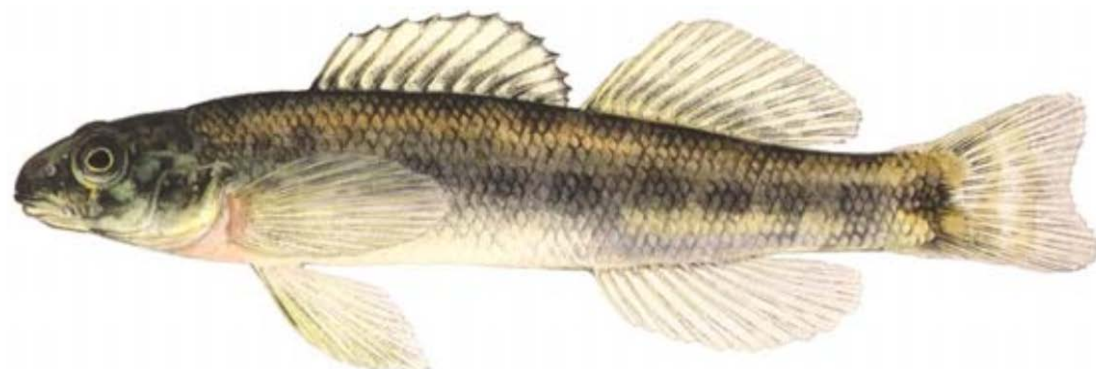
COSEWIC
Assessment and Status Report

on the

Channel Darter
Percina copelandi

Lake Erie populations
Lake Ontario populations
St. Lawrence populations

in Canada



Lake Erie populations - ENDANGERED
Lake Ontario populations - ENDANGERED
St. Lawrence populations - SPECIAL CONCERN
2016

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:

COSEWIC. 2016. COSEWIC assessment and status report on the Channel Darter *Percina copelandi*, Lake Erie populations, Lake Ontario populations and St. Lawrence populations, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xvi + 68 pp. (http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1).

Previous report(s):

COSEWIC 2002. COSEWIC assessment and update status on report on the channel darter *Percina copelandi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 21 pp.

Phelps, A., and A. Francis. 2002. Update COSEWIC status report on the channel darter *Percina copelandi* in Canada, *in* COSEWIC assessment and update status on report on the channel darter *Percina copelandi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-21 pp.

Goodchild, C.D. 1993. COSEWIC status report on the channel darter *Percina copelandi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 24 pp.

Production note:
COSEWIC would like to acknowledge Jean-Sebastien Moore, Dominic Nowasad and John Mee for writing the status report on the Channel Darter, *Percina copelandi,* in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Nick Mandrak, Co-chair of the COSEWIC Freshwater Fishes Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Fouille-roche gris (*Percina copelandi*), populations du lac Érié, populations du lac Ontario et populations du Saint-Laurent, au Canada.

Cover illustration/photo:
Channel Darter — Illustration by © Ellen Edmonson (NYSDEC).

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COSEWIC
Assessment Summary

Assessment Summary – November 2016

Common name
Channel Darter - Lake Erie populations

Scientific name
Percina copelandi

Status
Endangered

Reason for designation
This small-bodied species occupies nearshore lake and river habitats that are undergoing major shoreline modifications and the negative impact of the invasive Round Goby, having resulted in likely extirpation from large areas of Lake Erie and Lake St. Clair.

Occurrence
Ontario

Status history
The species was considered a single unit and designated Threatened in April 1993. Status re-examined and confirmed in May 2002. When the species was split into separate units in November 2016, the "Lake Erie populations" unit was designated Endangered.

Assessment Summary – November 2016

Common name
Channel Darter - Lake Ontario populations

Scientific name
Percina copelandi

Status
Endangered

Reason for designation
This small-bodied species is limited to three small watersheds. The primary threat is the invasive Round Goby, which is now found throughout the Trent River and has resulted in declines in the abundance of this population. For the time being, populations along the Moira and Salmon rivers are largely unaffected by Round Goby. However, introductions upstream of dams via bait bucket transfers are considered likely**.**

Occurrence
Ontario

Status history
The species was considered a single unit and designated Threatened in April 1993. Status re-examined and confirmed in May 2002. When the species was split into separate units in November 2016, the "Lake Ontario populations" unit was designated Endangered.

Assessment Summary – November 2016

Common name
Channel Darter - St. Lawrence populations

Scientific name
Percina copelandi

Status
Special Concern

Reason for designation
This small-bodied species is broadly distributed, but there is evidence of extirpation at some localities within its range. The species is subjected to a variety of threats related to the impact of the invasive Round Goby and pollution. The species may become Threatened if these threats are not effectively managed.

Occurrence
Ontario, Quebec

Status history
The species was considered a single unit and designated Threatened in April 1993. Status re-examined and confirmed in May 2002. When the species was split into separate units in November 2016, the "St. Lawrence populations" unit was designated Special Concern.

COSEWIC
Executive Summary

Channel Darter
Percina copelandi

Lake Erie populations
Lake Ontario populations
St. Lawrence populations

Wildlife Species Description and Significance

The Channel Darter is a small (less than 72 mm total length) bottom-feeding fish that inhabits lake and river habitats. It is one of 12 species of the darter subfamily (Etheostomatinae) found, and one of four species of the genus *Percina*, in Canada. It can be distinguished from other darters by dark pigmentation on its first (or spiny) dorsal fin, small M-, V-, W-, or X-shaped marks along the dorso-lateral surface, 8-10 oblong or squarish black blotches along the lateral line, and the presence of two spiny rays on its anal fin. Three designatable units are identified in Canada: Lake Erie populations (DU1); Lake Ontario populations (DU2); and, St. Lawrence populations (DU3).

Distribution

The Channel Darter has a wide, but discontinuous, distribution throughout eastern North America. In the United States, it is found in the east from the Lower Peninsula of Michigan through to Alabama, Arkansas, Oklahoma, Mississippi, Louisiana, and southeastern Kansas. In Canada, the species is found in low numbers and its distribution is discontinuous. In Ontario, the species is restricted to the Bay of Quinte drainage, the Ottawa River drainage, and in the Lake Erie and Huron-Erie corridor. In Quebec, the species is found in the St. Lawrence River and many of its tributaries distributed in four hydrographic regions: Ottawa and Montréal; Southwest St. Lawrence; Northwest St. Lawrence; and Southeast St. Lawrence. Range disjunctions of > 300 km separate the southwestern Ontario, southeastern Ontario and Ottawa River / St. Lawrence populations.

Habitat

The Channel Darter inhabits both river and lake habitats. Adult Channel Darter typically live in small to large rivers with moderate current and coarse bed material. In lakes, the Channel Darter is predominantly found on sand and gravel beaches with moderate wave action.

Biology

The Channel Darter feeds predominantly on benthic invertebrates such as mayfly, caddisfly, and midge larvae. It matures after one year and can live up to five years. Spawning takes place in spring and summer, when males select and defend territories composed of pebbles and cobbles in areas of moderate water flow. Females bury eggs in the substrate, where the males fertilize them. Individuals can reproduce several times, with different partners, throughout the reproductive season. There is no parental care of the eggs. Some evidence exists that the Channel Darter migrates towards deeper portions of lakes or pools to overwinter, but this migratory behaviour remains poorly studied.

Population Sizes and Trends

The Channel Darter is found at low abundances throughout its range, and evidence suggests that abundances are generally declining throughout the Canadian range of the species. The previous COSEWIC report on the species (2002) identified six extirpated populations in Quebec. Recent targeted sampling confirmed that four of those populations are likely extirpated, but specimens have since been captured at the other two. In Ontario, targeted sampling in Lake Erie failed to capture Channel Darter at five historical sampling locations in the nearshore habitat. Furthermore, extensive sampling failed to capture Channel Darter from Lake St. Clair at sites where the species was previously captured, with the exception of a single individual captured in 2012. Increased sampling effort led to the discovery of seven new populations in Quebec since the last report, and confirmed the presence of the species in all six new locations reported in the previous report. In Ontario, a new population was discovered in the Salmon River since the publication of the last report, and the presence of the species was confirmed in one of three new locations from the previous report. Newly discovered populations are more likely the result of increased sampling effort than species range expansion.

Threats and Limiting Factors

The most severe threats to populations appear to be the Round Goby. Altered flow regimes, and sediment and nutrient loading also constitute a moderate threat in many river populations. Threats related to intensive agriculture and urban development (sedimentation, shoreline modifications, altered flow regimes, excess nutrient, and toxic substances) are also prominent, especially in Lake Erie, Ottawa River and the rivers in the southwestern St. Lawrence River drainage.

Protection, Status, and Ranks

The Channel Darter is listed as Threatened under Schedule 1 of the Canadian *Species at Risk Act* (SARA). In Ontario, the species is listed as Threatened under the Ontario *Endangered Species Act*, 2007 (ESA). In Quebec, the species is listed as 'Vulnérable' under the *Loi sur les Espèces Menacées ou Vulnérables*. These listings prohibit harvest or capture without authorization. The species is ranked as Apparently Secure globally by NatureServe, and is not protected federally in the United States.

TECHNICAL SUMMARY – Lake Erie populations - DU1

Percina copelandi

Channel Darter
Lake Erie populations

Fouille-roche gris
Populations du lac Érié

Range of occurrence in Canada (province/territory/ocean): Ontario

Demographic Information

Generation time	2 yrs
Is there an inferred continuing decline in number of mature individuals?	Yes
Estimated percent of continuing decline in total number of mature individuals within 5 years	Unknown
Percent reduction in total number of mature individuals over the last 10 years?	Unknown
Percent reduction in total number of mature individuals over the next 10 years.	Unknown
Percent reduction in total number of mature individuals over any 10 years 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?	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence Present: 2918 km² Recent Historical: 1828 km²	2918 km²
Index of area of occupancy (IAO) Present: 180 km² Recent Historical: 80 km²	180 ²
Is the total population severely fragmented?	No
Number of locations* (Historically 6 locations, currently 3 or 4)	3-4
Is there an inferred continuing decline in extent of occurrence?	No
Is there an inferred continuing decline in index of area of occupancy?	No
Is there a continuing decline in number of populations?	Yes
Is there an 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

* See Definitions and Abbreviations on the COSEWIC website and IUCN 2010 for more information on this term.

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
Detroit River	Unknown
St. Clair River	Unknown
Lake Erie – Western Basin	Unknown
Lake Erie – Central Basin (likely extirpated)	Unknown
Lake Erie – Eastern Basin (likely extirpated)	Unknown
Lake St. Clair (likely extirpated, but one specimen collected in 2012)	Unknown
Total	Unknown
6 populations; 3 likely extirpated	

Quantitative Analysis

Probability of extinction in the wild is at least 20% within 20 years or 5 generations or 10% within 100 years.	Unknown

Threats (actual or imminent, to populations or habitats)

Exotic species Pollution

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? United States: N4 (Apparently secure; NatureServe 2011) Vulnerable or imperiled in 12 out of the 14 states where it is found.	
Is immigration known or possible?	Possible, but unknown
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?	Yes
Are conditions for the source population deteriorating?	Yes
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	Unlikely

Data-Sensitive Species

Is this a data-sensitive species? No

[*] See Definitions and Abbreviations on the COSEWIC website and IUCN 2010 for more information on this term.

Status History

COSEWIC: The species was considered a single unit and designated Threatened in April 1993. Status re-examined and confirmed in May 2002. When the species was split into separate units in November 2016, the "Lake Erie populations" unit was designated Endangered.

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** B1ab(iii,iv,v)+2ab(iii,iv,v)
Reasons for designation: This small-bodied species occupies nearshore lake and river habitats that are undergoing major shoreline modifications and the negative impact of the invasive Round Goby, having resulted in likely extirpation from large areas of Lake Erie and Lake St. Clair.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Unknown number of mature individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B1ab(iii,iv,v)+2ab(iii,iv,v), because of small extent of occurrence, small index of area of occupancy, few locations, and observed decline in quality of habitat, number of locations and an inferred decline in the number of mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Unknown number of mature individuals.
Criterion D (Very Small or Restricted Total Population): Not applicable. Unknown number of mature individuals.
Criterion E (Quantitative Analysis): Quantitative analyses have not been completed.

TECHNICAL SUMMARY – Lake Ontario populations - DU2

Percina copelandi

Channel Darter
Lake Ontario populations

Fouille-roche gris
Populations du lac Ontario

Range of occurrence in Canada (province/territory/ocean): Ontario

Demographic Information

Generation time	2 yrs
Is there an inferred continuing decline in number of mature individuals?	Yes
Estimated percent of continuing decline in total number of mature individuals within 5 years	Unknown
Percent reduction in total number of mature individuals over the last 10 years?	Unknown
Percent reduction in total number of mature individuals over the next 10 years.	Unknown
Percent reduction in total number of mature individuals over any 10 years 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?	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence Present: 1655 km^2 Recent Historical: 667 km^2	1655 km^2
Index of area of occupancy (IAO) Present: 392 km^2 Recent Historical: 172 km^2	392 ^{2}
Is the total population severely fragmented?	No
Number of locations*	4-9
Is there an inferred continuing decline in extent of occurrence?	No
Is there a continuing decline in index of area of occupancy?	No
Is there a continuing decline in number of populations?	No
Is there an observed continuing decline in number of locations?	No
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

* See Definitions and Abbreviations on the COSEWIC website and IUCN 2010 for more information on this term.

Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Moira River system (including tributaries: Skootamatta, Black)	Unknown
Salmon River (likely two populations due to a dam blocking upstream movement of invasive species)	Unknown
Trent River	Unknown
Total	
4 populations	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least 20% within 20 years or 5 generations or 10% within 100 years.	Unknown

Threats (actual or imminent, to populations or habitats)

Exotic species

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? United States: N4 (Apparently secure; NatureServe 2011) Vulnerable or imperiled in 12 out of the 14 states where it is found.	
Is immigration known or possible?	Possible but unknown
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?	Yes
Are conditions for the source population deteriorating?	Unknown
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	Unlikely

Data-Sensitive Species

Is this a data-sensitive species? No

Status History

COSEWIC: The species was considered a single unit and designated Threatened in April 1993. Status re-examined and confirmed in May 2002. When the species was split into separate units in November 2016, the "Lake Ontario populations" unit was designated Endangered.

Recommended Status and Reasons for Designation

Recommended Status: Endangered	**Alpha-numeric code:** B1ab(iii,v)+2ab(iii,v)

Reasons for designation: This small-bodied species is limited to three small watersheds. The primary threat is the invasive Round Goby, which is now found throughout the Trent River and has resulted in declines in the abundance of this population. For the time being, populations along the Moira and Salmon rivers are largely unaffected by Round Goby. However, introductions upstream of dams via bait bucket transfers are considered likely.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Unknown number of mature individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B1ab(iii,v)+2ab(iii,v), because the species has a small extent of occurrence, small index of occupancy, a substantial reduction in the quality of habitat due to the invasion of Round Goby and an inferred reduction in the number of individuals.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Unknown number of mature individuals.
Criterion D (Very Small or Restricted Total Population): Not applicable. Unknown number of mature individuals.
Criterion E (Quantitative Analysis): Quantitative analyses have not been completed.

TECHNICAL SUMMARY – St. Lawrence populations - DU3

Percina copelandi

Channel Darter
St. Lawrence populations

Fouille-roche gris
Populations du Saint-Laurent

Range of occurrence in Canada (province/territory/ocean): Ontario and Quebec

Demographic Information

Generation time	2 yrs
Is there an inferred continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within 5 years	Unknown
Percent reduction in total number of mature individuals over the last 10 years?	Unknown
Percent reduction in total number of mature individuals over the next 10 years.	Unknown
Percent reduction in total number of mature individuals over any 10 years 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?	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence Present – 53,215 km² Recent Historical – 47,000 km²	>53,215 km²+
Index of area of occupancy (IAO) Present - 7,664 km² Recent Historical - 5,620 km²	>7,664 km²+
+ Does not include new records received after 2-Month Provisional Report.	
Is the total population severely fragmented?	No
Number of locations*	29
Is there an inferred continuing decline in extent of occurrence?	No
Is there a continuing decline in index of area of occupancy?	No
Is there a continuing decline in number of populations?	Yes
Is there an observed continuing decline in number of locations?	Yes
Is there an observed continuing decline in area, extent, and quality of habitat?	Yes

* See Definitions and Abbreviations on the COSEWIC website and IUCN 2010 for more information on this term.

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**
Little Rideau Creek	Unknown
Ottawa River	Unknown
Lake Saint-Louis	Unknown
Gatineau River	Unknown
Blanche River (Gatineau)	Unknown
Blanche River (Thurso)	Unknown
Petite-Nation River	Unknown
Saumon River	Unknown
Rouge River	Unknown
Ruisseau Calumet	Unknown
Pointe-au-Chêne	Unknown
Richelieu River	Unknown
Châteauguay River	Unknown
Yamaska River	Unknown
Saint-François River	Unknown
Lake Saint-François	Unknown
Lake Saint-Pierre	Unknown
St. Lawrence River, downstream of Lake Saint-Pierre	Unknown
Nicolet River	Unknown
L'Assomption River	Unknown
Bayonne River	Unknown
Du Loup River	Unknown
Grande Yamachiche River	Unknown
Batiscan River	Unknown
Jacques-Cartier River	Unknown
Sainte-Anne River	Unknown
Bécancour River	Unknown
Du Sud River	
Du Chêne River	
Total	Unknown
29 populations	

Quantitative Analysis

Probability of extinction in the wild is at least 20% within 20 years or 5 generations or 10% within 100 years.	Unknown

Threats (actual or imminent, to populations or habitats)

Exotic species, Pollution

[*] See Definitions and Abbreviations on the COSEWIC website and IUCN 2010 for more information on this term.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? United States: N4 (Apparently secure; NatureServe 2011) Vulnerable or imperiled in 12 out of the 14 states where it is found.	
Is immigration known or possible?	Possible, but unknown
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?	Yes
Are conditions deteriorating for source populations?	Unknown
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	Unlikely

Data-Sensitive Species

Is this a data-sensitive species? No

Status History

COSEWIC: The species was considered a single unit and designated Threatened in April 1993. Status re-examined and confirmed in May 2002. When the species was split into separate units in November 2016, the "St. Lawrence populations" unit was designated Special Concern.

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Not applicable
Reasons for designation: This small-bodied species is broadly distributed, but there is evidence of extirpation at some localities within its range. The species is subjected to a variety of threats related to the impact of the invasive Round Goby and pollution. The species may become Threatened if these threats are not effectively managed.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Unknown number of mature individuals.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. All thresholds exceeded.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Unknown number of mature individuals.
Criterion D (Very Small or Restricted Total Population): Not applicable. Unknown number of mature individuals.
Criterion E (Quantitative Analysis): Quantitative analyses have not been completed.

