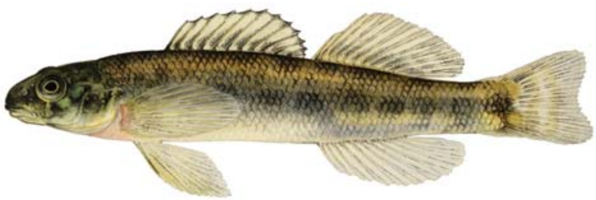
RECOVERY POTENTIAL ASSESSMENT OF CHANNEL DARTER (*Percina copelandi*) IN CANADA



Channel Darter (Percina copelandi)
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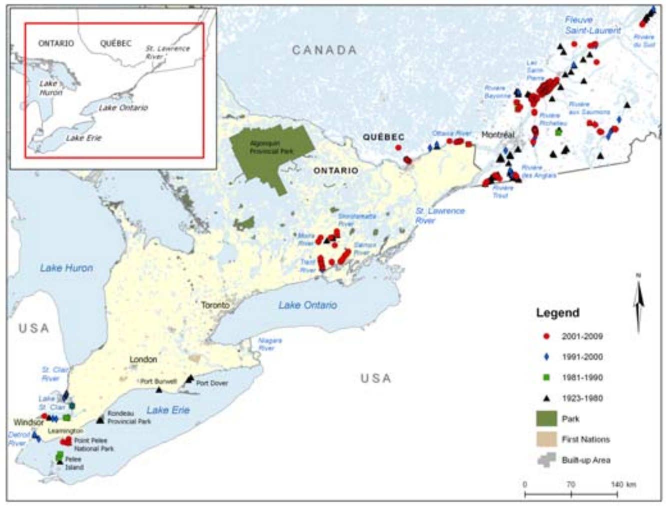

Figure 1. Distribution of Channel Darter in Canada.

Context :

*The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the status of Channel Darter (*Percina copelandi*) in April 1993. The assessment resulted in the designation of Channel Darter as Threatened. In May 2002, the status was re-examined and confirmed by COSEWIC. This designation was assigned because the species exists in low numbers where found, and its habitat is negatively impacted by siltation and fluctuations in water levels. Subsequent to the COSEWIC designation, Channel Darter was included on Schedule 1 of the Species at Risk Act (SARA) when the Act was proclaimed in June 2003.*

A species Recovery Potential Assessment (RPA) process has been developed by Fisheries and Oceans Canada (DFO) Science to provide the information and scientific advice required to meet the various requirements of the SARA, such as the authorization to carry out activities that would otherwise violate the SARA as well as the development of recovery strategies. The scientific information also serves as advice to the Minister of DFO regarding the listing of the species under SARA and is used when analyzing the socio-economic impacts of adding the species to the list as well as during subsequent consultations, where applicable. This assessment considers the scientific data available with which to assess the recovery potential of Channel Darter in Canada.

SUMMARY

- In Ontario, the current and historic Channel Darter distribution is limited to four distinct areas of the Great Lakes basin: Lake St. Clair; Lake Erie; Bay of Quinte; and, Ottawa River (Figure 1). Five historic locations are thought to be extirpated: Holiday Beach; Point Pelee;

Port Burwell; Rondeau Bay; and, Port Dover. Channel Darter has recently been detected from two new locations: Little Rideau Creek; and, Salmon River.

- In Quebec, the current and historic Channel Darter distribution is limited to 18 distinct watersheds. Current data are available for eight watersheds, while many historic locations have not been recently sampled. Channel Darter has recently been detected in a few new locations: St-Francois; and, Ottawa River system. Many systems with suitable Channel Darter habitat have yet to be sampled.

- In Ontario, Channel Darter is typically found in a variety of habitats, including wave-swept gravel and sand lacustrine beaches, coarse substrate shoals and riffles in large rivers, and riffles and pools of small- and medium-sized rivers. In Quebec, the Channel Darter generally occurs in moderate-flowing rivers or rivulets with waters less than 60 cm deep and gravel substrates composed of a combination of cobble and other types of material. In its known distribution range, habitat variables associated with the presence of the species vary, which seem to indicate that the species adapts well in different types of habitat.

