy similar habitats. Round Goby can feed on fish eggs and larvae (Thomas and Haas 2004, Poos et al. 2010), potentially including those of River Darter; however, more recently, Burkett and Jude (2015) found that eggs may not constitute an important component of Round Goby diet. Overall, the ongoing threat of invasive species to the Great Lakes – Upper St. Lawrence populations of River Darter is considered to be pervasive in spatial scope and slight-serious severity (COSEWIC 2016) with low certainty.

1.6 Knowledge gaps

There are many knowledge gaps associated with the Great Lakes – Upper St. Lawrence populations of River Darter that limit guidance for management of this species. Key among these gaps is knowledge of the current distribution, long-term population trends, effective population size, reproductive biology (e.g. fecundity at size and age, clutch size, spawning sex ratios), other vital rates such as stage-based survival, larval drift, genetic population structure, and habitat requirements (see Table 3). An optimal sampling methodology for this species is key to addressing these knowledge gaps. Furthermore, there is a need to investigate the magnitude, extent, and cumulative impacts of threats to River Darter, which is required to more effectively guide threat mitigation actions, such as evaluating the necessity and feasibility of population enhancement and reintroduction. At the time of the writing of this strategy, there was no Aboriginal Traditional Knowledge available for River Darter.

2.0 Recovery

2.1 Recommended recovery goal

The recommended recovery goal for the River Darter (Great Lakes – Upper St. Lawrence populations) is to restore and maintain self-sustaining, viable populations at historical and current sites, respectively, across the historical range. Based on the limited number of individuals caught, the species is likely in low abundance and may require population enhancement and/or reintroduction to maintain self-sustaining, viable populations.

2.2 Recommended protection and recovery objectives

Table 3. Recommended protection and recovery objectives.

Number	Protection or recovery objective
1	Determine current distribution and long-term population abundance trends.
2	Determine habitat requirements for all life stages and long-term habitat trends.
3	Determine key life-history traits.
4	Evaluate and minimize threats to the species and its habitat.
5	Determine necessity and feasibility of population enhancement and reintroduction.
6	Enhance recovery efforts through coordination with aquatic and terrestrial species and ecosystem recovery teams and other appropriate groups.
7	Improve overall awareness of River Darter and the role of healthy aquatic ecosystems, and their importance to humans.

2.3 Recommended approaches to recovery

Table 4. Recommended approaches to recovery of the River Darter (Great Lakes – Upper St. Lawrence populations) in Ontario.

Objective 1: Determine current distribution and long-term population trends.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Critical	Short-term	Research	**1.1** Identify appropriate sampling method to inventory current distribution and monitor long-term population trends. • Conduct study to determine best gear and effort to capture the species and optimal sampling methodology.	Knowledge gaps: • Optimal sampling methodology.
Critical	Short-term	Inventory	**1.2** Inventory current distribution. • Conduct in current and potential habitats within Bear Creek, Lake St. Clair, lower Thames River, Raleigh Plains drain, and Sydenham River. • Use optimal sampling methodology (see Objective 1.1). • Use habitat model (see Objective 2) to guide choice of sampling locations.	Knowledge gaps: • Extent of current distribution.
Critical	Ongoing	Monitoring and Assessment	**1.3** Implement long-term monitoring of population trends in known habitats within Sydenham River, lower Thames River and Lake St. Clair. • Use optimal sampling methodology (see Objective 1.1). • Conduct genetic analyses to determine past and present effective population sizes and bottlenecks.	Knowledge gaps: • Long-term population trends. • Effective population size.
Necessary	Ongoing	Inventory, Monitoring and Assessment, Education and Outreach, Stewardship	**1.4** Engage local First Nations and stakeholders. • Inventory current distribution. • Implement long-term monitoring of population trends if species found.	Knowledge gaps: • Extent of current distribution. • Long-term population trends.