PREFACE

The Channel Darter in Canada was last assessed by COSEWIC in 2002 and was assigned the status of Threatened. Following the proclamation of the *Species at Risk Act* (SARA) in 2003, Channel Darter was included on Schedule 1 of SARA, which required Fisheries and Oceans Canada (DFO) to undertake action towards the recovery of the species (DFO 2010; DFO 2011). As a consequence, much new information has been collected on the species since the publication of the last report. The present report includes new information on the population structure of the species that follows from an increase in the number of targeted sampling studies and genetic analyses. Those studies have provided evidence for the existence of three designatable units within the Channel Darter distribution in Canada, discovered new populations, and revisited many historical sites whose status was unknown in the last report. New population extirpations are also documented. However, quantitative estimates of abundance and trends are still lacking. New studies have also improved our knowledge of the Channel Darter habitat requirements and have allowed a better characterization of the threats faced by the species.

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
(2016)

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.

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

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

COSEWIC Status Report

on the

Channel Darter
Percina copelandi

Lake Erie populations
Lake Ontario populations
St. Lawrence populations

in Canada

2016

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Class: Actinopterygii

Order: Perciformes

Family: Percidae

Subfamily: Etheostomatinae

Genus: *Percina*

Species*: *Percina copelandi* (Jordan, 1877)

Synonyms: *Rheocrypta copelandi* - Jordan 1877a:9

Cottogaster copelandi - Jordan & Evermann 1896-1900: 1045

Hadropterus copelandi - Hubbs and Lagler 1958:107

Common Name: English: Channel Darter*

French: fouille-roche gris (Page *et al.* 2013) (formerly dard gris)

The family Percidae is a diverse collection of freshwater fishes with a Holarctic distribution (Sloss *et al.* 2004). Darters (subfamily Etheostomatinae) are a North American clade and are the most diverse group of percids (Sloss *et al.* 2004; Near *et al.* 2011). The darter clade includes approximately 250 species (12 in Canada; Page *et al.* 2013), which is more than 20% of the entire North American freshwater fish fauna (Scott and Crossman 1973). There are four well-supported (i.e., reciprocally monophyletic) and commonly recognized genera of darters: *Ammocrypta*, *Crystallaria*, *Etheostoma,* and *Percina* (Near *et al.* 2000; Page 1983, 2000; Simons 1992; Near *et al.* 2011; Smith *et al.* 2011; Page *et al.* 2013). The estimated age of the most recent common ancestor of all darters is between 34 and 40 million years, which places the origin of the darters some time during the Late Eocene or Early Oligocene (Near *et al.* 2011; Smith *et al.* 2011). Most extant darter species, however, are thought to have originated in the last 15 million years. For example, the estimated age of the *Percina* genus is between 17.8 and 20.9 million years (Near *et al.* 2011). Hence, most darter diversification probably occurred during the Pliocene. A general mechanism for the extreme diversification of darter species has yet to be elucidated (Near and Peck 2005).

The genus *Percina*, with 45 species, is the second largest genus of darters (Page *et al.* 2013). The most recent phylogenetic analyses of *Percina* suggest that former groupings of species into subgenera or other hierarchical groupings (e.g., Bailey *et al.* 1954; Page 1974, 1981, 2000; Bailey and Etnier 1988; Bart and Page 1992) do not reflect monophyletic relationships (Near 2002; Near *et al.* 2011). Hence, Near *et al.* (2011) suggested 11 new or revised "species clades" within *Percina* that reflect monophyletic groupings. Under this new classification, the Channel Darter (Figure 1) is one of eight members of the *Etnieperca* clade and one of three members, along with the Pearl Darter (*Percina aurora*) and the Coal Darter (*Percina brevicauda*), of the *Cottogaster* clade. Those two other species are not found in Canada and Channel Darter is, thus, the only member of that clade found in Canada. There are no recognized *Percina copelandi* sub-species.

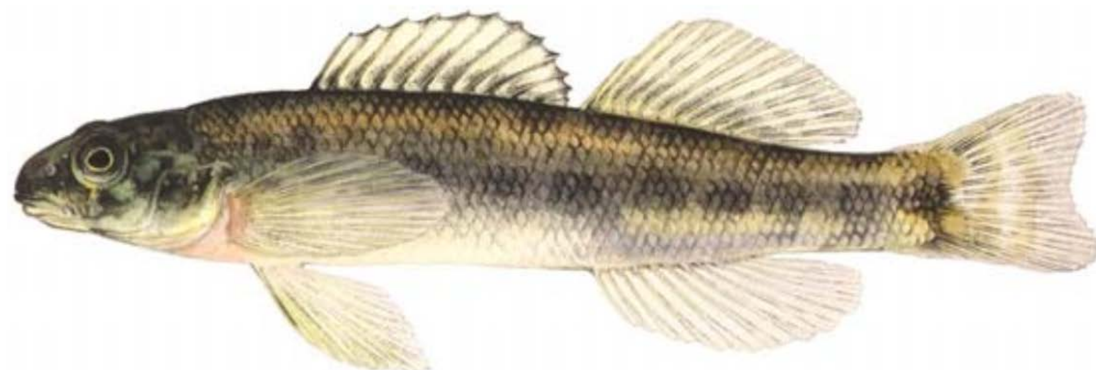

Figure 1. Channel Darter (*Percina copelandi*) © Ellen Edmonson (NYSDEC).

Morphological Description

Adults typically reach a maximum of 62 mm total length (TL) (Page and Burr 2011), although specimens measuring up to 72 mm TL have recently been captured (Holm *et al.* 2009). Body colouration can range from yellow to olive with brown speckles that run along the dorsal portion of the body (Holm *et al.* 2009, Figure 1). The ventral regions are pale. A series of characteristic small brown, round, or oblong blotches also run along the side of the Channel Darter body and can be joined by a thin line (Scott and Crossman 1973). The fins are generally clear and sometimes show light speckles (Scott and Crossman 1973). Males in breeding conditions can show a darker colouration, especially around the head (Scott and Crossman 1973; Holm *et al.* 2009).

The geographical range of the Channel Darter overlaps that of other morphologically similar darters. The Channel Darter can be distinguished from most Canadian darters by the small M-, V-, W-, or X-shaped marks along its mid-side (Holm *et al.* 2009). The Johnny Darter (*Etheostoma nigrum*) and Tessellated Darter (*E. olmstedi*), however, can also display such marks. The Channel Darter differs from those two species by the presence of two anal spines, compared to only one for the Johnny Darter and Tessellated Darter (Scott and Crossman 1973). The Channel Darter can also be confused with the River Darter (*Percina* *shumardi*). The Channel Darter has dark pigmentation at the base and side of the spiny dorsal fin, while River Darter has a small anterior black spot and a large posterior black spot on the dorsal fin (Holm *et al.* 2009; Bouvier and Mandrak 2010).

Population Spatial Structure and Variability

In Canada, the Channel Darter appears to be absent from a 300 km stretch of the St. Lawrence River between Lake Ontario (Bay of Quinte drainage) and Lake St. Louis. Both parts of the range were probably re-colonized from the same glacial refugium (Mississippian) (Mandrak and Crossman 1992). The Channel Darter likely initially colonized glacial Lake Maumee (now Erie) from the Mississippian refugium through the Fort Wayne outlet, ca. 14,000 YBP (Mandrak and Crossman 1992). Fish species in the Erie basin could then subsequently disperse eastward into the Ontario basin through the Buffalo outlet (see Mandrak and Crossman 1992 for summary of postglacial lakes and outlets in the Great Lakes basin) and later via Niagara Falls. The species would have then been readily able to disperse through the Ontario basin. Its presence in the Champlain watershed indicates that it likely dispersed through the Mohawk outlet, which drained early glacial Lake Iroquois into the Champlain basin, ca.12,500 YBP (Mandrak and Crossman 1992). Mandrak (1990) hypothesized that a species, Eastern Sand Darter (*Ammocrypta pellucida*), with a disjunct range and postglacial dispersal history similar to Channel Darter, may have been more widespread in eastern Ontario until the end of the Hypsithermal warm period (ca. 6,000 YBP) when, as a result of the climate cooling, the original postglacial range contracted to suitable microhabitats. This would be consistent with disjunct patterns exhibited by other Prairie plant and animal species. Many of these microhabitats have been degraded in recent times (see Threats section), likely leading to further disjunction. There is also evidence for Eastern Sand Darter populations in the vicinity of Prince Edward County and Bay of Quinte in southeastern Ontario may have been isolated prior to a secondary colonization of the St. Lawrence River basin following the recession of the Champlain Sea from that basin (see Designatable Units section; R. Walter *et al.*, University of Windsor, unpubl. data).

A recent study combining mitochondrial DNA (cytochrome b) and 10 microsatellite markers described genetic structure of 10 populations distributed across Ontario and Quebec (Kidd *et al.* 2011, Reid *et al.* 2013). A total of 67 mitochondrial DNA haplotypes were identified; 12 unique haplotypes were associated with western Lake Erie and the Huron-Erie corridor populations, 24 unique haplotypes were associated with Bay of Quinte drainage populations, and 19 unique haplotypes were associated with Ottawa River - St Lawrence system populations. However, 80% of unique haplotypes were associated with individual populations and only 6 haplotypes were shared across multiple populations. Only two haplotypes were found across all populations. This pattern could reflect a complex pattern of postglacial re-colonization, or postglacial diversification. Analysis using individual-based clustering (STRUCTURE 2.3), pairwise genetic distances (Nei's measure, POPULATIONS 1.2.28), and microsatellite data revealed both regional- and local- scale population structure. At a range-wide scale, population genetic structure reflected the disjunct distribution of Channel Darter populations (Figures 2, 3). Significant structuring between sampled populations within each region was also identified. Genetic subdivisions suggest that dispersal among rivers is limited. Currently, dispersal among many populations is limited by anthropogenic and natural barriers (dams and waterfalls). Similar to Channel Darter, populations of Eastern Sand Darter (R. Walter *et al.*, University of Windsor, unpubl. data) in Prince Edward County show greater genetic affinity to southwestern Ontario than to the closer St. Lawrence populations, hypothesized to be the result of early isolation of Prince Edward County populations and subsequent secondary colonization of the St. Lawrence River drainage (R. Walter, University of Windsor, unpubl. data) (see Designatable Units section).

The range disjunction observed in the Canadian distribution of the species does not qualify as severely fragmented according to the COSEWIC definition. There is good evidence that each portion of the range is large enough to support viable populations (Venturelli *et al.* 2010) (see Table 4).

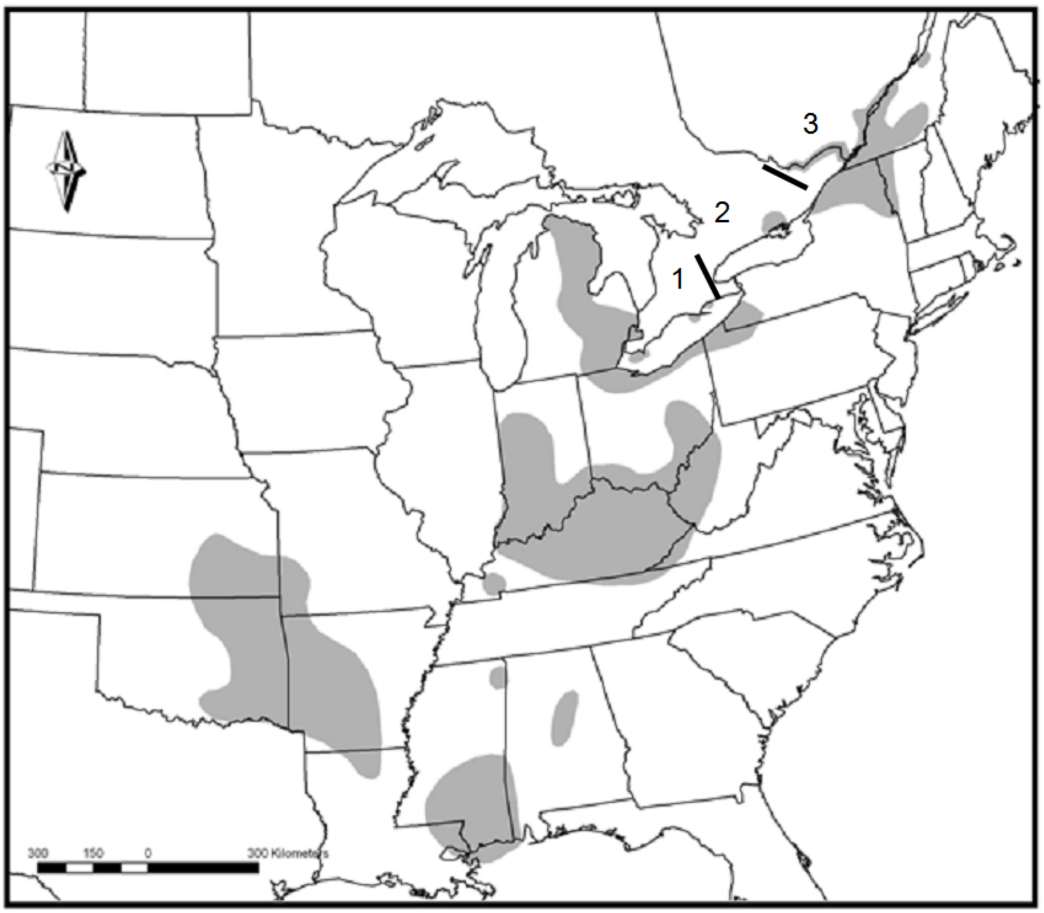

Figure 2. Global distribution of the Channel Darter (modified from DFO 2011). The thick black diagonal lines represent the divisions between DU1 (southwestern Ontario), DU2 (southeastern Ontario) and DU3 (Ottawa River / St. Lawrence) populations.

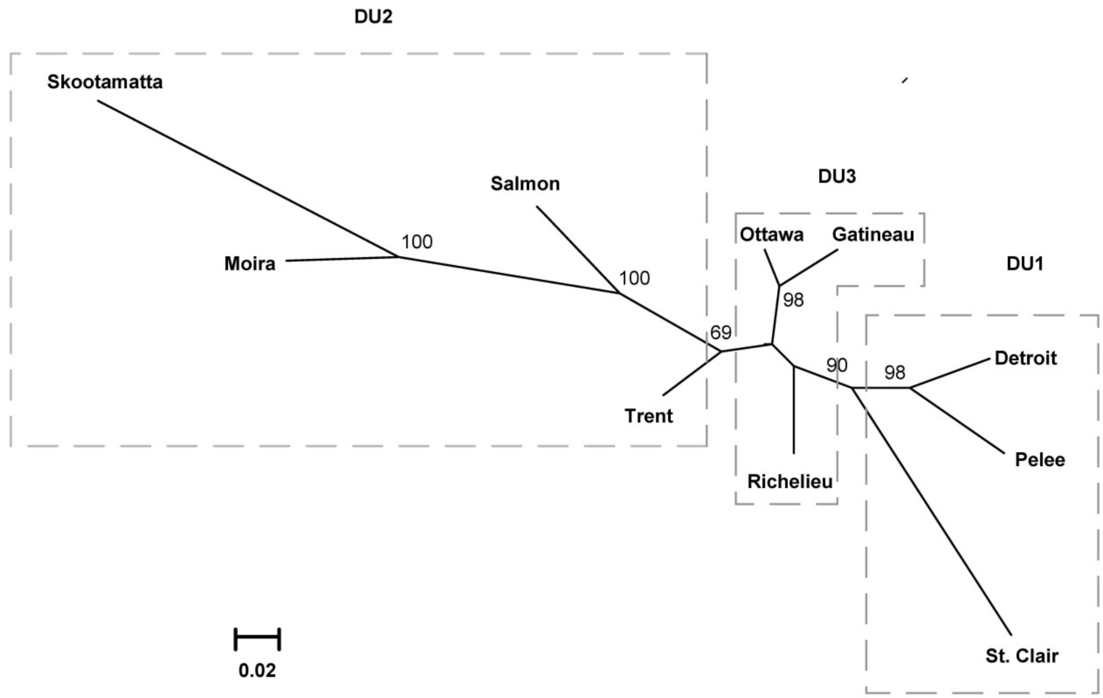

Figure 3. Unrooted Neighbor-joining tree of Ontario and Quebec populations of the Channel Darter based on Nei genetic distance (D_A). Numbers at branch points represent percentage bootstrap support of each branching point from 1,000 pseudoreplications. The three designatable units (DUs) are contained within the dashed boxes.

Designatable Units

All Canadian populations of the Channel Darter are found within the Great Lakes-Upper St. Lawrence National Freshwater Biogeographic Zone. Within this range, the Channel Darter consists of three designatable units (DUs) that satisfy the discreteness and significance criteria of the COSEWIC (2009) guidelines: Lake Erie (Lake Erie and Huron-Erie corridor); Lake Ontario (Bay of Quinte drainage); and, St. Lawrence populations.

First, the three DUs are disjunct from one another in Canada; each is separated from the nearest other by a minimum 300 km stretch of uninhabited area (Figure 2). The portion of the range between the southeastern Ontario populations and the St. Lawrence populations is separated by the section of the St. Lawrence River between Lake Ontario and Lake St. François. In Canada, there are no historical records of Channel Darter captures in this section of the St. Lawrence River itself, only in American tributaries. Local extirpations along the north shore of Lake Erie have increased the degree of spatial separation between southwestern and southeastern Ontario populations. The discreteness of DUs is further supported by microsatellite DNA data that provided support for grouping populations based on geography (Figure 3, Kidd *et al.* 2011, Reid *et al.* 2013). Genetic subdivisions between populations within DUs indicate that dispersal among rivers is limited and, between DUs, unlikely under contemporary time frames.

Southwestern Ontario populations include (and were historically dominated by) the only Canadian populations found in large lakes of the scale of the Laurentian Great Lakes. In other parts of its national and global distribution, it is completely or largely dominated by riverine populations. Differences in the physical (i.e. flow regimes) and biological (e.g. benthic invertebrate community) characteristics between these two environments can be inferred to affect morphology and life history and have resulted in distinct adaptations. Second, the disjunctions likely represent a natural consequence of different postglacial colonization histories for the three DUs and, thus, represent part of the historical legacy of the Channel Darter in Canada. Similar disjunctions are found in Eastern Sand Darter (*Ammoycrypta pellucida*)(Reid and Dextrase 2014; Ginson *et al.* 2015; R. Walter, University of Windsor, unpubl. data), both of which have southeastern Ontario populations that are more closely related to southwestern Ontario populations than the closer Quebec populations. This is hypothesized to be the result of early isolation of Bay of Quinte populations and subsequent secondary colonization of the St. Lawrence River drainage (R. Walter, University of Windsor, unpubl. data). Finally, loss of the southeastern Ontario DU would result in an extensive gap in the range of the species in Canada (from two smaller gaps of about 300-400 km each to a single large one of more than 700 km).

Consequently, this report recognizes three Designatable Units:

- DU 1 – Lake Erie
- DU 2 – Lake Ontario
- DU 3 – St. Lawrence

Special Significance

Channel Darter is not a species of economic or social importance. It is not restricted to Canada and is widely distributed in the United States. Its ecological role is not well known, but it could be a prey item for other species. The genus *Percina* comprises 45 other species (Near *et al.* 2011), four of which are found in Canada (Page *et al.* 2013). Channel Darter contributes to the aquatic biodiversity of Canada and may be considered a sentinel species because it appears to be easily affected by human activities. Channel Darter is the only member of the *Cottogaster* clade found in Canada (Near *et al.* 2011).