- To achieve a 95% probability of persistence over 250 years, given a 5% chance of catastrophe per generation, a population with 6 800 adults is required. If the chance of catastrophe were 10%, a population with 31 000 adults is needed.

- Under current conditions, and in the absence of recovery efforts, a Channel Darter population at 10% of either of these minimum viable population (MVP) sizes will take 23 years to reach a 95% probability of recovery. Depending on the recovery strategy applied, the time to recovery improved, ranging from 10 to 20 years.

- A population with 6 800 adults requires at least 0.9 ha of suitable habitat. A population with 31 000 adults requires at least 4.1 ha of suitable habitat.

- If eight discrete populations are at, or above, the minimum viable population (MVP), the risk of extinction in Canada is 2.5% over 250 years. If the number of discrete populations at MVP is increased to 10, the risk of extinction in Canada is reduced to 1% over 250 years.

- In Ontario, the greatest threats to the survival and persistence of Channel Darter is related to the introduction of exotic species, shoreline modifications and increases in turbidity and sediment loading. Secondary threats include nutrient loading, altered flow regimes, incidental harvest, contaminants and toxic substances, and barriers to movement. Similar threats are negatively affecting Quebec populations; although, it is noted that threats with the greatest negative effect stem from agricultural activities including turbidity and sediment loading, contaminants and toxic substances, and nutrient loading. Secondary threats include shoreline modifications, and altered flow regimes.

- Channel Darter population dynamics are particularly sensitive to perturbation of annual survival probabilities in the first, second, and third years of life, and the fertility of first- and second-time spawners. Harm to these life history characteristics of Channel Darter should be minimized to avoid jeopardizing the survival and future recovery of Canadian populations.

- There remain numerous sources of uncertainty related to Channel Darter biology, ecology, life history, YOY and juvenile habitat requirements, population abundance estimates, population structure, and species distribution. A thorough understanding of the threats affecting the decline of Channel Darter populations is also lacking. Numerous threats have been identified for Channel Darter populations in Canada, although the severity of these threats is currently unknown.

BACKGROUND

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Channel Darter (*Percina copelandi)* population in Canada as Threatened in April 1993. In May 2002, this status was re-examined and confirmed by COSEWIC. Channel Darter was subsequently included on Schedule 1 of the *Species at Risk Act* (SARA) when the Act was proclaimed in June 2003. When COSEWIC designates an aquatic species as Threatened or Endangered and the Governor in Council decides to list it, the Minister of Fisheries and Oceans Canada (DFO) is required by the SARA to undertake a number of actions. Many of these actions require scientific information such as the current status of the population, the threats to its survival and recovery, and the feasibility of its recovery. This scientific advice is developed through a Recovery Potential Assessment (RPA). This allows for the consideration of peer-reviewed scientific analyses in subsequent SARA processes, including permitting on harm and recovery planning. This RPA focuses on the Channel Darter populations in Canada, and is a summary of a Canadian Science Advisory Secretariat peer-review meeting that occurred on November 30 and December 1, 2009 in Burlington, Ontario. Three research documents, one providing background information on the species biology, habitat preferences, current status, threats and mitigations and alternatives in Ontario (Bouvier and Mandrak 2010), the second that presents this same information for Quebec (Boucher and Garceau 2010) and a third on allowable harm, population-based recovery targets, and habitat targets (Venturelli *et al*. 2010) provide an in-depth account of the information summarized below. Finally a proceedings document discusses the activities and key discussions of the meeting (DFO 2010).