Objective 2: Determine habitat requirements and long-term habitat trends.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Critical	Short-term	Research	**2.1** Identify habitat requirements for all life stages. • Conduct habitat mapping within current and historical range. • Conduct studies to determine habitat requirements. • Develop habitat models to predict potential distribution.	Threats: • Physical and chemical habitat alteration. Knowledge gaps: • Habitat requirements.
Critical	Ongoing	Monitoring and Assessment	**2.2** Implement long-term monitoring of habitat trends in known habitats within Sydenham River, lower Thames River and Lake St. Clair.	Knowledge gaps: • Long-term habitat trends.
Critical	Short-term	Protection	**2.3** Develop habitat regulation. • Address knowledge gaps based on Objectives 1 and 2.1-2.3 prior to developing habitat regulation.	Knowledge gaps: • Habitat requirements.
Necessary	Ongoing	Inventory, Monitoring and Assessment, Education and Outreach, Stewardship	**2.4** Engage local First Nations and stakeholders. • Implement long-term monitoring of habitat trends if species found,	Knowledge gaps: • Long-term habitat trends.

Objective 3: Determine key life-history traits.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Necessary	Short-term	Research	**3.1** Identify reproductive biology. • Conduct studies to determine reproductive biology.	Knowledge gaps: • Fecundity at size and age, clutch size, spawning sex ratios, larval drift.
Necessary	Short-term	Research	**3.2** Identify survival rates for all life stages. • Conduct studies to determine survival rates.	Knowledge gaps: • Stage-based survival.

Objective 4: Evaluate and minimize threats to the species and its habitat.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Critical	Short-term	Research	**4.1** Confirm threats. • Conduct lab and field studies to determine threshold to, magnitude and extent of, hypothesized threats.	Threats: • Physical and chemical habitat alterations. • Invasive species. Knowledge gaps: • Magnitude and extent of threats.
Critical	Ongoing	Protection, Research, Stewardship	**4.2** Implement threat mitigation. • Conduct lab and field studies to evaluate effectiveness of potential threat mitigation actions. • Implement potentially effective threat mitigation actions. • Evaluate effectiveness of implemented threat mitigation actions.	Threats: • Physical and chemical habitat alterations. • Invasive species. Knowledge gaps: • Effective threat mitigation actions.
Necessary	Ongoing	Protection, Stewardship	**4.3** Engage local First Nations and stakeholders. • Implement potentially effective threat mitigation actions if species found.	Threats: • Physical and chemical habitat alterations. • Invasive species.

Objective 5: Determine necessity and feasibility of population enhancement and reintroduction.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Necessary	Short-term	Management, Stewardship	**5.1** Evaluate necessity and feasibility of population enhancement and reintroduction. • Conduct assessment of population enhancement and reintroduction feasibility, including population viability and genetic population analyses.	Threats: • Physical and chemical habitat alterations. • Invasive species. Knowledge gaps: • Population enhancement and reintroduction feasibility. • Genetic population structure. • Effective population size.
Beneficial	Long-term	Research, Management, Stewardship	**5.2** Develop husbandry methods if population enhancement and reintroduction deemed necessary and feasible. • Conduct study to determine how to spawn and rear River Darter in captivity.	Threats: • Physical and chemical habitat alterations. • Invasive species. Knowledge gaps: • Population enhancement and reintroduction feasibility.
Beneficial	Long-term	Management, Stewardship	**5.3** Identify potential locations for population enhancement or reintroduction if deemed necessary and feasible. • Using the results of population and habitat inventory, monitoring, and modeling, identify potential locations for suitable and sustainable population enhancement or reintroduction.	Threats: • Physical and chemical habitat alterations. • Invasive species. Knowledge gaps: • Population enhancement and reintroduction feasibility.

Objective 6: Enhance recovery efforts through coordination with aquatic and terrestrial species and ecosystem recovery teams and other appropriate groups.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Necessary	Ongoing	Education and Outreach, Communication, Stewardship	**6.1** Coordinate with other recovery teams and appropriate groups. • Communicate with other recovery teams and appropriate groups.	Threats: • Physical and chemical habitat alterations. • Invasive species.

Objective 7: Improve overall awareness of River Darter and the role of healthy aquatic ecosystems, and their importance to humans.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Necessary	Ongoing	Protection, Education and Outreach, Communication	**7.1** Conduct outreach on the species to relevant groups to make them aware of the existence of this species and how to protect it and its habitat. • Meet with local First Nations. • Provide outreach material to baitfish harvesters, dealers and users, and the general public. • Provide information for biologists with government agencies, municipalities and consulting firms.	Threats: • Physical and chemical habitat alterations. • Invasive species.