DISTRIBUTION

Global Range

The Channel Darter has a wide, but disjunct, distribution throughout the eastern United States and southeastern Canada (Figure 2; Page and Burr 2011; NatureServe 2011). In the United States, it is found across 15 different states along the eastern margin of the lower peninsula of Michigan, south to Alabama, Arkansas, Oklahoma, and southeastern Kansas (Page and Burr 2011). Individuals have been captured in Lake Champlain bordering New York and Vermont.

Canadian Range

In Canada, the distribution of the Channel Darter is disjunct and restricted to southern Quebec and Ontario (Figures 4-6). In Ontario, the Channel Darter is currently distributed in four distinct areas in the eastern portion of the Great Lakes basin: Lake St. Clair drainage; Lake Erie drainage (Figure 4); Bay of Quinte drainage (Figure 5); and, Ottawa River drainage (Figure 5). Historical sampling suggests that Channel Darter distribution was always limited to these four areas, although presence/absence at specific sites has changed in recent decades. In Quebec, the Channel Darter is currently distributed in the St. Lawrence River and several of its tributaries (Figure 6). Its distribution encompasses four different hydrographic regions: Outaouais and Montréal; southwestern St. Lawrence; southeastern St. Lawrence; and, northwestern St. Lawrence.

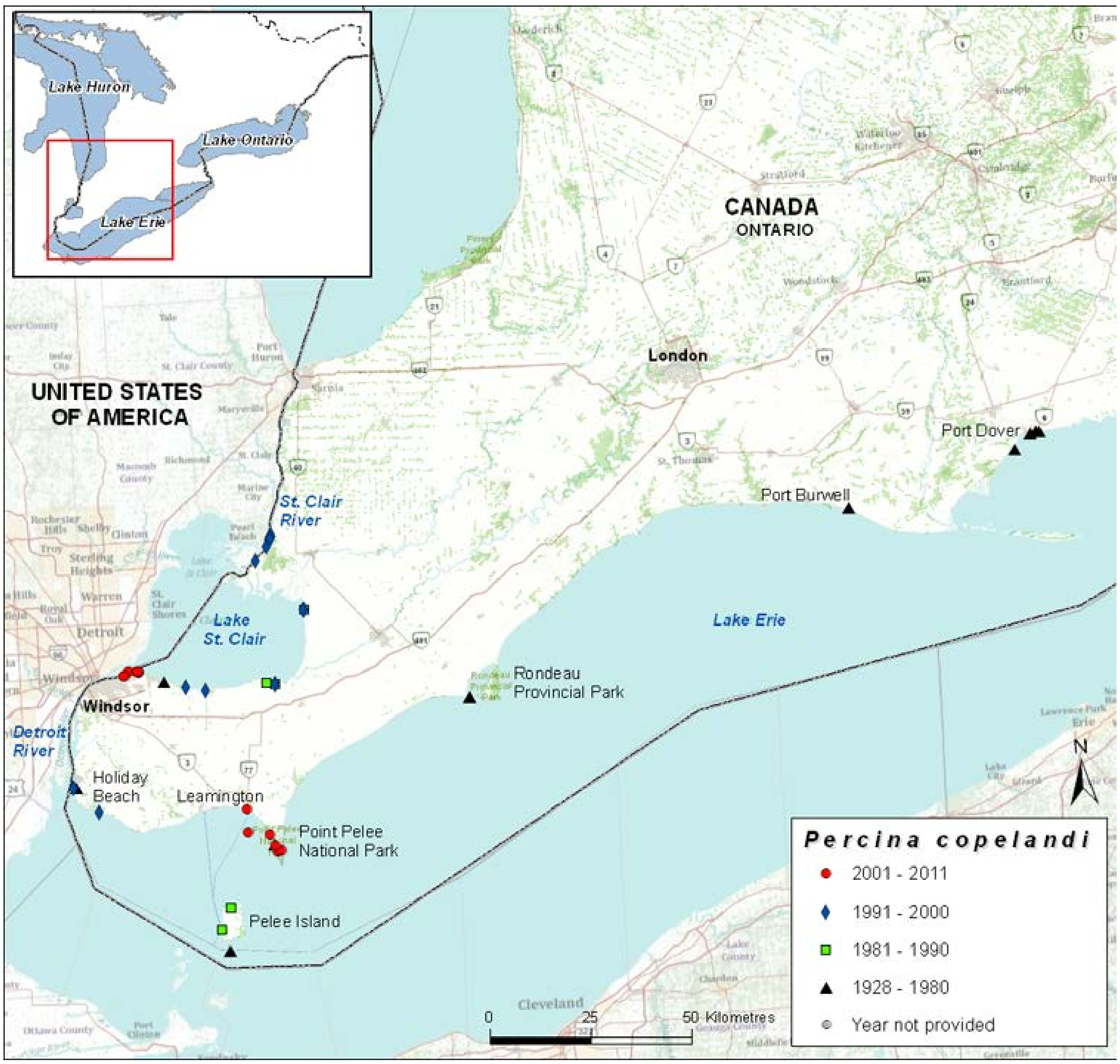

Figure 4. Range of Channel Darter in the Lake Erie DU.

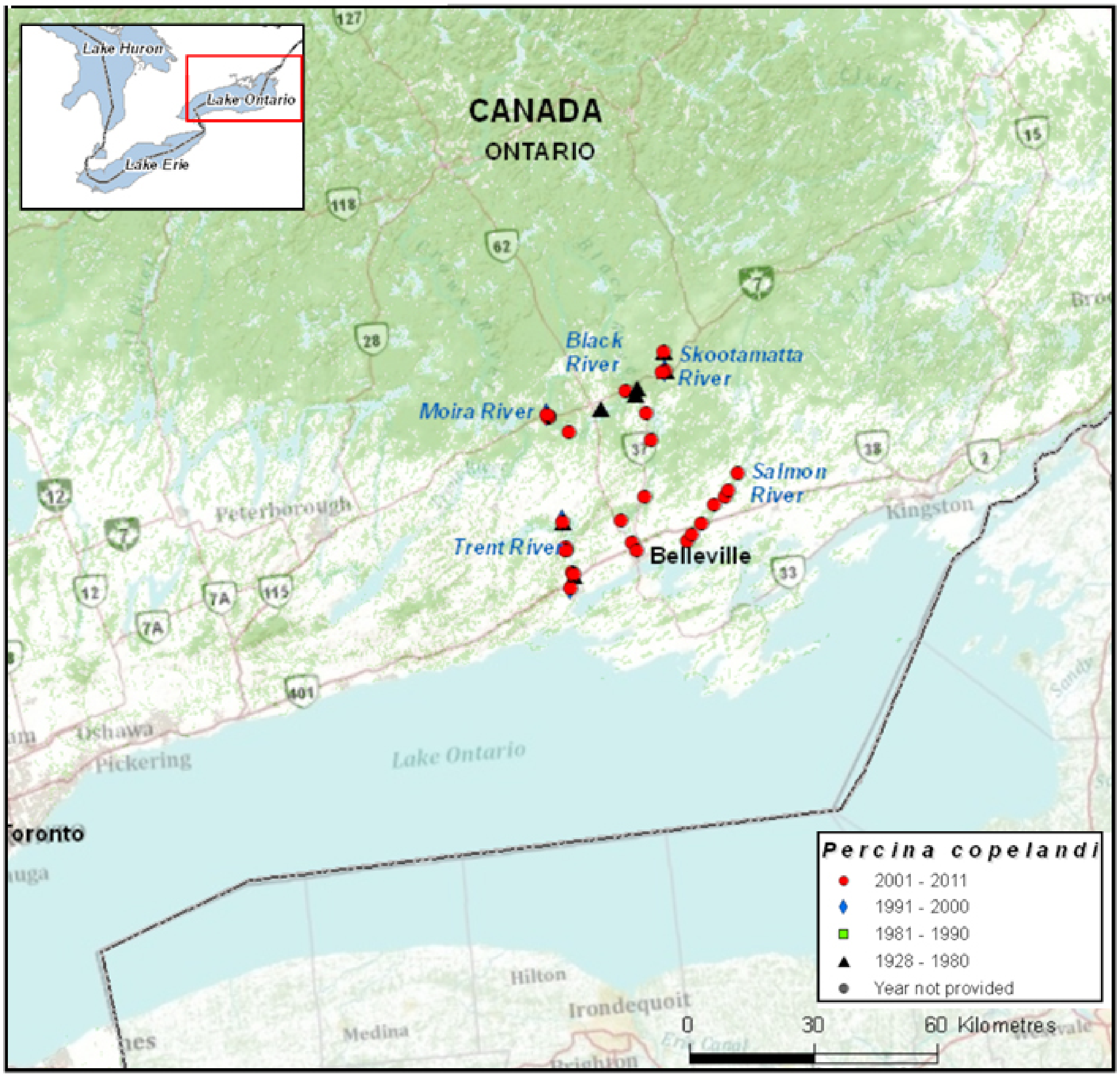

Figure 5. Range of Channel Darter in the Lake Ontario DU.

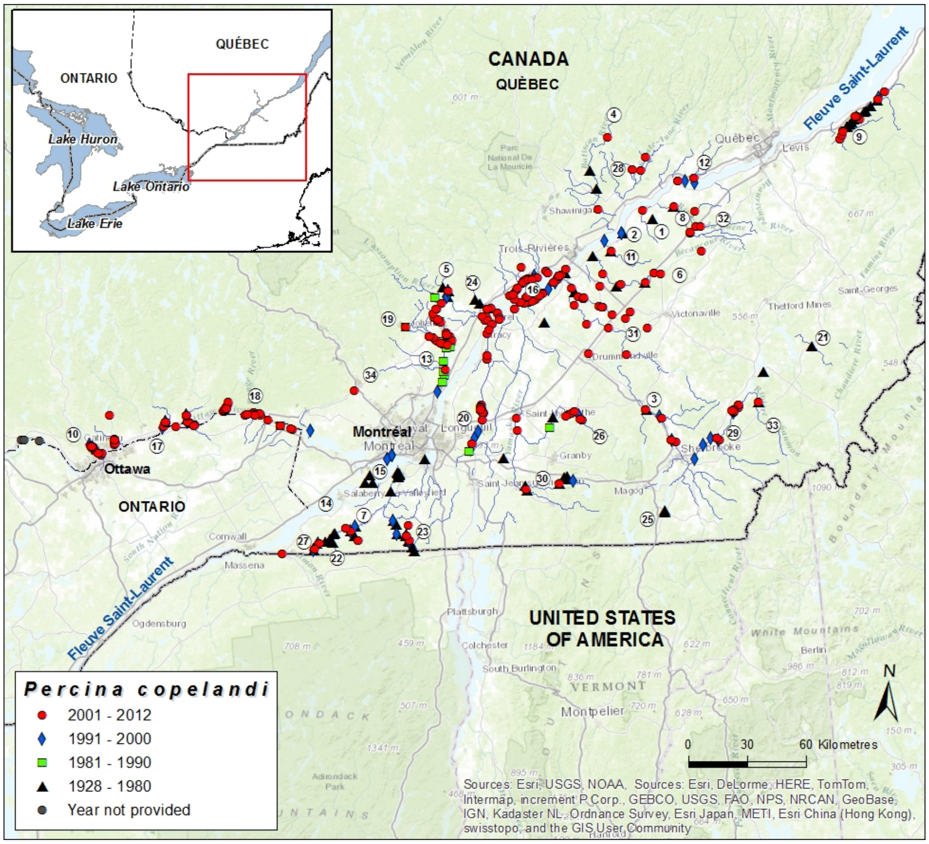

Figure 6. Range of Channel Darter in St. Lawrence DU.

Numbers refer to the following legend:

1. Aux Ormes River
2. Aux Orignaux River
3. Au Saumon River
4. Batiscan River
5. Bayonne River
6. Bécancour River
7. Châteauguay River
8. Du Chêne River
9. Du Sud River
10. Gatineau River
11. Gentilly River
12. Jacques-Cartier River
13. L'Assumption River
14. Lake Saint-François
15. Lake St-Louis
16. Lake Saint-Pierre
17. Ottawa River
18. Ottawa River watershed: Pointe aux Chênes, Rouge, Calumet
19. Ouareau River
20. Richelieu River
21. Rivière aux Bleuets
22. Rivière Aux Outardes
23. Rivière des Anglais
24. Rivière Chicot
25. Rivière Niger
26. Rivière Noire
27. Rivière Trout
28. Saint-Anne River
29. Saint-François River
30. Yamaska River
31. Rivière Nicolet
32. Rivière Henri
33. Rivière aux Saumons
34. Rivière du Nord

Recent reports have defined populations of Channel Darter based on watersheds (e.g., Boucher and Garceau 2010; Bouvier and Mandrak 2010). We follow this convention because it is plausible that many of the threats identified in the next section would affect a large proportion of watersheds simultaneously. For example, point-source pollution related to industrial activities or sewage outfall would introduce contaminants to many areas downstream of the source of pollution. Many threats to Channel Darter are also related to agricultural activities, whose diffuse source effects on water quality include increased sedimentation, turbidity, and nutrient loading that are all likely to affect many parts of a watershed simultaneously. Dams would also influence flow regimes in areas both upstream and downstream of the dam. Designating watersheds as locations is, therefore, consistent with the threat-based definition of a ‘location’ recognized by COSEWIC. There are two exceptions to this ‘one watershed, one location’ rule. First, Lake Erie was divided into three separate locations: the Western, Central, and Eastern basins. This was done because of the large size of the lake and because the Western Basin supports an apparently healthy population of Channel Darter while it appears extirpated in the other two basins. This suggests that the threats faced by one location do not necessarily affect the others in the same way and warrants separate location designation. Second, we separated the St. Lawrence River into four locations: Lake Saint-Louis, Lake Saint-François, Lake Saint-Pierre, and downstream of Lake Saint-Pierre. The large size of the St. Lawrence River makes it unlikely that threats are distributed equally. Furthermore, there is no record of Channel Darter capture in the river between those four ‘lakes’, suggesting that they are independent locations. Note that some locations were not recognized in the previous assessments (Boucher and Garceau 2010) either because they were combined into one (Lake Erie) or because data were not available to the authors at the time.

In the Lake Erie DU, six locations are recognized (from west to east): St. Clair River; Lake St. Clair; Detroit River; Lake Erie Western Basin (restricted to the Point Pelee area); Lake Erie Central Basin (likely extirpated); Lake Erie Eastern Basin (likely extirpated);

In the Lake Ontario DU, 4-9 locations are recognized, depending on whether Round Goby is a current (3) or future (9) threat: Trent River (1); Moira River system (including tributaries Skootamatta and Black rivers) (1-4); and, Salmon River (2-4).

In the St. Lawrence DU, 30 locations are recognized: Little Rideau Creek;Ottawa River; Lake Saint-Louis; Gatineau River; Blanche River (Gatineau); Blanche River (Thurso); Petite-Nation River; Saumon River; Rouge River; Calumet; Pointe-au-Chêne; Richelieu River; Châteauguay River; Yamaska River; Saint-François River; Lake Saint-François; Lake Saint-Pierre; downstream of Lake Saint-Pierre; Nicolet River; L’Assomption River; Bayonne River; Du Loup River; Grande Yamachiche River; Batiscan River; Jacques-Cartier River; Sainte-Anne River; Bécancour River; Du Sud River; Du Chêne River.

Extirpated locations

Several locations were reported as extirpated by Phelps and Francis (2002). In Ontario, two specimens were collected in 1948 in an unnamed creek near Moira Lake, but no Channel Darter were collected when the site was revisited in 1997 (A. Dextrase, pers. comm.; Phelps and Francis 2002). Being part of the Moira River watershed, however, it is unclear whether this population should really be considered extirpated, given the Moira River appears to support a relatively abundant population. Phelps and Francis (2002) also reported six extirpated populations in Quebec: Rivière aux Bleuets, Rivière du Sud, Rivière Niger, Rivière Maskinongé, Rivière Chicot, and Port Saint-François. Rivière du Sud was re-sampled in 2005 and 2013, and a total of two and 29 specimens of Channel Darter were collected, respectively (Boucher and Garceau 2010; HydroNet 2013). Port Saint-François is just downstream of Lake Saint-Pierre, and Channel Darter was observed 1.6 km from that site in 2007 (M.-A. Couillard, pers. comm.). This population, therefore, cannot be considered extirpated. The status of the other four populations (aux Bleuets, Niger, Maskinongé, Chicot rivers) has not changed; as sampling in 1996, 2012, and 2013 failed to capture Channel Darter from these locations (Desrochers *et al.* 1996; Boucher and Garceau 2010; WSP 2013). In addition to these extirpated sites, Phelps and Francis (2002) reported nine sites that had not been re-sampled and whose status was uncertain. Of these nine sites, eight have since been re-sampled and the presence of Channel Darter was confirmed in: Rivière Chateauguay, Rivière Richelieu, Rivière au Saumon, Rivière du Chêne, and Rivière l'Assomption, Rivière aux Ormes, Rivière Henri, Rivière Bécancour (Table 2). Pointe-du-Buisson has not been sampled since 1942, therefore the status of this location is unknown.

New extirpations have also been reported since the publication of Phelps and Francis in Ontario (2002). Intensive targeted sampling of the shores of Lake Erie in 2005-2006 failed to capture Channel Darter at five historical sites: Holiday Beach andPelee Island in the western basin; Port Burwell, Rondeau Bay, and Port Dover in the eastern basin (Reid and Mandrak 2008). Therefore, the populations of the central and eastern basins of Lake Erie appear extirpated. However, Channel Darter was collected in the western basin in 2005-2006 (Reid and Mandrak 2008), from a bottom trawl in 2009 (M. Belore, unpubl. data) and using a seine net (over 50 individuals collected) in 2010 (S. Reid, pers. comm.). The population along the south shore of Lake St. Clair may also be extirpated. The last Canadian record of Channel Darter from Lake St. Clair dates back to 1996, and targeted sampling of historical sites in 2004-2005 and 2007-2010 yielded no captures (Bouvier and Mandrak 2010). A trawling survey conducted by the Michigan Department of Natural Resources conducted between 1996 and 2001 captured a total of six Channel Darter, but the report does not specify the year of captures (Thomas and Haas 2004). Additional sampling in 2011 yielded no captures (M. Belore, pers. comm.). There was a single specimen captured in 2012 (J. Barnucz, pers. comm.). It is unclear if a viable population of Channel Darter still exists in Lake St. Clair.

In summary, sampling since the publication of the last report confirmed the majority of the population extirpations reported by Phelps and Francis (2002). The only exception is Rivière du Sud, where 29 specimens were collected in 2013 (HydroNet 2013). In Ontario, intensive targeted sampling failed to capture the species at many historical nearshore collection sites in lakes Erie and St. Clair, indicating that lacustrine populations are experiencing more severe declines than riverine populations. A recent unpublished compilation of occurrence data from Quebec waterways summarizes data from collections made 2010-2013 (Table 2). Of the sampling sites reported, 22 confirmed continuing occurrence, five recorded new occurrences and nine failed to capture Channel Darter at sites that previously had the species. Sampling was not extensive enough to conclude that there were local extirpations, but indicate this potential.