Species Description and Identification

Channel Darter (*Percina copelandi*) is a small, benthic fish with an elongate, slender body. The total length (TL) of this species has been listed as 34 to 63 mm although, more recently, individuals have been captured up to 73 mm. Body colouration can range from yellow to olive, with brown speckles (often M-, V-, W-, or X-shaped) that run along its back and the belly is pale. Channel Darter has a characteristic series of small brown, round or oblong blotches that run along each side of the body and can be joined by a thin line. The fins are typically clear or slightly speckled. Breeding males can become noticeably darker particularly around the head.

There is an overlap in Channel Darter distribution with various similar darters, which may lead to confusion when identifying this species. All Ontario and Quebec darters, with the exception of Johnny Darter (*Etheostoma nigrum*) and Tessellated Darter (*E. olmstedi*), lack small M-, V-, W-, or X-shaped marks. Channel Darter can be distinguished by the presence of two anal spines, as opposed to the single anal spine of the Johnny Darter and Tessellated Darter. Channel Darter can also be confused with the River Darter (*P. shumardi*), although these two species can be distinguished by spiny dorsal fin pigmentation; Channel Darter has dark pigmentation at the base and side of the dorsal fin, while River Darter has a small anterior black spot and a large posterior black spot.

ASSESSMENT

Ontario - Current Species Status

Bay of Quinte Drainage

Recent sampling of the Bay of Quinte drainage has verified the presence of Channel Darter throughout the Moira, Skootamatta, Black, and Trent rivers, as well as detected the presence of Channel Darter in the Salmon River. The Salmon River population was first detected in 2003.

Lake Erie Drainage

In the Lake Erie drainage, Channel Darter was recently captured in the Detroit River, and to the west of, and at, Point Pelee (western basin). The most recent Channel Darter specimen from the Detroit River was captured in 2009 at the north end of the river near the opening to Lake St. Clair, and was quite a distance from the previous Channel Darter sites. Intensive targeted sampling of historic nearshore sites in 2005 and 2006 throughout Lake Erie failed to capture Channel Darter at Holiday Beach, Pelee Island, Port Burwell, Rondeau Bay and Port Dover suggesting that Channel Darter may now be extirpated from these historic nearshore sites. However, recent bottom trawls completed by the Ontario Ministry of Natural Resources (OMNR) Lake Erie Management Unit (LEMU) yielded one Channel Darter at a depth of 10.8 m, indicating that Channel Darter may be present at deeper depths.

Lake St. Clair Drainage

The most recent capture of Channel Darter in the Lake St. Clair drainage dates back to 1996, when 65 individuals were captured throughout Walpole Island. The presence of Channel Darter was recorded from two additional sites on the south shore of Lake St. Clair, although targeted sampling of historic sites in 2004 and 2005 yielded no captures.

Ottawa River Drainage

The presence of Channel Darter was also detected at the mouth of the Little Rideau Creek where it flows into the Ottawa River for the first time in 1989, with the capture of a single individual. One additional individual was recorded for this area in 2004.

Quebec - Current Species Status

In Quebec, the species is at its northernmost global distribution range. The species is discontinuously distributed and populations occur in the tributaries of the upper St. Lawrence (Lapointe 1997). In the St. Lawrence River, a few specimens were captured in Lake Saint-Louis, in the section between Bécancour and Batiscan, in the section between Grondines and Donnacona, as well as in Lake Saint-Pierre and its archipelago. The species has also been found in tributaries of ten regions of the province: Montréal, Laval, Montérégie, Estrie, Outaouais, Mauricie, Centre du Quebec, Lanaudière, Capitale-Nationale and Chaudière-Appalaches.

Since 1995, an increase in species-specific sampling has lead to confirmation of the presence and absence of Channel Darter at some historic sites. Such inventories have also lead to the discovery of Channel Darter in several new waterbodies, including nine rivers located in the Ottawa River drainage.