2.5 Area for consideration in developing a habitat regulation

Under the *ESA*, a recovery strategy must include a recommendation to the Minister of Natural Resources and Forestry on the area that should be considered in developing a habitat regulation. A habitat regulation is a legal instrument that prescribes an area that will be protected as the habitat of the species. The recommendation provided below by the author will be one of many sources considered by the Minister when developing the habitat regulation for this species.

As the River Darter has a limited distribution in the Canadian Great Lakes basin, it is recommended that the habitat regulation include areas of Lake St. Clair, Bear Creek, Sydenham River, and Thames River where the species is currently found (Figure 1). These systems are found in an area of southwestern Ontario highly modified by agriculture and the current riverine habitats likely do not reflect the habitat present prior to European colonization. As the specific habitat requirements of River Darter in the Great Lakes basin are largely unknown and, thus, a knowledge gap and recovery objective, the specific features of its habitat cannot be described at this time. For riverine records, ecological stream classifications group stream segments with similar landscape-level features that may be correlated to fish distributions. River Darter may be present in other areas of Bear Creek, Sydenham River, and Thames River in the same aquatic ecosystem class as the sites where it has been found. Therefore, a preliminary habitat regulation for the tributaries could apply to occupied segments and contiguous areas of the same ecological classification, identified by ecological stream classifications such as the Aquatic Landscape Inventory System (Stanfield and Kuyvenhoven 2003) or a new unpublished MNRF stream classification (N. Jones, pers. comm. 2017).

For Lake St. Clair, the River Darter has been collected over sand substrate in depths of less than 3 m, which are found throughout much of the Canadian waters of Lake St. Clair (GLAHF 2017). Therefore, a preliminary habitat regulation for Lake St. Clair could apply to currently occupied sites and contiguous areas with sand substrate.

Given that habitat is an extensive knowledge gap, the habitat regulation should be re-evaluated once the recovery objective of identifying the habitat requirements of the River Darter is addressed.

Glossary

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): The committee established under section 14 of the Species at Risk Act that is responsible for assessing and classifying species at risk in Canada.

Committee on the Status of Species at Risk in Ontario (COSSARO): The committee established under section 3 of the *Endangered Species Act, 2007* that is responsible for assessing and classifying species at risk in Ontario.

Conservation status rank: A rank assigned to a species or ecological community that primarily conveys the degree of rarity of the species or community at the global (G), national (N) or subnational (S) level. These ranks, termed G-rank, N-rank and S-rank, are not legal designations. Ranks are determined by NatureServe and, in the case of Ontario's S-rank, by Ontario's Natural Heritage Information Centre. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by the letter G, N or S reflecting the appropriate geographic scale of the assessment. The numbers mean the following:

1 = critically imperilled
2 = imperilled
3 = vulnerable
4 = apparently secure
5 = secure
NR = not yet ranked

Ctenoid scale: Type of fish scale with many tiny projections on the edge like the teeth of a comb, making the scale rough to the touch.

Endangered Species Act, 2007 (ESA): The provincial legislation that provides protection to species at risk in Ontario.

Invasive species: Species not native to an area, but introduced and having negative ecological impacts.

Nuptial tubercles: Small raised bumps on certain areas of the fish that typically only appear during spawning season.

Species at Risk Act (SARA): The federal legislation that provides protection to species at risk in Canada. This act establishes Schedule 1 as the legal list of wildlife species at risk. Schedules 2 and 3 contain lists of species that at the time the Act came into force needed to be reassessed. After species on Schedule 2 and 3 are reassessed and found to be at risk, they undergo the SARA listing process to be included in Schedule 1.

Species at Risk in Ontario (SARO) List: The regulation made under section 7 of the *Endangered Species Act, 2007* that provides the official status classification of

species at risk in Ontario. This list was first published in 2004 as a policy and became a regulation in 2008.

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List of abbreviations

COSEWIC: Committee on the Status of Endangered Wildlife in Canada
COSSARO: Committee on the Status of Species at Risk in Ontario
CWS: Canadian Wildlife Service
DFO: Fisheries and Oceans Canada
ESA: Ontario's *Endangered Species Act, 2007*
MNRF: Ontario Ministry of Natural Resources and Forestry
NTU: Nephelometric Turbidity Unit
SARA: Canada's Species at Risk Act
SARO: Species at Risk in Ontario