Newly identified populations

In the last report, Phelps and Francis (2002) reported the discovery of Channel Darter in four new waterbodies in Ontario and six in Quebec (for details, see Appendix 1; Phelps and Francis 2002). Re-sampling has since occurred in all six new sites in Quebec and confirmed the presence of Channel Darter in all cases (Figure 6). In Ontario, two of the newly discovered locations (Lake St. Clair and St. Clair River) were sampled since the publication of the last report (Figure 4, 5). Targeted sampling yielded no recaptures in Lake

St. Clair. Recent sampling also occurred in the St. Clair River and yielded no captures. This trawling survey, however, occurred in the fall when water temperatures were low, and failure to capture Channel Darter may be due to environmental conditions (J. Barnucz, pers. comm.). Channel Darter has been captured in trawls in the American portion of the St. Clair River (Burkett and Jude 2015). Channel Darter has also been captured from new waterbodies since the publication of the previous report in 2002. In Quebec, seven new populations have recently been discovered in Blanche River (Thurso), Sainte-Anne River, du Loup River, Grande Yamachiche River, Jacques-Cartier River, Calumet and Pointe-au-Chêne (Table 2) (Boucher and Garceau 2010; Levert 2013; ZIP du lac Saint-Pierre 2013; WSP 2014). In addition, Channel Darter has recently (2009-2010) been collected from two new tributaries, Miscou River and Huron River, in the watersheds of du Sud River and du Chêne River, respectively. In Ontario, a new population of Channel Darter was discovered in the Salmon River in 2003 (Reid *et al.* 2005). In summary, new populations of Channel Darter continue to be discovered, thus, extending the known range of the species. It should be noted, however, that these new discoveries are more likely the result of increased sampling effort rather than increases in abundance or population expansions (Figures 4-6).

Extent of Occurrence and Index of Area of Occupancy were estimated using observations made from 1980-1999 and in the following decade, 2000-present, for each DU:

- DU 1 – Lake Erie (EOO 1980-1999=1,828 km^2; 2000-present= 2,918 km^2: IAO 1980-1999= 80 km^2; 2000-present= 180 km^2)
- DU 2 – Lake Ontario (EOO 1980-1999= 667 km^2; 2000-present= 1,655 km^2: IAO 1980-1999= 172 km^2; 2000-present= 392 km^2)
- DU 3 – St. Lawrence (EOO 1980-1999= 47,000 km^2; 2000-present= >53,215 km^2: IAO 1980-1999= 5,620 km^2; 2000-present= 7,664 km^2). N.B. Does not include new records received after 2-Month Provisional Report.

Search Effort

Recent search effort for Channel Darter is summarized in Table 1, focusing mostly, but not only, on sampling done since the last report (Phelps and Francis 2002). Targeted surveys for Channel Darter have been increasing in frequency and intensity in recent years. Note that detailed effort data are often lacking and that many surveys were designed only to confirm the presence of the species and, therefore, such sampling stopped once a specimen was found (e.g., Garceau *et al.* 2007). In a few cases, detailed effort information is available and we refer the reader to the original report for details. This is especially true of recent surveys (e.g., Reid and Mandrak 2008). In general, the effort and gear used varied between surveys, making comparisons difficult. Recent efforts, however, have been using standardized survey methods across different geographical areas and should make future assessments of relative abundance easier. For example, DFO has been conducting trawl surveys using a new method in the Huron-Erie Corridor and the Ottawa River (J. Barnucz, pers. comm.). Finally, the table reports effort for each population, but many sites were often visited for each population. In most cases, Channel Darter was only captured at a subset of the sites visited. Whenever information was available on the number of sites visited, we included it in the table.

Table 1. Summary of recent fish surveys, 1995-2013, in known areas of Channel Darter occurrence and sources of the information. *Populations in bold were discovered since the publication of the previous COSEWIC report in 2002. Gear: a = backpack electrofisher, b = seine net; c = drift/kick net; d = boat electrofishing; e = trawl.

Population	Year of survey	CD targeted?	Gear	Quantity	Source	Effort or CPUE data?
DESIGNATABLE UNIT 1						
Bay of Quinte Drainage						
Moira system: Moira, Skootamatta and Black Rivers	2001, 2003	yes	a, b	61	Reid *et al.* 2005	no
Salmon River	2001, 2003	yes	a, b	65	Reid *et al.* 2005	no
Trent River	2002-2010	yes	a	>20 / year	Coker and Portt 2011 Reid (unpublished data)	Yes. Details in report.
DESIGNATABLE UNIT 2						
Lake Erie Drainage						
Detroit River	2010-2011	yes	e	79 in 2011	J. Barnucz pers. comm.	170 x ~2min trawls in 2011
Western basin: Pelee Island, Point Pelee, Holiday Beach	2010	yes	b	>50	S. Reid pers. comm	no
Central Basin: Port Burwell, Erieau	2005-2006; 2007-2008	yes	b, d	0;0	Reid and Mandrak 2008; Yunker *et al.* 2009	2 to 5 seine hauls per site (13 sites); see report
Eastern basin: Port Dover, Rondeau Bay	2005-2006; 2007-2008	yes	b, d	0;0	Reid and Mandrak 2008; Yunker *et al.* 2009	2 to 5 seine hauls per site (11 sites); see report
Lake St. Clair Drainage						
St. Clair River	2010	yes	e	**0**	J. Barnucz pers. comm.	
Lake St. Clair	2005, 2007-2011	no	b	**0**	M. Belore pers. comm.	>600 seine hauls
DESIGNATABLE UNIT 3						
Ottawa River Drainage						
Little Rideau Creek	2010	no	a	2	S. Reid pers. comm.	no
Ottawa and Montreal Drainage						
Ottawa River	2011	yes	e	144	S. Reid pers. comm.	no
Ottawa River west of Gatineau	2006	yes	a, d	**0**	Pariseau *et al.* 2009	no

Population	Year of survey	CD targeted?	Gear	Quantity	Source	Effort or CPUE data?
Lake St. Louis	1999	no	b	41	J. Boucher pers. comm.	no
	1997, 2005			0		
Gatineau River	1995, 2000, 2012, 2013			≥ 1	Table 2	no
	2011	yes	a	183	S. Reid pers. comm.	no
Blanche (Gatineau)	2011, 2012	yes	a	48	Levert 2013	213 plots surveyed; details in report
Blanche (Thurso)	1995, 2000, 2013			≥ 1	Table 2	
	2011, 2012	yes	a	38	Levert 2013	277 plots surveyed; details in report
Petite-Nation River	1995, 2000, 2013			≥ 1	Table 2	no
	2011, 2012	yes	a	62	Levert 2013	325 plots surveyed; details in report
Saumon River	2011, 2012	yes	a	78	Levert 2013	361 plots surveyed; details in report
Rouge River	1995, 2006			≥ 1	Table 2	no
Calumet	2006			≥ 1	Table 2	no
Pointe-au- Chêne	2006, 2007			≥ 1	Table 2	no
Southwest St. Lawrence River Drainage						
Richelieu River	2009-2011	no	b	29, 58, 34	N. Vachon pers. comm.	no
	2012			≥ 1	Table 2	no
Châteauguay River (inc. trib : aux Outardes, Trout, des Anglais)	2006	yes	a	≥ 1 per station	Garceau *et al.* 2007	16 stations sampled (350 m each)
des Anglais	2012	yes	a	11	Ambioterra 2013	
	2013			≥ 1	Table 2	no
Yamaska River	2010-2011	yes	a	2	Garceau *et al.* 2011	26 sites visited
	2013			≥	Table 2	no
Rivière Noir	2013 (x2)	yes; no	a b	12; 57	WSP 2014; HydroNet 2013	6 stations sampled; 30 stations sampled
Saint-François River	2008-2009, 2011; 2012; 2013	yes	a b	12; 0; ≥ 1	M.-A. Couillard pers. comm.; ZIP du lac Saint- Pierre 2013	no; details in report
Rivière aux Bleuets***	2013	yes	a b	0	WSP 2014	6 stations sampled

Population	Year of survey	CD targeted?	Gear	Quantity	Source	Effort or CPUE data?
Rivière Niger***	2013	yes	a b	0	WSP 2014	3 stations sampled
Rivière aux Saumon (at Richmond)	2013	yes	a b	0	WSP 2014	3 stations sampled
Rivière aux Saumon (at Weedon)	2013	yes	a b	1	WSP 2014	7 stations sampled
Rivière Maskinongé***	1996; 2012	yes	a, b	0	Desrochers *et al.* 1996; Table 2	no
Lake Saint-François	1996, 2004			0	Table 2	no
	2009	no	b	1	M.-A. Couillard pers. comm.	no
Lake Saint-Pierre	2010	no	b	7	M.-A. Couillard pers. comm.	no
Downstream of Lake Saint-Pierre	2001, 2008, 2012			0	Table 2	
Bécancour-Batiscan	1996			≥ 1	Table 2	
Grondines-Donnacona	2006			≥ 1	Table 2	
Nicolet River	2012; 2013	yes; no	a b	0; 38	ZIP du lac Saint-Pierre 2013; HydroNet 2013	Details in report; 30 stations sampled
Northwest St. Lawrence River Drainage						
L'Assomption River	2002; 2009; 2010; 2011; 2012	yes	a b	8; 10; 5; 77; 2	M.-A. Couillard pers.comm.; CARA 2013	no
Ouareau River	2009; 2011; 2012	yes	a b	10; 6; ≥ 1	CARA 2013	no
Bayonne River	1996; 2012	?	b	5; ≥ 1	M.-A. Couillard pers. comm.	no
Rivière Chicot***	1996; 2012	no	?	0; ≥ 1	J. Boucher pers. comm.	no
Du Loup River	2012; 2013	yes	a b	6; 3	ZIP du lac Saint-Pierre 2013; WSP 2014	Details in report; 7 stations sampled
Grande Yamachiche River	2012, 2013	yes	a b	1; 0	ZIP du lac Saint-Pierre 2013; WSP 2014	Details in report: 4 stations sampled
Batiscan River	2013	yes	a b	11	WSP 2014	14 stations sampled
Jacques-Cartier River	2003; 2013	yes	a b	1; 0	M.-A. Couillard pers. comm.; WSP 2014	no; 11 stations sampled
Saint-Anne River	2002; 2013	?; yes	?; a b	1; 2	Boucher and Garceau 2010; WSP 2014	no; 15 stations sampled
Southeast St. Lawrence River Drainage						
Bécancour River	2013	yes	a b	≥ 1	Table 2	no
Aux Orignaux River	2013	yes		0	WSP 2014	4 stations sampled
Aux Ormes River	2013		a b	2	WSP 2014	6 stations sampled

Population	Year of survey	CD targeted?	Gear	Quantity	Source	Effort or CPUE data?
Gentilly River	2013	yes	a b	6	WSP 2014	5 stations sampled
Du Sud River	2005; 2013	yes; no	a	2; 29	M.-A. Couillard pers. comm.; HydroNet 2013	no; 30 stations sampled
Bras Saint-Nicolas	2012; 2013	yes	a	5; 2	OBV de la Côte-du-Sud 2013; Paradis 2014	Details in report; 10 stations sampled
Du Chêne River	2005, 2010; 2013	yes	a b	≥ 1; 6	Table 2; WPS 2014	7 stations sampled
Henri River	2013	yes	a b	2	WPS 2014	3 stations sampled

Table 2. Summary of Channel Darter occurrences at 53 sample sites in the St. Lawrence DU. X=occurrence; 0=absent despite inventories directed on the species; (XXXX)=year of capture; FMN=data from the St. Lawrence Fish Monitoring Network. The 1930-2009 data is summarized in DFO (2013), and the 2010-2013 data is a recent unpublished compilation available at the Centre de données sur le patrimoine écologique du Quebéc.

Watercourse	Years of confirmed Channel Darter occurrence				
	1930-1949	1950-1969	1970-1989	1990-2009	2010-2013
St. Lawrence River					
Lake St. François					
Lake St. François[RSI]				O (1996[RSI], 2004[RSI]) X (2009[RSI])	
Lake St. Louis					
Lake St. Louis[RSI]	X (1941)			O (1997[RSI], 2005[RSI]) X (1999)	O (2011)[RSI]
Pointe-du-Buisson	X (1942)				
Lachine Rapids	X (1941)				
Lake St. Pierre					
Lake St. Pierre				X (1995[RSI], 2002[RSI], 2006, 2007[RSI])	X (2010, 2012)[MDDEFP]
Lake St. Pierre archipelago[RSI]				O (1995[RSI]) X (2001, 2003[RSI])	X (2010)[RSI]
Port Saint-François			X (1972)	O (1995)	
Downstream section					
Bécancour-Batiscan section[RSI]				X (1996[RSI]) O (2001[RSI], 2008 [RSI])	O (2012)[RSI]
Grondines-Donnacona section[RSI]				X (1997[RSI]) X (2006[RSI])	
Montreal and Ottawa drainage					
Des Sept drainage					
Blanche River (Gatineau)				X (1995, 2000)	X (2011, 2012, 2013)[Univ. Ottawa]
Gatineau River				X (1999, 2002, 2003 2004)	X (2013)[MDDEFP]
Du Lièvre drainage					
Blanche River (Thurso)					X (2011, 2012, 2013)[Univ. Ottawa]
Rouge/Petite-Nation/Saumon drainage					
Calumet Creek				X (2006)	
Petite Nation River		X (1964)		X (1995, 2000)	X (2011, 2012, 2013)[Univ. Ottawa]

Watercourse	Years of confirmed Channel Darter occurrence				
	1930-1949	1950-1969	1970-1989	1990-2009	2010-2013
Pointe-au-Chêne River				X (2006, 2007)	
Rouge River				X (1995, 2006)	
Saumon River (or Kinonge River)				X (1995, 2007)	X (2011, 2012, 2013)[Univ. Ottawa]
Ottawa River drainage					
Ottawa River			X	X (2006)	
Northwest St. Lawrence River drainage					
Batiscan-Champlain drainage					
Batiscan River			X (1973)		X (2013)[Génivar]
Bayonne drainage					
Bayonne River			X (1971)	X (1996)	X (2012)[MDDEFP]
Chicot River	X (1941)		X (1971)	O (1996)	O (2012)[MDDEFP]
L’Assomption drainage					
L’Assomption River			X (1981, 1987)	X (1991, 2002, 2009)	X (2010, 2011, 2012)[CARA]
Ouareau River			X (1981)	X (1990, 2002, 2009)	X (2011, 2012)[CARA]
Du Loup/Yamachiche drainage					
Rivière du Loup					X (2012[ZIP Lac Saint-Pierre], 2013[Génivar])
Grande Yamachiche River					X (2012)[ZIP Lac St-Pierre] O (2013)[Génivar]
Jacques-Cartier drainage					
Jacques-Cartier River				X (2003)	O (2013)[Génivar]
Sainte-Anne drainage					
Blanche River				X (2002)	
Noire River					X (2013)[Génivar]
Southwest St. Lawrence River drainage					
Châteauguay drainage					
Allen Creek			X (1976)		
Châteauguay River	X (1941, 1942, 1944)		X (1976, 1987)	X (2006)	X (2012)[MDDEFP]
Des Anglais River			X (1976)	X (1996, 2006, 2009)	X (2010, 2011, 2012, 2013)[Ambioterra]

Watercourse	Years of confirmed Channel Darter occurrence				
	1930-1949	1950-1969	1970-1989	1990-2009	2010-2013
Aux Outardes River (East)			X (1976)	X (1996, 2002, 2006)	
Trout River	X (1941)		X (1976)	X (1996, 2006)	X (2010)[Ambioterra]
Richelieu drainage					
Richelieu River				X (1991, 1993, 1994, 1997, 1999, 2001, 2003, 2006, 2009)	X (2010, 2011, 2012)[MDDEFP]
Saint-François drainage					
Aux Bleuets River			X (1977)	O (1992, 1996)	O (2013)[Génivar]
Lake Elgin outlet (or Maskinongé River) drainage	X (1934)			O (1996)	O (2012)[MDDEFP]
Niger River	X (1931)			O (1996)	O (2013)[Génivar]
St. François River	X (1944)			X (1998, 2003, 2008, 2009)	X (2011[MDDEFP], 2013[MDDEFP+Odanak]) O (2012)[ZIP Lac St-Pierre]
Aux Saumons River (Richmond/Melbourne)	X (1932)			X (2009)	O (2013)[Génivar]
Aux Saumons River (Weedon/Lingwick)			X (1977)		X (2013)[Génivar]
Yamaska drainage					
Noire River		X (1964)	X (1987)	X (1995)	X (2013)[Génivar, Hydronet]
Yamaska River		X (1969)	X (1971)	X (1995)	X (2010)[MDDEFP] X (2012)[MDDEFP]
Southeast St. Lawrence River drainage					
Bécancour drainage					
Bécancour River		X (1964)			X (2013)[MDDEFP]
Aux Orignaux River			X (1975)		O (2013)[Génivar]
Aux Ormes River	X (1941)				X (2013)[Génivar]
Gentilly River	X (1941)				X (2013)[Génivar]
Côte-du-Sud drainage					
Bras Saint-Nicolas			O (1975), X (1980)	X (1997), O (2003, 2005, 2007, 2010)	X (2012, 2013)[OBV Côte-du-Sud]
Du Sud River	X (1941)	X (1964)	O (1988)	O (1991, 1992,1996, 1997, 2004) X (2005)	X (2013)[Hydronet]

Watercourse	Years of confirmed Channel Darter occurrence				
	1930-1949	**1950-1969**	**1970-1989**	**1990-2009**	**2010-2013**
Miscou River (tributary of Du Sud River)				X (2009)	
Du Chêne drainage					
Du Chêne River			X (1971)	X (2007)	X (2010, 2013[Génivar])
Henri River			X (1971)		X (2013)[Génivar]
Huron River					X (2010)[MDDEFP]
Nicolet drainage					
Nicolet River	X (1944)				O (2012)[ZIP Lac St-Pierre] X (2013)[MDDEFP, Hydronet]

HABITAT

Habitat Requirements

The following sections describe the general habitat requirements for the different life stages of the Channel Darter. Note that specific locations identified as critical habitats have been listed in the Recovery Strategy (DFO 2013).

<u>Adult habitats</u>

Adult Channel Darter are found in small, medium, and large river habitats where the current is moderate and on lakeshore beaches with clean coarse sand and fine gravel (Phelps and Francis 2002; Bouvier and Mandrak 2010; Boucher and Garceau 2010). Reid (2004) used electrofishing to collect a total of 347 Channel Darter from riffle and shoal habitats in the Salmon and Trent rivers. Reid *et al.* (2005) examined associations between riffle characteristics (width, depth, velocity, conductivity, median particle size) and occurrence of adult Channel Darter in five rivers in the Lake Ontario basin. While they failed to identify a statistically significant difference between sites with and without adult Channel Darter, they did note that most captures took place where riffles flowed into deep sand-bottomed run or pool habitats. The upstream limit of distribution in four of those rivers was associated with impassable barriers. In Quebec, Boucher *et al.* (2009) examined the habitat requirements of Channel Darter in the Richelieu and Gatineau rivers. In the Gatineau River, the sites where Channel Darter was captured had significantly higher water velocities and increased presence of periphyton. In the Richelieu River, capture sites were shallower, had higher water velocity, and increased presence of woody debris. The only variable associated with Channel Darter presence in both rivers was water velocity, and most individuals were captured at sites with intermediate water velocities of 0.39-0.48 m/s. Boucher *et al.* (2009) suggested that these intermediate water velocities could represent a compromise between prey availability and energy expenditures required at high velocities.

Alternatively, it has also been suggested that moderate velocities may help maintain a fine-sediment-free substrate, perhaps for spawning (Scott and Crossman 1973). In their survey of beach habitat of Lake Erie, Reid and Mandrak (2008) captured most individuals on coarse sand-fine gravel beaches. Channel Darter was also collected from one site characterized as a fine-sand beach (Reid and Mandrak 2008). The habitat preference of Channel Darter in four tributaries of the Ottawa River (Gatineau, Blanche (Thurso), Petite-Nation, Saumon) over three seasons (spring, summer, fall) was also recently examined (Levert 2013). In all four tributaries, Channel Darter was found over heterogeneous, coarse substrates (gravel, pebbles and cobble), a shallow gradient, and water velocities ranging from 0.25 to 1 m/s. However, substrate type appeared to be the only fixed variable in determining the presence of Channel Darter in all four tributaries, suggesting habitat preference may be less specific than what was described in previous studies (e.g., Boucher *et al.* 2009, Bouvier and Mandrak 2010).

Note that most sampling has been conducted in the summer months and that comparatively little appears to be known about the overwintering habitat requirements of the Channel Darter. Reid (2004) reported decreasing catch-per-unit-effort (CPUE) in late summer-fall, with the number of fish collected per minute (electrofishing) 66% lower in August (water temperature 22°C) compared to the spawning season. CPUE in October (7°C) further decreased and was 90% lower than during the spawning season. This would suggest that Channel Darter move to other river habitats during the winter months. Alternatively, Channel Darter may be less active and, thus, more difficult to catch, in the winter season. Reid and Mandrak (2008) also noticed a seasonal shift in Channel Darter capture rates in Lake Erie. The trend, however, appears to be reversed in the lacustrine habitat, with more individuals collected in the fall (27 Sept-12 Oct, 2005-2006) during night seining than in the spring (5-21 Jun). While this suggests a seasonal shift in habitat, it also suggests that this shift occurs differently in lacustrine and riverine habitats. Alternatively, it raises the possibility that, after the spawning season is over, Channel Darter migrate from running water to slower moving and deeper habitats. Branson (1967) observed movement from the main stems of a river in Oklahoma to quieter leaf and debris filled backwaters for overwintering.

Spawning habitats

Channel Darter spawns in the spring and early summer when water temperatures range between 14 and 26°C (Comtois *et al.* 2004; Reid 2004). In general, suitable spawning habitats appear characterized by moderate water velocities and a coarse substrate (Reid 2004; Lemieux *et al.* 2005; Boucher *et al.* 2009). In Quebec, one particular spawning site in the Gatineau River has been identified and repeatedly visited over the years and yields insight into the spawning requirements of the Channel Darter (Boucher and Garceau 2010). In 1999, seven males and one female in spawning condition were captured between May 20 and June 21, in water temperatures varying between 14 and 19°C and depth of capture varying between 0.5 and 5 m (Comtois *et al.* 2004). In 2003, spawning females and heavily pigmented males were observed in the same area between July 14 and 27 (J. Boucher, pers. comm.). However, individuals in spawning condition constituted a very small proportion of the catch at that time (2-5 possibly ripe individuals out of a total of 137 captured; J. Boucher, pers. comm.), perhaps suggesting that the spawning season was reaching its end. This is consistent with the observations of Reid (2004) who collected males in spawning condition and ripe females in the Trent River throughout June 2003 when water temperatures increased from 14.5 to 25°C. No Channel Darter in spawning condition were captured after July 4 (water temperature: 27°C) in the Trent River and after July 1 (26°C) in the Salmon River, suggesting that Channel Darter preferentially spawn in waters with temperatures of less than approximately 26°C. This is further supported by the observation that spawning in the Cheboygan River, Michigan, occurred a month earlier than in the Trent River, but was associated with similar temperatures (Winn 1953). Reid (2004) measured a series of habitat variables at the sites on the Trent River where gravid Channel Darter were captured. Those measurements suggested that spawning occurs at sites with mean mid-column water velocities of 0.46 m/s (range 0-1.0), mean water depths of 0.49 m (range 0.23-0.77), and coarse substrate (21% gravel, 64% cobble). These spawning conditions are comparable those observed in four tributaries of the Ottawa River [Gatineau, Blanche (Thurso), Petite-Nation, Saumon], where 22 males with spawning colouration were observed from June 26th and July 17th at shallow depths (0.14 – 0.50 m), in water velocities of 0.076 to 3.5 m/s with coarse substrates and temperatures ranging from 17.5 and 23.9 °C (Levert 2013).

Together, these observations from a variety of locations all support the importance of a coarse substrate and a moderate water velocity. This is further supported by Winn's (1953) observation that spawning ceased in the Cheboygan River, after water flow became interrupted. Winn (1953) also observed multiple spawning events directly at this location and noted that eggs were deposited in coarse to fine gravel, but not in fine sand. Males also appeared to defend breeding territories, which were often centered on a large rock (Winn 1953).

Young-of-the-year (YOY) and juvenile habitat

Limited information exists on the habitat requirements of juvenile Channel Darter. A literature review by Lane *et al.* (1996) noted that the presence of juveniles was associated with substrates such as gravel and sand and, to a lesser degree, silt. They also noted that juveniles were more common in streams than in lakes (Lane *et al.* 1996). Eggs and larvae were collected at a spawning site in the Gatineau River (Lemieux *et al.* 2005). The larvae collected emerged from the eggs as sampling was occurring and it is unclear whether the larvae would have moved later to a different habitat (Lemieux *et al.* 2005). Using electrofishing in the Salmon and Trent rivers, Reid (2004) failed to capture Channel Darter that were less than one-year old, and only two individuals out of a total of 54 individuals aged were one-year old. All other individuals were two to five years old. This suggests that smaller individuals were either less susceptible to capture with the electrofishing method, or that juveniles use different habitats than adults.

Residence

Channel Darter does not construct residences during its life cycle.

Habitat Trends

There has been a net loss of Channel Darter habitat due to agricultural activities and urban development throughout the Canadian range of the species. Deforestation associated with agricultural and urban development, and shoreline modifications along lakeshores have increased sedimentation and decreased the availability of the coarse substrate preferred by Channel Darter (BAPE 2003; Vachon 2003; Reid and Mandrak 2008). The moderate water velocities required for Channel Darter spawning have been altered in many areas by dams and impoundments (Reid 2006; Boucher and Garceau 2010). Decreased water quality (e.g., Berryman 2008; ECCC 2017) and invasive species (Reid and Mandrak 2008) may also have made some habitats less available to Channel Darter. For example, in Lake Erie, harmful algal blooms have been increasing in frequency and the summer of 2010 saw an unprecedented bloom of toxic blue-green algae (Lake Erie Lakewide Management Plan 2011). This is especially worrisome because the western basin of Lake Erie, home to the only remaining population of Channel Darter in Lake Erie, was most severely affected (Lake Erie Lakewide Management Plan 2011). Habitat availability in the American distribution of the Channel Darter has also been decreasing (Rudolph *et al.* 2001; NatureServe 2011).

In Quebec, increased environmental awareness has led to the implementation of mitigation measures that may have beneficial effects for habitat availability over the longer term. For example, along the Yamaska River, concerted effort by industries in the small city of Granby led to a significant reduction in the concentration of PCBs (Berryman 2008). Regulations have also been put in place regarding management of the shoreline, but compliance was still low as of 2004 (Sager 2004). More rules regarding the use of manure as fertilizer and maximum number of animals per area may reduce the environmental impact of pork production, but the impacts of this industry are likely to remain important (BAPE 2003). Finally, Hydro-Québec is becoming aware of the impacts of alterations to flow regimes brought about by dams and has commissioned at least one study to explore ways to regulate flow in a way as to preserve Channel Darter spawning opportunities (Lemieux *et al.* 2005).

In Ontario, a variety of measures have also been put in place to improve water quality in the Great Lakes (e.g., Koonce *et al.* 1996). For instance, a partnership has been established between Environment Canada and the Ontario Ministry of the Environment and Climate Change to coordinate the development and implementation of remedial actions for several Areas of Concern (AOCs) around the Great Lakes (ECCC 2010). These AOCs cover parts of the Ontario range of the Channel Darter and include the Bay of Quinte, Detroit River, and St. Clair River. For example, in the Bay of Quinte, actions led to a reduction of phosphorus loadings in the bay by 16 500 kg and sediment loadings by 12 000 T (Environment Canada and Ontario Ministry of the Environment 2011a). Actions were also undertaken to increase monitoring of fish habitats and to implement stricter regulations for pulp and paper mills in the region (Environment Canada and Ontario Ministry of the Environment 2011a). The effects of these actions on Channel Darter habitat are unknown. In the Detroit River, provincial Municipal/Industrial Strategy for Abatement (MISA) regulations were implemented, which contributed to significant reductions in persistent toxic substances (Environment Canada and Ontario Ministry of the Environment 2011b). Large-scale natural shoreline protection and restoration programs were also implemented to increase fish habitat in several municipalities bordering the river (Environment Canada and Ontario Ministry of the Environment 2011b) and this could have a beneficial impact on Channel Darter, although it has not been quantified. The range of Channel Darter in Ontario also falls under the jurisdiction of a number of conservation authorities whose role is to deliver services and programs that protect and manage water resources in given watersheds. For example, Quinte Conservation has jurisdiction over the Moira and Salmon rivers watershed and is responsible for shoreline habitat restoration projects. Those watersheds are severely impounded and no plans are in place to remove dams (B. McNevin, pers. comm.). Quinte Conservation does not have projects specifically targeting Channel Darter habitat (B. McNevin, pers. comm.).

Together, these mitigation measures may lead to an increase in habitat availability in the future, but the combined impacts of intensive agriculture and urban development will likely continue to be important.

BIOLOGY

The biology of Channel Darter was previously summarized by Goodchild (1994) and Phelps and Francis (2002). However, new studies have clarified some aspects of Channel Darter biology, particularly regarding its reproductive biology (e.g., Reid 2004; Boucher *et al.* 2009).

Feeding and nutrition

Channel Darter is a demersal fish that feeds primarily on benthic invertebrates (Scott and Crossman 1973; Goodchild 1994; Lapointe 1997). Gut analyses from Lake Erie, ON, Cheboygan River, MI, and the Ohio River suggest that Channel Darter feed predominantly on chironomid larvae (midge larvae), small trichopteran larvae (caddisfly larvae), ephemeropteran naiads (mayfly larvae) and, occasionally, ostracods (Turner 1921; Winn 1953, Page 1983; Strange 1997). Zooplankton and pupae comprise the remainder of the diet, although the proportion of these prey items consumed varies depending on the geographical locality of Channel Darter and the composition of the local invertebrate community (Strange 1997). Algae, organic matter, and debris have also been reported as food items for Channel Darter (Turner 1921; Goodchild 1994), although it is unclear whether these items are consumed incidentally while feeding on invertebrates or are deliberately ingested.

Dispersal and migration

The migration and dispersal of Channel Darter remains poorly understood. Channel Darter is found in both riverine and lacustrine habitats often associated with coarse substrates with moderate flow or wave action (Phelps and Francis 2002; Reid and Mandrak 2008; Bouvier and Mandrak 2010; Boucher and Garceau 2010). In rivers, Reid *et al.* (2005) frequently caught Channel Darter on coarse substrates near sandy runs or pools. Within lakes, Trautman (1981) observed daily movements of Channel Darter, finding them mainly at depths greater than 3 m during the day and under 1 m at night. Seasonal movements of Channel Darter remain poorly understood (Reid 2004; Reid and Mandrak 2008), although Branson (1967) suggested that Channel Darter utilize deep, debris-filled backwater pools as overwintering habitats. Evidence for overwintering dispersal also comes from decreasing catch-per-unit-effort at riverine sampling sites from August to October (Reid 2004). This was associated with a concomitant increase in CPUE in deeper riverine habitats, perhaps suggesting that Channel Darter overwinter in deeper riverine environments (Reid 2004).

Inter-specific associations and interactions

Channel Darter has been sampled in Ontario from areas associated with Logperch (*Percina caprodes*) and Mimic Shiner (*Notropis volucellus*) (Goodchild 1994) and, in Quebec, with Johnny Darter, Trout-perch (*Percopsis omiscomaycus*), and White Sucker (*Catostomus commersonii)* (Lapointe 1997). In four tributaries of the Ottawa River (Gatineau, Blanche (Thurso), Petite-Nation, Saumon) Channel Darter was mainly found in the presence of Logperch, Fantail Darter (*Etheostoma flabellare*), and Longnose Dace (*Rhinichthys cataractae*) (Levert 2013). In Bras St. Nicolas (tributary of du Sud River), it was found with Cutlip Minnow (*Exoglossum maxillingua*), Rock Bass (*Ambloplites rupestris)*, Spottail Shiner (*Notropis hudsonius*), and Mimic Shiner (OBV de la Côte-du-Sud 2013). It has been suggested that in the areas where Johnny Darter and Logperch co-occur with Channel Darter, inter-specific competition for spawning territories may occur along with potential hybridization between these species (Goodchild 1994). The reproductive behaviours of Channel Darter and Johnny Darter, however, differ substantially (Grant and Colgan 1984) making hybridization between these species unlikely.

Predators of Channel Darter remain poorly understood. However, Reid (2005) found Channel Darter in the Trent River, ON in areas alongside Smallmouth Bass (*Micropterus dolomieu*) and Rock Bass, two piscivorous species (Scott and Crossman 1973). Therefore, it is possible that these predators prey on Channel Darter, although evidence for this is lacking.

Channel Darter overlaps in range with invasive Round Goby (*Neogobius melanostomus),* in areas of the St. Clair River, Lake St. Clair, Detroit River, Lake Ontario (around the Bay of Quinte), and the St. Lawrence River (Bernatchez and Giroux 2000; Phelps and Francis 2002; Reid 2006; Reid and Mandrak 2008; Boucher and Garceau 2010). Round Goby is a competitor for food and habitat resources (including spawning habitat) with Channel Darter (Baker 2005; Reid and Mandrak 2008). Additionally, it has been suggested that Round Goby is a possible predator of Channel Darter eggs and young

(French and Jude 2001; Boucher and Garceau 2010; Bouvier and Mandrak 2010). Reid and Mandrak (2008) noted that, within Lake Erie, CPUE was highest for Channel Darter in areas where Round Goby CPUE was lowest, suggesting that Round Goby displaces Channel Darter where these two species co-occur. Burkett and Jude (2015) attributed significant declines in Channel Darter CPUE and >80% decline in Channel Darter relative abundance in the St. Clair River to the impact of Round Goby. Further evidence of invasive Round Goby displacing native benthic fishes has been reported in Canada, including instances of the displacement of several additional darter species (Thomas and Haas 2004; Baker 2005).

Life cycle and reproduction

Most Channel Darter become sexually mature after one year (although some individuals may take two years; Page 1983; Etnier and Starnes 1993) and specimens have been aged from two to five years old (Reid 2004). Mature spawning fish in Ontario ranged 46-71 mm TL (Reid 2006), with males generally attaining greater lengths than females (Scott and Crossman 1973; Reid 2006). Spawning takes place in spring and summer months when temperatures range from 14.5°C to 26°C (Comtois *et al.* 2004; Reid 2004), but the duration of the spawning season is believed to vary according to latitude, with more southern populations having a longer breeding season (Hubbs 1985). Along with temperature, water flow is an important cue for Channel Darter spawning, with measured water velocities in spawning habitat ranging from 0.24 to 0.60 m/s in the Gatineau River (Comtois *et al.* 2004). The importance of water flow is further supported by observations by Winn (1953) that, when water flow was restricted to spawning habitats, Channel Darter breeding behaviour ceased. Winn (1953) observed the spawning and courtship behaviour of Channel Darter in the Cheboygan River, Michigan and estimated that males established spawning territories of approximately 1 m^2. Males select breeding territories composed predominately of cobble and pebble ranging 30-67% of the total substrate present (Comtois *et al.* 2004, Lemieux *et al.* 2005) and often have a large boulder present within their territories (Winn 1953). Winn (1953) observed that when females approached a male’s territory, he would try to drive her into the centre of his territory. Spawning takes place between rocks or in gravel when the female partially immerses herself in the substrate and the male is positioned above her, cradling her body between his pelvic fins with both the male and females caudal fins depressed together (Winn 1953). The eggs are immediately fertilized within such “nests”. Winn (1953) excavated three “nests” and determined that they contained 4-10 mildly adhesive eggs that were approximately 1.4 mm in diameter. Winn (1953) also noted that female Channel Darter mate with several males during the breeding season and estimated that females could lay up to 357-415 eggs per mating season. However, due to the communal spawning behaviour of Channel Darter, the number of males present may limit the females ability to lay all of her eggs (Goodchild 1994). There is no parental care of the eggs (Winn 1953) and little is known about juvenile Channel Darter, except that young-of-year appear to be found in sand and gravel areas (Lane *et al.* 1996).

Physiology and Adaptability

There is no information available on the physiology and adaptability of Channel Darter, although inferences may be drawn from investigations of congeneric species. In an investigation of the sensory physiology and behaviour of Logperch, Bergstrom and Mensinger (2009) showed that this *Percina* species suffers weight loss in competition with the invasive Round Goby. This competitive disadvantage may be compounded in situations of low light, as Logperch was found to be less active and to have shorter prey strike distances than Round Goby at low light intensities (Bergstrom and Mensigner 2009).

In a study of Leopard Darter (*P. pantherina*), Schafer *et al.* (2003) suggested that use of deeper, cooler waters by this species in late summer suggests that thermal refugia may be important habitats for long-term management. This implies that this species does not rely on physiological adaptability (i.e., plasticity) to cope with temperature change, but rather behavioural response and the presence of thermal refugia is of primary importance.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

The number of surveys targeting Channel Darter increased substantially since the publication of the last COSEWIC report (Phelps and Francis 2002; Table 1). However, quantitative data allowing an assessment of abundanceremain scarce. Indeed, many of the surveys conducted were designed to confirm the presence of the species, not to measure abundance, and sampling would often stop as soon as one or a few specimens were identified in the interest of protecting the species and its habitat (J. Boucher, pers. comm.). Some surveys (e.g., Reid and Mandrak 2008) include catch-per-unit-effort that can allow an evaluation of relative abundance. Comparison among populations is difficult because of the different gear used and the different habitat sampled in the different surveys (see Table 1).

All the available information on population abundance and trajectories (prior to 2010) was summarized and integrated in a series of reports published by DFO (Boucher and Garceau 2010; Bouvier and Mandrak 2010; DFO 2010). Those reports develop qualitative indices that allow an evaluation of the relative status of populations. We refer the reader to the original reports for details regarding the methods. In short, a Relative Abundance Index (RAI) was assigned to each known population of Channel Darter as Low, Medium, High, Extirpated, or Unknown. The index is calculated relative to the population with the highest estimated abundance (Trent River in Ontario) and is based on sampling parameters such as gear used, area sampled, sampling effort, and whether the study was specifically targeting Channel Darter. Further, the lack of standardized sampling design forced the authors to assume that sampling in different habitats (large river, small river, lakes) and using different gear types yielded comparative results. Finally, each RAI was assigned a level of certainty from 1 to 3, according to the following criteria: 1 = quantitative analysis; 2 = CPUE or standardized sampling; 3 = expert opinion. The RAI was also complemented by a similar assessment of Population Trajectory, with each population being assessed as

Decreasing, Stable, Increasing, or Unknown. This was also based on the best available knowledge regarding trends in the number of individuals caught over time for each population. Note that, because the authors of the report did not have access to information on some populations, they were not included in these analyses. The level of certainty of these estimates was assigned using the same scheme as with the RAI. Finally, the information of the RAI and Population Trajectory were combined in a single index of Population Status, describing each population as being Extirpated, or of Unknown, Good, Fair, or Poor condition. This status was assigned to populations according to the matrix presented in Table 3. The level of certainty assigned to the Population Status estimate is the lowest level of certainty associated with either of the initial ranks. Also, note that, because it relies on the RAI, the Population Status index is also relative, and a 'Good' designation simply implies that the population is doing better than others, not that it is not at risk of extinction.

Table 3. Matrix showing the relation between the Relative Abundance Index and the Population Trajectory Index in the calculation of the Population status (from Bouvier and Mandrak 2010).

		Population Trajectory			
		Increasing	**Stable**	**Decreasing**	**Unknown**
Relative Abundance Index (RAI)	High	Good	Good	Fair	Fair
	Medium	Fair	Fair	Poor	Poor
	Low	Poor	Poor	Poor	Poor
	Unknown	Unknown	Unknown	Unknown	Unknown
	Extirpated	Extirpated	Extirpated	Extirpated	Extirpated

Table 4. Relative Abundance Index and Population Trajectory Index for populations of Channel Darter in Quebec and Ontario (modified from Bouvier and Mandrak 2010 and Boucher and Garceau 2010). Certainty: 1 = quantitative analysis; 2 = CPUE or standardized sampling; 3 = expert opinion.

Population	Relative Abundance Index (RAI)	Certainty	Population Trajectory	Certainty
DESIGNATABLE UNIT 1 – LAKE ERIE POPULATIONS				
Detroit River	Unknown	3	Unknown	3
Lake Erie Western basin: Pelee Island, Point Pelee, Holiday Beach	Medium	2	Decline	2
Lake Erie Central/Eastern basin: Port Dover, Port Burwell, Rondeau Bay	Extirpated	2	NA	2
St. Clair River*	Unknown NA		Unknown	NA
Lake St. Clair	Low	2	Unknown	2
DESIGNATABLE UNIT 2 – LAKE ONTARIO POPULATIONS				
Moira system: Moira, Skootamatta and Black Rivers	High	2	Unknown	2

Population	Relative Abundance Index (RAI)	Certainty	Population Trajectory	Certainty
Salmon River	High	2	Unknown	2
Trent River	High	2	Decline	2
DESIGNATABLE UNIT 3 – ST. LAWRENCE POPULATIONS				
Lake Saint-Louis*	Unknown NA		Unknown	NA
Gatineau River				
Blanche River (Gatineau)*	Not Assessed	NA	NotAssessed	NA
Blanche River (Thurso)*	Not Assessed	NA	Not Assessed	NA
Petite-Nation River*	Not Assessed	NA	Not Assessed	NA
Saumon River*	Not Assessed	NA	Not Assessed	NA
Rouge River*	Not Assessed	NA	Not Assessed	NA
Calumet*	Not Assessed	NA	Not Assessed	NA
Pointe-au- Chêne*	Not Assessed	NA	Not Assessed	NA
Richelieu River	High	2	Stable	2
Châteauguay River	Medium	2	Decline	2
Yamaska River	Low	3	Decline	3
Saint-François River	High	2	Stable	2
Lake Saint-François*	Unknown	NA	Unknown	NA
Lake Saint-Pierre*	Unknown	NA	Unknown	NA
Downstream of Lake Saint-Pierre*	Not Assessed	NA	Not Assessed	NA
Nicolet River	Unknown	3	Unknown	3
L'Assumption River	Medium	2	Stable	3
Bayonne River	Medium	2	Stable	3
Du Loup River*	Not Assessed	NA	Not Assessed	NA
Grande Yamachiche River*	Not Assessed	NA	Not Assessed	NA
Batiscan River	Unknown	3	Unknown	3
Jacques-Cartier River	Unknown	3	Unknown	3
Saint-Anne River	Unknown	3	Unknown	3
Bécancour River	Unknown	3	Unknown	3
Du Sud River	Low	2	Decline	2
Du Chêne River	Unknown	3	Unknown	3

*Populations not evaluated in Bouvier and Mandrak (2010) or Boucher and Garceau (2010).

Some important surveys have been conducted in a few locations since the 2010 reports (Boucher and Garceau 2010; Bouvier and Mandrak 2010; DFO 2010). First, a trawling survey of the Huron-Erie corridor (i.e. St. Clair River, Lake St. Clair, and Detroit River) was conducted 2009-2013 by DFO. This survey, which uses a new trawling technique (J. Barnucz, pers. comm.), allowed the capture of over 100 specimens over the last three years, all from the Detroit River. A similar technique has also been applied to the Ottawa River where 125 specimens were captured in 2011 (S. Reid, pers. comm.). Second, the Richelieu River has been the focus of intensive annual sampling as part of a study on Copper Redhorse (*Moxostoma hubbsi*) recruitment (N. Vachon, pers. comm.). These surveys used seine nets in the fall from 1999 to 2011 (except 2000, 2002, 2005) and captured a total of 200 Channel Darter over the nine years where sampling occurred (N. Vachon, unpubl.data). In addition, multiple surveys have recently been conducted (2010-2013) in Quebec to confirm the presence or absence of Channel Darter at new and historical sites. For example, in 2012 “La Comité ZIP du lac Saint-Pierre” conducted multiple surveys in tributaries of the St. Pierre River, and from 2012 to 2013 “L’Organisme des Bassins Versants (OBV) de la Côte-du-Sud” conducted surveys within the du Sud River. The Quebec government (MDDEFP) also surveyed several tributaries in 2012 and 2013 including Bayonne, Nicolet, Bécancour and Gatineau rivers.

Abundance

Abundance in populations of Channel Darter, evaluated according to the RAI described above, is summarized in Table 4. In summary, the areas where Channel Darter is found in greatest abundance are in the Bay of Quinte drainage in Ontario, and in the Ottawa River and southwestern St. Lawrence River drainage (with the exception of the Yamaska River) in Quebec. Abundance also appears to be high in the Ottawa drainage including the Gatineau, Blanche (Thurso), Blanche (Gatineau), Petite-Nation, and Saumon rivers; however, the RAI for these populations have not yet been assessed. The areas where Channel Darter is found in lowest abundance appear to be the populations in Lake Erie, Lake St. Clair and connecting rivers. Abundance in the southeastern St. Lawrence River drainage also appears low, although lack of information precludes assessment of many rivers in that drainage. More information would also be necessary to make an assessment of abundance in the northwestern St. Lawrence River drainage. Sites that have been sampled in that region, however, appear to show moderate abundance of Channel Darter.

Fluctuations and Trends

Trends in population abundance, characterized according to the methods described in the above section, are summarized in Table 4 for each population in each of the Designatable Units. The trends in abundance suggest that the situation of the Channel Darter in Canada has deteriorated since the last COSEWIC report (Phelps and Francis 2002). First, no population appears to be increasing in abundance. Second, five populations were judged to be declining in abundance. Most of the declines are for populations already showing low abundance, which is worrisome for the long-term persistence of those populations. Even abundant populations, however, appear to show signs of declines. Most notably, the Trent River population, which is deemed to be the most abundant Ontario population, shows signs of declining abundance (S. Reid, pers. comm.).

Burkett and Jude (2015) reported significant declines in Channel Darter CPUE and >80% decline in Channel Darter relative abundance from trawls undertaken in offshore habitats in 3-11 m depths of the St. Clair River, adjacent to the Canadian side, from 1994 to 2011.

The Population Status index, which combines the information of the RAI and the Population Trajectory index, is shown for each population in Table 5 for each population in each of the Designatable Units: lacustrine populations in Ontario, and populations in the southwestern St. Lawrence River drainage show poorer population status than the Ottawa River or populations from the southwest St. Lawrence River drainage (again with the notable exceptions of the Yamaska and Châteauguay rivers).

Table 5. Population Status Index for populations of Channel Darter in Quebec and Ontario (modified from Bouvier and Mandrak 2010 and Boucher and Garceau 2010). Certainty: 1 = causative study; 2 = correlative study; 3 = expert opinion.

Population	Population Status	Certainty
DESIGNATABLE UNIT - 1 LAKE ERIE POPULATIONS		
Detroit River	Unknown	3
Western basin: Pelee Island, Point Pelee, Holiday Beach	Poor	2
Central/Eastern basin: Port Dover, Port Burwell, Rondeau Bay	Extirpated	2
St. Clair River*	Unknown	NA
Lake St. Clair	Poor	2
DESIGNATABLE UNIT 2 – LAKE ONTARIO POPULATIONS		
Moira system: Moira, Skootamatta and Black Rivers	Fair	2
Salmon River	Fair	2
Trent River	Fair	2
DESIGNATABLE UNIT 3 – ST. LAWRENCE POPULATIONS		
Little Rideau Creek	Unknown	2
Ottawa River	Good	2
Lake Saint-Louis*	Unknown	NA
Gatineau River*	Unknown	NA
Blanche River (Gatineau)*	Not Assessed	NA
Blanche River (Thurso)*	Not Assessed	NA
Petite-Nation River*	Not Assessed	NA

Population	Population Status	Certainty
Saumon River*	Not Assessed	NA
Rouge River*	Not Assessed	NA
Calumet*	Not Assessed	NA
Pointe-au- Chêne*	Not Assessed	NA
Richelieu River	Good	2
Châteauguay River	Poor	2
Yamaska River	Poor	3
Saint-François River	Good	2
Lake Saint-François*	Unknown	NA
Lake Saint-Pierre*	Unknown	NA
Downstream Lake Saint-Pierre*	Not Assessed	NA
Nicolet River	Unknown	3
L'Assomption River	Fair	2
Bayonne River	Fair	2
Du Loup River *	Not Assessed	NA
Grande Yamachiche River*	Not Assessed	NA
Batiscan River	Unknown	3
Jacques-Cartier River	Unknown	3
Saint-Anne River	Unknown	3
Bécancour River	Unknown	3
Du Sud River	Poor	2
Du Chêne River	Unknown	3

* Populations not evaluated in Bouvier and Mandrak (2010) or Boucher and Garceau (2010).

In the absence of quantitative estimates of abundance or trends, it is difficult to evaluate the probability of extinction of the Channel Darter. Nevertheless, an analysis evaluating the recovery potential of Channel Darter based on stochastic models was performed by Venturelli *et al.* (2010) and offers some insights regarding the factors liable to render the species more vulnerable. We do not provide details on the methods, but simply summarize the salient points of the results. The analysis determined that any actions that would reduce the survival of Channel Darter in its first three years of life, or that would reduce the fecundity of first- and second-time spawners, would be particularly damaging to the demographic recovery of the species. The authors suggested that for a lacustrine population to remain demographically sustainable (i.e., have a 95% probability of persistence over 250 years), it should be composed of more than 6,800 adults and have access to up to 125.2 ha of suitable habitat (Venturelli *et al.* 2010). This is assuming that the probability of catastrophic declines (declines in population size of more than 50%) is 5% or less. While current knowledge does not allow us to evaluate whether extant populations have those characteristics or not, the numbers provide guidelines for future recovery targets. The authors also calculated that, assuming the population sizes are currently at 10% of the target population size, it would take 23 years for them to reach 95% of the target population size if they suffered from no additional harm or did not benefit from recovery actions (Venturelli *et al.* 2010). This time could be reduced by half in cases where recovery actions such as habitat restorations are implemented such that survival is improved by 10% (Venturelli *et al.* 2010).

Rescue Effect

Limited data are available on the dispersal propensity of Channel Darter. Its disjunct distribution in Canada, however, suggests that movement between watersheds is fairly rare. Significant genetic differences at microsatellite loci observed between watersheds further suggest that dispersal is limited (Kidd *et al.* 2011). The potential for a rescue effect to mitigate extirpations or population decline would appear limited.

The Channel Darter is more widely distributed in the United States than in Canada. The only area where the Canadian and American distributions are adjacent is on the shores of Lake Erie and in the Detroit and St. Clair rivers, and some rivers in Quebec (e.g.,Châteauguay River). The Channel Darter is present on the southern shore of Lake Erie in the states of Michigan, Ohio, Pennsylvania, and New York. In all of these states, the Channel Darter is ranked by NatureServe as equally imperiled, or, in the case of Michigan, as more imperiled than in Ontario (see Table 7). Furthermore, the threats impacting Channel Darter on the Canadian and American sides of Lake Erie are likely similar. It, thus, appears unlikely that a rescue effect from American populations would have a significant mitigating impact on extirpations or population declines in Canada, even if those populations would likely be adapted to survive in Canada.

THREATS AND LIMITING FACTORS

We first summarize the available information on all potential threats to Channel Darter currently identified in the literature. We then report a threat analysis performed in a series of recent reports published by DFO that provide a qualitative assessment of the relative importance of each threat for different populations of Channel Darter (Table 6).Finally, we provide a summary of the threats calculated separately for the three designatable units (Appendix 1-3).

Table 6. Threat status of each threat for populations of Channel Darter from Ontario and Quebec (modified from Bouvier and Mandrak 2010 and Boucher and Garceau 2010). The number in brackets refers to the level of certainty assigned to the Threat Status (1=causative studies; 2= correlative studies; 3=expert opinion).

Population	Turbidity and sediment loading	Contaminant and toxic substances	Nutrient loading	Shoreline modifications	Altered flow regimes	Barriers to movement	Exotic species and diseases	Incidental harvest
DESIGNATABLE UNIT 1 - LAKE ERIE POPULATIONS								
Detroit River	Medium (3)	Medium (3)	Medium (3)	Medium (3)	High (3)	NA	High (2)	Low (3)
Western basin: Pelee Island, Point Pelee, Holiday Beach	Medium (3)	Unknown (3)	Medium (3)	High (2)	NA	NA	High (2)	Low (3)
Central/Eastern basin: Port Dover, Port Burwell, Rondeau Bay	Medium (3)	Unknown (3)	Medium (3)	High (2)	NA	NA	High (2)	Low (3)
St. Clair River*	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)
Lake St. Clair	Medium (3)	Low (3)	Low (3)	High (2)	Unknown (3)	NA	High (2)	Low (3)
DESIGNATABLE UNIT 2 - LAKE ONTARIO POPULATIONS								
Moira system: Moira, Skootamatta and Black Rivers	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Medium (2)	Low (3)	Low (3)
Salmon River	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)	Low (3)
Trent River	Medium (3)	Low (3)	Low (3)	Low (3)	Medium (3)	Medium (2)	High (2)	Low (3)
DESIGNATABLE UNIT 3								
Little Rideau Creek	Low (3)	Unknown (3)	Unknown (3)	Unknown (3)	Unknown (3)	Unknown (3)	High (2)	Unknown (3)
Ottawa River	Low (2)	Low (2)	Low (2)	Low (3)	High (1)	Medium (1)	Unknown (3)	Low (1)
Lake Saint-Louis*	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)
Gatineau River*	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)
Blanche River (Gatineau)*	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed
Blanche River (Thurso)*	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed
Petite-Nation River*	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed
Saumon River*	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed

Population	Turbidity and sediment loading	Contaminant and toxic substances	Nutrient loading	Shoreline modifications	Altered flow regimes	Barriers to movement	Exotic species and diseases	Incidental harvest
Rouge River	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed
Calumet*	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed
Pointe-au- Chêne*	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed
Richelieu River	Medium (2)	Medium (1)	Medium (1)	Medium (2)	Low (3)	Low (1)	Unknown (2)	Low (1)
Châteauguay River	Medium (2)	Medium (1)	Medium (1)	High (3)	Low (3)	Medium (1)	Unknown (2)	Low (1)
Yamaska River	High (2)	High (1)	High (1)	Low (3)	Medium (3)	Low (1)	Unknown (2)	Low (1)
Saint-François River	Medium (2)	Medium (2)	Low (2)	Low (2)	High (2)	High (2)	Unknown (3)	Low (1)
Lake Saint-François*	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)
Lake Saint-Pierre*	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)	Unknown (NA)
Downstream Lake Saint-Pierre*	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed
Nicolet River	Medium (2)	Medium (2)	Medium (2)	Medium (2)	Unknown (2)	Low (2)	Unknown (3)	Low (1)
L'Assomption River	Medium (2)	Medium (2)	Medium (2)	Medium (2)	Low (2)	Low (2)	Unknown (3)	Low (1)
Bayonne River	Medium (2)	Medium (2)	Medium (2)	Medium (2)	Low (2)	Low (2)	Unknown (3)	Low (1)
Du Loup River *	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed
Grande Yamachiche River*	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed	Not Assessed
Batiscan River	Low (2)	Low (2)	Low (2)	Low (2)	Unknown (2)	Unknown (2)	Unknown (3)	Low (1)
Jacques-Cartier River	Low (2)	Low (2)	Low (2)	Unknown (3)	Unknown (3)	Unknown (2)	Unknown (3)	Low (1)
Saint-Anne River	Low (2)	Low (2)	Low (2)	Unknown (3)	Unknown (3)	Unknown (2)	Unknown (3)	Low (1)
Bécancour River	Medium (2)	Medium (2)	Medium (2)	Medium (2)	Unknown (2)	Unknown (2)	Unknown (3)	Low (1)
Du Sud River	Medium (3)	Medium (3)	Medium (3)	Medium (3)	Medium (2)	Unknown (2)	Unknown (3)	Low (1)
Du Chêne River	Unknown (3)	Unknown (3)	Unknown (3)	Unknown (3)	Low (2)	Low (2)	Unknown (3)	Low (1)

* Populations not evaluated in Bouvier and Mandrak (2010) or Boucher and Garceau (2010).

Table 7. Global, national, and subnational heritage ranks of the Channel Darter *Percina copelandi* (NatureServe 2011).

Rank Level	Rank[1]	Jurisdictions
Global	G4 (24 Sept 1996)	
National	N3	**Canada**
	N4	United States
Subnational	S1	Vermont
	S1S2	Louisiana, Michigan
	S2	Indiana, New York, Ohio, Pennsylvania, Virginia, **Ontario**
	S2S3	Tennessee, West Virginia, **Quebec**
	S3	Kansas, Missouri
	S4	Arkansas, Kentucky

[1] G4/N4/S4 – Apparently Secure: Uncommon but not rare; some cause for long-term concern due to declines or other factors; N3/S3 – Vulnerable: Vulnerable in the nation/state or province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation; S2 – Imperilled: Imperilled in the state or province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state or province; S1 – Critically Imperilled: Critically imperilled in the state or province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state or province. For more information on ranking see: http://www.natureserve.org/explorer/glossary/gloss_s.htm

Turbidity and sediment loading

Channel Darter appears to display a strong preference for gravel or coarse sand substrate for spawning and few individuals are captured in silt or fine sand habitats (Winn 1953; Reid *et al.* 2005; Reid and Mandrak 2008). Coarse substrate may be necessary for spawning and egg survival, and increased sedimentation and siltation could increase egg mortality (Winn 1953; Vachon 2003). Furthermore, it has been suggested that increased siltation and turbidity may reduce the availability of the Channel Darter's preferred benthic prey (Goodchild 1994; Lapointe 1997; Phelps and Francis 2002). Correlative evidence for links between increasing sediment loading and turbidity and decreased Channel Darter abundance come from two studies in the United States. In the Ohio River, a decline in Channel Darter abundance appears to have coincided with increased sedimentation and turbidity caused by the construction of impoundments (Trautman 1981). In a study of the effect of siltation on fish communities in Missouri streams, Berkman and Rabeni (1987) found the benthic insectivore feeding guild (the guild to which Channel Darter would belong) to be the most heavily impacted by increased sediment loading. Agricultural practices and urbanization have led to increased sediment loading and turbidity over much of the Canadian range of the Channel Darter (Vachon 2003). For example, 47% of the Yamaska River drainage is agricultural land (Berryman 2008). Moreover, more than half of this agricultural land is made up of high intensity cultures like corn, which is cultivated in such a way that much of the land is tiled, which greatly increases runoff and erosion (Berryman 2008). Turbidity is also a problem along many stretches of the Yamaska River (Berryman 2008). While the Yamaska River is probably one of the most polluted rivers in Quebec, other rivers suffer from similar problems, albeit of smaller magnitude (e.g., Simoneau and Thibault 2009).

Alteration of flow regimes

Based on the evidence that all known Channel Darter spawning grounds are located in rivers with moderate water flow velocity and that spawning has been observed to cease when water flow stops (Winn 1953), alteration of flow regimes during the spawning period (May to July) would appear to pose an important threat to *riverine* populations of Channel Darter populations (little is known about spawning sites of lacustrine populations). Dams modify flow regimes and constitute a threat for some populations of Channel Darter, particularly in the Moira and Trent river populations in Ontario (Reid 2006; Bouvier and Mandrak 2010). For example, along the Trent-Severn Waterway, Reid (2005) observed temporary (1-2 h) drops in water levels (0.3-0.5 m) downstream of navigational dams. Those drops in water level caused large portions of shoals and nearshore habitats to be exposed. In October, portions of the river where Channel Darter were captured in the summer appeared completely dry. Another extreme dewatering event was observed on the Trent River in 2010 (S. Reid, pers. comm.) when extensive dewatering of tailwater habitats downstream of a dam stranded several Channel Darter individuals. The dewatering led to an investigation by OMNRF, DFO, and Parks Canada Agency, but no charges were laid under the ESA or SARA (S. Reid, pers. comm.). Exposure and dewatering of spawning habitats would result in mortality of eggs incubating in the gravel and could, thus, constitute an important threat to those populations. In Quebec, several rivers also have dams in place (e.g., Gatineau, Ottawa, Yamaska, Saint-François) and alteration of flow regimes could constitute an important threat. Severe dewatering was observed in in the Gatineau River below Farmers Rapid dam on September 26, 2016 (Simon Nadeau, pers. comm.).. In 2005, a study commissioned by Hydro-Québec focused on the Channel Darter spawning grounds adjacent to the power plant in the Farmers Rapids sector of the Gatineau River (Lemieux *et al.* 2005). The study did not report exposed or dry areas, but outlined the flow requirements and the critical periods for Channel Darter spawning. The report recommends flow-rate management plans compatible with the survival and spawning requirements of the Channel Darter (Lemieux *et al.* 2005). Another potential cause of flow alteration would be the modification of streams for agriculture activities. Although the creation and modification of streams is important, at least in Quebec (BAPE 2003), there is little information on its direct consequences for flow regime alterations in general, and its impact on Channel Darter in particular.

Shoreline modifications

Shoreline modifications can impact Channel Darter in both their riverine and lacustrine habitats, although effects on lacustrine populations appear more severe. In rivers, Channel Darter prefers habitats with moderate water-flow velocities and coarse substrate and only spawn during periods when the water temperature is between 14 and 26°C (Comtois *et al.* 2004; Reid 2004). Deforestation of riparian strips can lead to increased sedimentation, increased runoff of manure and fertilizers, and an increase in water temperature (Vachon 2003); effects that can potentially alter Channel Darter preferred habitats. In lakes, Channel Darter prefers nearshore habitats characterized by coarse sand substrate (Reid and Mandrak 2008). The construction of groynes, jetties, marinas, docks, and breakwaters modify shorelines and nearshore sediment transport (Edsall and Charlton 1996; Reid and Mandrak 2008), which can destroy Channel Darter habitat. Note that a major consequence of shoreline modification is increased sedimentation, a topic covered in a previous section. Lakes Erie and St. Clair have been subjected to extensive shoreline modifications. For instance, a large portion of the Lake St. Clair shoreline has been artificially hardened, filled, or dredged (EERT 2008; Bouvier and Mandrak 2010) and is no longer suitable habitat for Channel Darter. Reid and Mandrak (2008) noted that the extirpation of Channel Darter from two historical sites in Lake Erie might have been related to the construction of jetties that created large sand depositions. In Quebec, deforestation of riparian strips to increase cropland is a problem in the region where Channel Darter is found (FAPAQ 2002; BAPE 2003; Vachon 2003) and Quebec's policies and regulations regarding shorelines and littoral zones have not been applied very extensively as of 2004 (Sager 2004).

Invasive species and disease

The Round Goby, an invasive species from the Ponto-Caspian region, is established in the Great Lakes and St. Lawrence River (Bernatchez and Giroux 2000; Corkum *et al.* 2004) and has recently colonized the Trent River (S. Reid, pers. comm.). Being a small benthic fish, it has been suggested that the Round Goby may compete with the Channel Darter for space and resources (Phelps and Francis 2002; French and Jude 2001). Fish eggs are commonly found in the stomachs of Round Goby and, thus, predation on Channel Darter eggs is also a risk (Corkum *et al.* 2004). Compelling evidence for the importance of this threat to Channel Darter comes from Reid and Mandrak (2008), who found that Channel Darter CPUE was highest when Round Goby CPUE was lowest in targeted sampling in Lake Erie. Burkett and Jude (2015) attributed significant declines in Channel Darter CPUE and >80% decline in Channel Darter relative abundance in the St. Clair River to the impact of Round Goby. In addition, a short time series of Channel Darter abundance during the current Round Goby invasion in the Trent River shows strong negative correlations (S. Reid, pers. comm.).

Barriers to movement

There is some evidence that Channel Darter use different habitats for spawning and for overwintering (Branson 1967; Goodchild 1994). Maintenance of movement potential between these habitats could be important. At a larger scale, exchange of migrants between populations may be important, and fragmentation could have detrimental demographic and genetic consequences. Dams are important barriers to movement and are found on many of the rivers inhabited by Channel Darter, both in Quebec (Boucher and Graceau 2010) and Ontario (Reid 2006). Other structures, such as poorly constructed culverts or bridges, can provide important obstacles to movement (Boucher and Garceau 2010). There is little direct evidence that such structures impact Channel Darter, but Reid *et al.* (2005) suggested that man-made structures in the Moira system might influence the current distribution of Channel Darter. Such barriers may also slow the spread of aquatic invasive species such as Round Goby.

Nutrient loading

Increased nutrient levels can lead to the development of algal blooms, which leads to depletion of dissolved oxygen (EERT 2008; Lake Erie Lakewide Management Plan 2011). While we could not find data specifically evaluating the impact of decreased oxygen levels of Channel Darter, it is assumed that their effects would be detrimental. In Quebec, excess fertilizer runoff in rivers from intensive agriculture is a well-documented problem (FAPAQ 2002). Many of the rivers inhabited by Channel Darter are in important areas of pork production, an industry with demonstrated impacts on aquatic environments (BAPE 2003). For example, it has been estimated that 67% of the phosphorus present at the mouth of the Yamaska River is of agricultural origin (Berryman 2008). In Ontario, the range of Channel Darter is also found in important agricultural areas where manure and fertilizer runoffs are common (EERT 2008). In addition, nutrient input from sewage treatment is observed (EERT 2008). In Lake Erie, harmful algal blooms have recently increased, probably because of increased temperature and increased nutrient loadings in at least two rivers (Lake Erie Lakewide Management Plan 2011).

Incidental catches

Federal and provincial regulations prevent the harvest of Channel Darter in both Quebec and Ontario. However, the distribution of Channel Darter overlaps with that of other small fishes targeted by the commercial baitfish fishery. Incidental captures could, thus, represent a risk for Channel Darter. This risk has been specifically evaluated in Quebec through a sampling program aiming to quantify the presence of species at risk in the commercial catches (Boucher *et al.* 2006). No specimens of Channel Darter were observed in the 41,500 fishes sampled (Boucher *et al.* 2006), suggesting that the threat associated with this activity is low. In Ontario, the risk associated with incidental catches has not been quantitatively evaluated, but is believed to be low as well (Bouvier and Mandrak 2010).

Contaminants and toxic substances

There is no direct evidence allowing for an evaluation of the effects of contaminants and toxic substances on Channel Darter. Areas surrounding Lake St. Clair, however, have increased levels of toxic substances that have been demonstrated to have an impact on the fish community as a whole (ECCC 2017). Both the St. Clair and Detroit rivers are Areas of Concern recognized by Environment and Climate Change Canada and the Ontario Ministry of the Environment and Climate Change. As such, they are being monitored and remediation actions are currently underway (ECCC 2017). Rivers in Quebec, such as the Yamaska, also have high levels of toxic substances where they flow close to urban areas (Berryman 2008).

Climate change

While climate change has been identified as a potential threat in previous reports (e.g., Bouvier and Mandrak 2010), the paucity of information on the topic makes its evaluation difficult. Some climate models predict a general drop in water levels in lakes and rivers in the range of the Channel Darter, which could severely impact habitat availability. For example, a recent habitat assessment of the Huron-Erie corridor estimated from climate models that the water levels in Lake St. Clair could decrease by as much as 1 m within the next 50 years and that variability in water levels could increase (Mackey *et al.* 2006). Because Lake St. Clair water levels show a great deal of natural fluctuations (by as much as 2 m), it is unclear what the consequences of decreased water levels and increased variation may be for fish habitats in general and for Channel Darter in particular (Mackey *et al.* 2006). Climate change, by increasing water temperatures, is also expected to favor the development of hypoxic (low oxygen) conditions in Lake Erie (Lake Erie Lakewide Management Plan 2011). Increased precipitation expected with climate change could also increase runoff of nutrients, further exacerbating hypoxic conditions.

Threat Level

To evaluate the relative importance of these threats for each population of Channel Darter, a qualitative index was developed in a recent series of reports published by the DFO (Bouvier and Mandrak 2010; Boucher and Garceau 2010; DFO 2010). The methods used to develop this index is similar to that used for the indices of abundance discussed in a previous section. First, threat likelihood (i.e., whether the occurrence of a specific threat was documented for that particular population) was evaluated for each threat in each population. Second, threat impact (i.e., whether a specific threat is likely to have an impact for that particular population) was also evaluated for each threat in each population. The certainty of both was evaluated as follows: 1 = causative studies; 2 = correlative studies; and 3 = expert opinion. Threat likelihood and threat impact were then combined into a single index of Threat Status, which evaluates each threat as posing a High, Medium, Low, or Unknown risk to a particular population. The level of certainty assigned to the Threat Status estimates corresponds to the lowest level of certainty assigned to either of the initial indices. Only the Threat Status index presented for each population (Table 6), classified by drainage, but tables presenting values of threat likelihood and threat impact can be found in Bouvier and Mandrak (2010) and Boucher and Garceau (2010), along with further details regarding methods and full bibliographic information on the references used to evaluate the threats.

DU 1 – Lake Erie

The primary threats in this DU are invasion of Round Goby, shoreline modifications, and altered flow regimes, which have been assessed as high (Table 6). Threats associated with turbidity, altered flow regimes and barriers, nutrient loading, and contaminants/toxic substances have been assessed as medium across all locations where information is available (Table 6). The threats calculator ranked the overall threats for this DU as high with the invasive species category having a high impact ranking, the pollution category having a medium impact ranking, and the remaining evaluated categories having negligible rankings (Appendix 1).

DU 2 – Lake Ontario

The greatest threat in this DU is spatially restricted to the Trent River system where recent data clearly show that the invasive Round Goby population is rapidly growing resulting in declines in Channel Darter abundance (S. Reid, pers. comm.) and, therefore, a threat status of high (Table 6). Dams on the Moira and Salmon rivers have isolated upstream waters form Round Goby invasion. Other threats across this DU include those associated with turbidity, altered flow regimes and barriers, nutrient loading, and contaminants/toxic substances. These are geographically variable over the DU but have been assessed as low to medium threat status (Table 6). The threats calculator ranked the overall threats for this DU as medium with the invasive species category having a medium impact ranking and the remaining evaluated categories having negligible rankings (Appendix 2).

DU 3 –St. Lawrence

Threats are geographically variable across locations within this DU. Turbidity, altered flow regimes and barriers, nutrient loading, and contaminants/toxic substances are variable geographically over the DU and have been assessed as low to medium threat status (Table 6). The invasive Round Goby is now widespread in the St. Lawrence portion of this DU and Boucher and Garceau (2010) argued that it represents a major threat to Channel Darter. Yet, lack of specific information on Round Goby within this DU led Boucher and Garceau (2010) to rate this threat as unknown. We, therefore, conclude that the impacts of this invasive species are not as advanced as in other DUs, but that the threat is likely imminent. The threats calculator ranked the overall threats for this DU as high-medium with the invasive species category having a high impact ranking, the pollution category having a medium impact ranking, and the remaining evaluated categories having negligible rankings (Appendix 3).

ABORIGINAL TRADITIONAL KNOWLEDGE

The status of Aboriginal traditional knowledge for the Channel Darter was unknown at the time of writing (N. Jones, pers. comm.).

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

The Channel Darter is listed as Threatened under Schedule 1 of SARA. In Ontario, the species is listed as Threatened under the ESA. In Quebec, the species is listed as ‘Vulnérable’ under the *Loi sur les Espèces Menacées ou Vulnérables*. The Channel Darter is not listed under the American *Endangered Species Act*, and it is neither a candidate nor is it proposed for listing.

In Quebec, a recovery strategy was published in 2001 (Équipe de rétablissement du fouille-roche gris 2001). The document recommended: (1) to improve knowledge of the species; (2) to protect known habitats; (3) to improve known habitats; and, (4) to restore perturbed habitats. In Ontario, no recovery strategy is yet in place for Channel Darter (S. Gibson, pers. comm.). Federally, a Recovery Potential Assessment document was published in 2010 (DFO 2010) and a Recovery Strategy was published in 2013 (DFO 2013). Those documents provide a full list of actions already under way, as well as actions that are planned for the future. Here, we only provide a summary of those actions. First, several studies have been undertaken since the publication of the previous report that significantly improve our knowledge of the species' distribution, habitat requirements, and potential threats. These studies are cited in the present report. Second, several watershed- and ecosystem-based recovery strategies are now in place, notably in the Essex-Erie region (Lake St. Clair, Detroit River and Lake Erie populations; EERT 2008), Walpole Island (Lake St. Clair population; Bowles 2005), and the Outardes Est and Gatineau watersheds. Third, both provinces addressed the potential impact of commercial baitfish fishing (Boucher *et al.* 2006; Cudmore and Mandrak 2011). Fourth, efforts have been made to educate the public through an educational fact sheet produced by DFO (http://www.qc.dfo-mpo.gc.ca/publications/species-especes/fouille-channel-eng.asp).

The Recovery Strategy also identifies future actions and strategic direction for recovery (DFO 2013). The document recommends that actions be undertaken to address five categories of objectives: (1) Research; (2) Monitoring; (3) Management and Coordination; (4) Protection, Restoration and Stewardship; and, (5) Communication and Public Awareness. The Research objectives include plans to increase knowledge of the species' biology, habitat and threats, but also to evaluate the potential of the species for re-establishment and captive breeding. For Monitoring, it is recommended that existing and historical capture localities be sampled regularly, but also that potential new sites be explored based on what is already known on the species' habitat requirements. In terms of Management and Coordination, it is recommended that the different levels of government in Canada coordinate their efforts with those of NGOs and American agencies. Specific recommendations are also made regarding the planning and permitting of projects that may affect Channel Darter habitat and regarding the flow requirements of the species and how hydroelectric dams and navigable waterways could be managed to mitigate their impacts on the species. Several approaches are recommended for the protection and restoration of Channel Darter habitat and aim to encourage stewardship and Best Management Practices among the agricultural, waterpower, urban, and industrial sectors operating in watershed where the species is found. Finally, the need for communication with industry, municipalities and the public is stressed.

Non-Legal Status and Ranks

The Channel Darter is not listed in the IUCN Red List of Threatened Species. NatureServe (2011) gives a global rank of G4 to the species (i.e., the species is apparently secure). The species is not listed in the American Fisheries Society Endangered Species Committee list of imperilled freshwater and diadromous fishes of North America (Jelks *et al.* 2008). In Canada, the species is ranked as N3 (i.e., vulnerable), in Ontario as S2 (i.e., imperilled) and in Quebec as S2S3 (i.e., vulnerable to imperilled). Table 7 lists the NatureServe ranks of the species in all national and subnational jurisdictions where the species occurs.

Habitat Protection and Ownership

The protection afforded by the federal *Fisheries Act* is uncertain because the Channel Darter is unlikely to be considered to be of direct significance to Commercial, Recreational, or Aboriginal (CRA) fisheries. It may, however, receive protection if they can be demonstrated to be supporting a CRA fishery species.

Channel Darter received habitat protection due to its listing under the ESA in Ontario as of June 2013. In Quebec, the *Règlement sur les habitats fauniques* of the *Loi sur la conservation et la mise en valeur de la faune* can offer habitat protection on public lands, but it requires that the habitat characteristics of the species be identified and published in the Gazette Officielle du Québec, which has not been done yet for the species (J. Boucher, pers. comm.). Although the Channel Darter is listed as Threatened under Schedule 1 of SARA, critical habitat for the species will not be protected until an Order has been put in place for national parks and wildlife areas within 90 days after the federal Recovery Strategy is posted to the SARA Registry and for all other areas within 180 days. The Recovery Strategy (DFO 2013) identifies critical habitats for the species, which should receive appropriate protection.

Many provincial regulations and policy directly or indirectly protect Channel Darter habitat. COSEWIC (2009) reviewed these regulations with respect to Eastern Sand Darter (*Ammocrypta pellucida*) and these have been adapted to apply to Channel Darter. Several provincial laws and policies indirectly protect Channel Darter. In Ontario, fish habitat provisions of the Provincial Policy Statement (PPS) under the provincial *Planning Act* provides adjacent lands with policy-level protection. Channel Darter habitats may also be indirectly protected by the *Lakes and Rivers Improvement Act* when applications for the construction or maintenance of dams and dredging activities are reviewed. Channel Darter habitats may also be indirectly protected by several aspects of the *Nutrient Management Act, Environmental Protection Act, Water Resources Act,* and *Source Water Protection Act.* In Quebec, fish habitat protection is provided under the *Loi sur la Conservation et la Mise en Valeur de la Faune* and the *Loi sur la Qualité de l'Environnement*. Policy level indirect protection is also afforded through the 'Politique de Protection des Rives, du Littoral, et des Plaines Inondables' as well as a regulation framework dealing with municipal and urban planning.

Finally, parks protect a very small portion of the range of Channel Darter. The Channel Darter occurs in two federally protected areas in Ontario: Point Pelee National Park, and Trent-Severn Waterway National Historic Site (Mandrak and Brodribb 2006). Habitat protection is provided in those two sites by the *Canada National Parks Act* and by the *Department of Transport Act (Historic Canals Regulations),* respectively.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

At the time of writing the report, all three writers were working on graduate degrees under the supervision of Dr. Eric B. Taylor in the Department of Zoology, University of British Columbia. J.-S. Moore is a PhD candidate and works on the ecology and evolution of Arctic Char (*Salvelinus alpinus*) in the Canadian Arctic. He previously completed his BSc and MSc at McGill University, where he worked on Threespine Stickleback (*Gasterosteus aculeatus*) under the supervision of Dr. Andrew Hendry. D. Nowosad recently completed his MSc, which focused on the ecology and phylogeography of the Brassy Minnow (*Hybognathus hankinsoni*). He also has a BEd from UBC and a BSc from the University of Victoria. J. Mee received his PhD in 2011 for which he worked on an asexual species of dace that originated from hybridization between two sexual species of dace: *Phoxinus eos*, and *P. neogaeus*. He recently started a post-doctoral position with Dr. Sean Rogers at the University of Calgary, and previously received his MSc from the University of Toronto and BSc from the University of British Columbia.

COLLECTIONS EXAMINED

Although no collections were examined directly for this report, the authors would like to acknowledge the help they received from Erling Holm, assistant curator of fishes, Royal Ontario Museum. Many of the records of capture of Channel Darter reported here are from his inventory of the ROM fish collection.

Appendix 1. Threat Calculator results for Channel Darter (*Percina copelandi)* – Lake Erie populations (DU1).

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Channel Darter *Percina copelandi,* DU1 Lake Erie populations
Element ID	
Elcode	
Date (Ctrl + ";" for today's date):	21/10/2015
Assessor(s):	Dwayne Lepitzki, John Post, Jean-Sébastien Moore, Jim Grant, Sara Hogg, Marc-Antoine Couillard, Scott Reid, Isabelle Gauthier
References:	

Overall Threat Impact Calculation Help:

	Threat Impact	Level 1 Threat Impact Counts: high range	Level 1 Threat Impact Counts: low range
A	Very High	0	0
B	High	1	0
C	Medium	1	2
D	Low	0	0
	Calculated Overall Threat Impact:	High	Medium

Assigned Overall Threat Impact:	**B = High**
Impact Adjustment Reasons:	
Overall Threat Comments	3-4 locations (Detroit River, St. Clair River, Lake Erie [western - ok, central & eastern basins – likely extirpated], Lake St. Clair [likely extirpated]), no subpop estimates.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development						
1.1	Housing & urban areas						not applicable
1.2	Commercial & industrial areas						not applicable
1.3	Tourism & recreation areas						jetties, marinas and docks. Destruction of habitat. Not planned in the next 10 years. So not applicable.
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						not applicable
2.2	Wood & pulp plantations						not applicable

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.3	Livestock farming & ranching					not applicable
2.4	Marine & freshwater aquaculture					not applicable
3	Energy production & mining					
3.1	Oil & gas drilling					not applicable
3.2	Mining & quarrying					pipelines 4.2
3.3	Renewable energy					Windmills? Not applicable. Offshore windpower development plans for western Lake Erie put on hold.
4	Transportation & service corridors	Unknown	Small (1-10%)	Unknown	High (Continuing)	
4.1	Roads & railroads	Negligible	Negligible (<1%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	Ambassador Bridge twinning (abutments)? Pylons in the middle of the river. Siltation accounted for under 9. Habitat is not limiting for Channel Darter however populations at max capacity unknown. Bridge development is not going on now. Impact is unknown.
4.2	Utility & service lines	Negligible	Negligible (<1%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	pipeline close to St.Claire. timing unknown.
4.3	Shipping lanes	Unknown	Small (1-10%)	Unknown	High (Continuing)	dredging. Shipping lanes through St.Claire river. Timing is high. Proportion of this DU exposed to dredging is ??? Lake St.Clair also. Found through trawling in 2m deep in St.Claire river area and Detroit. Possible that they're using deeper habitat shipping lanes. In QC 7m deep (deeper than once thought). Habitat preference is unknown. Observations have declined in Lake Erie corridor (corresponding to Round Goby). Lack of data to quantify dredging threat level of impact.
4.4	Flight paths					not applicable
5	Biological resource use	Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals					not applicable
5.2	Gathering terrestrial plants					not applicable
5.3	Logging & wood harvesting					not applicable
5.4	Fishing & harvesting aquatic resources	Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Incidental catch is unquantified but suspected to be low in bait catch.
6	Human intrusions & disturbance	Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	
6.1	Recreational activities					not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.2	War, civil unrest & military exercises						not applicable
6.3	Work & other activities		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	No immediate plans for research (catch) but if so, negligible.
7	Natural system modifications		Negligible	Negligible (<1%)	Extreme (71-100%)	Low (Possibly in the long term, >10 yrs)	
7.1	Fire & fire suppression						not applicable
7.2	Dams & water management/use						not applicable
7.3	Other ecosystem modifications		Negligible	Negligible (<1%)	Extreme (71-100%)	Low (Possibly in the long term, >10 yrs)	Altered flow regimes high in Detroit River but low elsewhere in this DU. Not dams. Round Goby compete with Channel Darter (affects habitat - food sources). Softening of shoreline planned so hardening shouldn't get worse. Worst spots is along St.Clair River as well as Detroit River. Population hits and hardening is past so future projection (threat of hardening) is negligible. Long term deliterious impact projected into future from hardening is unknown. Erosion from wave action on Point Pelee is on opposite side of Channel Darter habitat.
8	Invasive & other problematic species & genes	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	
8.1	Invasive non-native/alien species	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	Round Goby eat Channel Darter eggs. RG in Detroit River now. RG throughout range in this DU. Predation is the predominant threat and therefore the quantification of invasive threat from Round Goby is accounted for under 8.1 as opposed to splitting between 7.3 and 8.1.
8.2	Problematic native species						not applicable
8.3	Introduced genetic material						not applicable
9	Pollution	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
9.1	Household sewage & urban waste water	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Household waste water or run off contributing to nutrient loading.
9.2	Industrial & military effluents		Unknown	Large (31-70%)	Unknown	High (Continuing)	Detroit River medium. St.Clair low. Lake Erie unknown. Impact, severity on Channel Darter is unknown from threat of toxic substances. General knowledge that toxins impact fish communities negatively. Overall negative. Industrilization in western part of Lake Erie impact on CD is unknown.
9.3	Agricultural & forestry effluents	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Increase in nutrient loading and sedimentation into western lake erie. Large algal blooms related to use of fertilizers from agricultural areas (9.3). Lake St.Clair shallow and warm and intensive agriculture. Most Channel Darters exposed to effluent since water flowing out of St.Clair.
9.4	Garbage & solid waste						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.5	Air-borne pollutants						not applicable
9.6	Excess energy						not applicable
10	Geological events						
10.1	Volcanoes						not applicable
10.2	Earthquakes/tsunamis						not applicable
10.3	Avalanches/landslides						not applicable
11	Climate change & severe weather		Not Calculated (outside assessment timeframe)	Pervasive (71-100%)	Unknown	Low (Possibly in the long term, >10 yrs)	Climate change and general drop in water level combined with fluctuations in level as well as increases in water temperature. Threat impact is unknown. Climate change? No increases in storm but two years of warmer than average temperatures.
11.1	Habitat shifting & alteration						all combined into level 1 threat (above)
11.2	Droughts						all combined into level 1 threat (above)
11.3	Temperature extremes						all combined into level 1 threat (above)
11.4	Storms & flooding						all combined into level 1 threat (above)

Appendix 2. Threat Calculator results for Channel Darter (*Percina copelandi)* – Lake Ontario populations (DU2).

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Channel Darter *Percina copelandi,* DU2 Lake Ontario populations
Element ID	
Elcode	
Date (Ctrl + ";" for today's date):	21/10/2015
Assessor(s):	Dwayne Lepitzki, John Post, Jean-Sébastien Moore, Jim Grant, Sara Hogg, Marc-Antoine Couillard, Scott Reid, Isabelle Gauthier
References:	

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts: high range	Level 1 Threat Impact Counts: low range
A	Very High	0	0
B	High	0	0
C	Medium	1	1
D	Low	1	1
Calculated Overall Threat Impact:		Medium	Medium

Assigned Overall Threat Impact:	**C = Medium**
Impact Adjustment Reasons:	
Overall Threat Comments	4 locations (Moira [Skootamata, Black), Salmon, Trent rivers), no subpop estimates; distribution figs 2, 4, 5. biggest threat to this DU is Round Goby.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development						
1.1	Housing & urban areas						not applicable
1.2	Commercial & industrial areas						not applicable
1.3	Tourism & recreation areas						not applicable
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						not applicable
2.2	Wood & pulp plantations						not applicable
2.3	Livestock farming & ranching						not applicable
2.4	Marine & freshwater aquaculture						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3	Energy production & mining						
3.1	Oil & gas drilling						not applicable
3.2	Mining & quarrying						not applicable
3.3	Renewable energy						not applicable
4	Transportation & service corridors						
4.1	Roads & railroads						not applicable
4.2	Utility & service lines						not applicable
4.3	Shipping lanes						not applicable
4.4	Flight paths						not applicable
5	Biological resource use		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						not applicable
5.2	Gathering terrestrial plants						not applicable
5.3	Logging & wood harvesting						not applicable
5.4	Fishing & harvesting aquatic resources		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Incidental catch is unquantified but suspected to be low in bate catch.
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	
6.1	Recreational activities						not applicable
6.2	War, civil unrest & military exercises						not applicable
6.3	Work & other activities		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	No immediate plans for research (catch) but if so, negligible.
7	Natural system modifications	D	Low	Pervasive (71-100%)	Slight (1-10%)	High - Moderate	
7.1	Fire & fire suppression						not applicable
7.2	Dams & water management/use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High - Moderate	No new dams but existing ones have continuous negative impact on population persistence via fragmentation. Therefore, lower severity but continuous threat impact. Impact of dams may be mitigated.
7.3	Other ecosystem modifications						Not a lot of activity in this DU wrt development. So not applicable.
8	Invasive & other problematic species & genes	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	Round Goby in the Trent but not in remaining habitat in this DU. Asian Carp? Grass Carp are present. Round Goby has not spread into the Moira and Salmon River. However in Trent, RG released at the top and coming up from Bay of Quinte facilitated by locks. Threat impact is estimated for 8.1 based on RG in the Trent. No consistent decline in CD in the Trent and, therefore, difficult to infer threat based on Round Goby (according to data). Severity is likely less than Lake Erie DU. Smallmouth Bass is likely controlling invasives but this is speculation.
8.2	Problematic native species						not applicable
8.3	Introduced genetic material						not applicable
9	Pollution		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
9.1	Household sewage & urban waste water		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	No large urban centres in this DU. So negligible. Scope and severity minimal in comparison.
9.2	Industrial & military effluents						Pulp mill in Trent is downstream from this DU so not applicable.
9.3	Agricultural & forestry effluents		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Land is going fallow in this part of Ontario. Practices are less intensive than in the past. Not industrial scale. So this threat is low if at all a threat. Nutrient loading is negligible in comparison to other 2 DU's.
9.4	Garbage & solid waste						not applicable
9.5	Air-borne pollutants						not applicable
9.6	Excess energy						not applicable
10	Geological events						
10.1	Volcanoes						not applicable
10.2	Earthquakes/tsunamis						not applicable
10.3	Avalanches/landslides						not applicable
11	Climate change & severe weather						Not a huge problem in comparison to other DU's. Higher water levels combined with flow structures maintain water levels. Increased temperatures is negligible as well since this is warmer temperature areas to begin with.
11.1	Habitat shifting & alteration						all combined into level 1 threat (above)
11.2	Droughts						all combined into level 1 threat (above)

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.3	Temperature extremes						all combined into level 1 threat (above)
11.4	Storms & flooding						all combined into level 1 threat (above)

Appendix 3. Threat Calculator results for Channel Darter (*Percina copelandi)* –St. Lawrence populations (DU3).

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Channel Darter *Percina copelandi,* DU3 St. Lawrence populations, ON and QC			
Element ID			**Elcode**	
Date (Ctrl + ";" for today's date):	21/10/2015			
Assessor(s):	Dwayne Lepitzki, John Post, Jean-Sébastien Moore, Jim Grant, Sara Hogg, Marc-Antoine Couillard, Scott Reid, Isabelle Gauthier			
References:				

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts: high range	low range
A	Very High	0	0
B	High	1	0
C	Medium	1	1
D	Low	0	1
	Calculated Overall Threat Impact:	High	Medium

Assigned Overall Threat Impact:	**BC = High - Medium**
Impact Adjustment Reasons:	
Overall Threat Comments	23-30 locations, no subpop estimates, distribution figs. 2, 6

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development						
1.1	Housing & urban areas						not applicable
1.2	Commercial & industrial areas						not applicable
1.3	Tourism & recreation areas						not applicable
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						not applicable
2.2	Wood & pulp plantations						not applicable
2.3	Livestock farming & ranching						not applicable
2.4	Marine & freshwater aquaculture						not applicable
3	Energy production & mining		Unknown	Large (31-70%)	Unknown	Moderate - Low	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.1	Oil & gas drilling		Unknown	Large (31-70%)	Unknown	Moderate - Low	Fracking. Not sure when this will occur but southern Quebec lowlands (St. Lawrence River to Appalachian mountains - south of St. Lawrence). Supposed to stop.
3.2	Mining & quarrying						not applicable
3.3	Renewable energy						not applicable
4	Transportation & service corridors		Unknown	Restricted - Small (1-30%)	Unknown	High (Continuing)	
4.1	Roads & railroads		Unknown	Restricted - Small (1-30%)	Unknown	High (Continuing)	roads and bridge work expected in part of range in this DU.
4.2	Utility & service lines		Unknown	Small (1-10%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	Pipeline going through one river with Eastern Sand Darter but not Channel Darter. Service lines may go through some of CD habitat.
4.3	Shipping lanes		Unknown	Small (1-10%)	Unknown	High (Continuing)	Dredging in the St.Lawrence but low. Ottawa unknown.
4.4	Flight paths						not applicable
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						not applicable
5.2	Gathering terrestrial plants						not applicable
5.3	Logging & wood harvesting						not applicable
5.4	Fishing & harvesting aquatic resources		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Incidental captures. Trying to stop bait fishery. Banned at certain times of the year. Research is active and usually fatal when caught but impact is minimal since once a site is confirmed, catch is minimized at that site. As well, better identification should increase catch and release events.
6	Human intrusions & disturbance		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities						not applicable
6.2	War, civil unrest & military exercises						not applicable
6.3	Work & other activities		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	not applicable
7	Natural system modifications		Unknown	Restricted - Small (1-30%)	Unknown	High (Continuing)	
7.1	Fire & fire suppression						not applicable

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.2	Dams & water management/use		Unknown	Restricted - Small (1-30%)	Unknown	High (Continuing)	Dams present in CD habitat without fish ladders. Causes isolation. Recolonization in smaller rivers is affected by isolation due to dams. Most of the impact wrt dams has occurred in the past. Positive impact to fish population above dams but negative below dams except that the habitat is better downstream and worse upstream due to predation from larger fish.
7.3	Other ecosystem modifications		Unknown	Restricted - Small (1-30%)	Unknown	High (Continuing)	Phosphorus leaching into the habitat from agriculture. Most CD habitat in this DU occur in agricultural areas. Encroachment from blooming flora in the riparian zones is altering shoreline habitat.
8	Invasive & other problematic species & genes	BD	High - Low	Large - Restricted (11-70%)	Serious - Moderate (11-70%)	High (Continuing)	
8.1	Invasive non-native/alien species	BD	High - Low	Large - Restricted (11-70%)	Serious - Moderate (11-70%)	High (Continuing)	Round Goby? Don't find RG often in Qc rivers. So impact is unknown in this DU. It is in the St. Lawrence and in Ottawa and Richelieu. It does eat CD eggs. Future impact projected to be a high threat over the next 10 yrs given the impact in the southwestern Ontarion DU.
8.2	Problematic native species						not applicable
8.3	Introduced genetic material						not applicable
9	Pollution	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
9.1	Household sewage & urban waste water	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	Concentration of developed areas is in CD habitat (QC, Montreal) and problems with Montreal sewage so threat is prevalent.
9.2	Industrial & military effluents		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Some industrial effluents but less than SW Ont DU. Plans for possible bigger port in St. Lawrence. So this may be intensive over the next 10yrs.
9.3	Agricultural & forestry effluents	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Yamaska River low agricultural but St. Lawrence and Ottawa River is mostly agricultural so high impact from nutrient loading
9.4	Garbage & solid waste						not applicable
9.5	Air-borne pollutants						not applicable
9.6	Excess energy						not applicable
10	Geological events						
10.1	Volcanoes						not applicable
10.2	Earthquakes/tsunamis						not applicable
10.3	Avalanches/landslides						not applicable
11	Climate change & severe weather		Not Calculated (outside assessment timeframe)	Pervasive (71-100%)	Unknown	Low (Possibly in the long term, >10 yrs)	Higher water levels and higher temperatures. But this may be beneficial for the species since Canada is northern range.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Habitat shifting & alteration						all combined into level 1 threat (above)
11.2	Droughts						all combined into level 1 threat (above)
11.3	Temperature extremes						all combined into level 1 threat (above)
11.4	Storms & flooding						all combined into level 1 threat (above)