The most recent capture sites in Quebec are:

1999: Rivière Gatineau (Comtois *et al*. 2004)
2001: Rivière Richelieu (Massé and Bilodeau 2003)
2002: Assomption and Ouareau rivers (CARA 2002); East Outardes River (Mr. Letendre, unpubl. data); Sainte-Anne River (Mr. Arvisais, pers. comm.)
2003: Saint-François River between Bromptonville and Windsor (Mr. Letendre, pers. comm.); Gatineau and Richelieu rivers (Boucher *et al*. 2009); Jacques-Cartier River (Mr. Arvisais, pers. comm.)
2004: Gatineau River in the Rapides-Farmer area (Lemieux *et al*. 2005)
2005: Du Sud River downstream of the Arthurville powerplant at Saint-Raphaël (P-Y. Collin, pers. comm.)
2006: Châteauguay, East aux Outardes, des Anglais and Trout rivers (Garceau *et al*. 2007); Ottawa and Rouge rivers, as well as Pointe au Chêne Creek and Calumet Creek (Pariseau and Fournier 2007)
2007: Salmon and du Chêne rivers (H. Fournier, pers. comm.)
2008: Saint-François River near East-Angus, upstream and downstream of the former Worby Dam (S. Garceau, pers. comm.)
2009: Assomption and Ouareau rivers (C. Côté, pers. comm.), and also in Saint-François River between Bromptonville and Windsor (S. Garceau, pers. comm.)

Recent stock data indicate that the species is spread more extensively than what was believed a few years ago. However, the detection of Channel Darter in these waterbodies is probably due to more intensive sampling rather than an increase in the range of Channel Darter distribution in the past few years, or an increase in the number of personnel involved in Quebec.

Population Status

To assess the Population Status of Channel Darter populations in Canada, each population was ranked in terms of its abundance (Relative Abundance Index) and trajectory (Population Trajectory). The level of certainty was associated with each assignment (1=quantitative analysis; 2=CPUE or standardized sampling; 3=expert opinion). The Relative Abundance Index and Population Trajectory values were combined in the Population Status matrix to determine the Population Status for each population. Each Population Status was subsequently ranked as Poor, Fair, Good, Unknown or Extirpated (Table 1). The Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter. Refer to Bouvier and Mandrak (2010) for the complete methodology on Population Status assessment.

Table 1. Population Status of all Channel Darter populations in Canada, resulting from an analysis of both the Relative Abundance Index and Population Trajectory. Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter (Relative Abundance Index, or Population Trajectory).

Population	Population Status	Certainty
ONTARIO		
Bay of Quinte Drainage		
Moira system: Moira, Skootamatta and Black rivers	Fair	2
Salmon River	Fair	2
Trent River	Fair	2
Lake Erie Drainage		
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
Lake St. Clair Drainage		
Lake St. Clair	Poor	2
Ottawa River Drainage		
Little Rideau Creek	Unknown	2
QUÉBEC		
Ottawa and Montreal		
Ottawa River	Good	2
Southwest St. Lawrence River		
Richelieu River	Good	2
Châteauguay River	Poor	2
Yamaska River	Poor	3
Saint-François River	Good	2
Nicolet River	Unknown	3
Northwest St. Lawrence River		
L'Assomption River	Fair	2
Bayonne River	Fair	2
Batiscan River	Unknown	3
Jacques-Cartier River	Unknown	3
Sainte-Anne River	Unknown	3
Southeast St. Lawrence River		
Bécancour River	Unknown	3
Du Sud River	Poor	2
Du Chêne River	Unknown	3
Aux Ormes River	Unknown	3
Henri River	Unknown	3
Gentilly River	Unknown	3
Aux Orignaux River	Unknown	3

Habitat Requirements

Spawning

In Ontario, spawning Channel Darter appear to have a narrow range of tolerance to water temperature, water flow and substrate. Spawning occurs in the spring and early summer when water temperatures range from 14.5 to 25°C. A high capture rate of ripe Channel Darter occurred during the months of June and July when water temperatures ranged between 19 and 26°C.

Channel Darter appear to migrate short distances to spawning grounds generally consisting of riffle habitat with clean coarse substrate, but have also been noted to spawn near large rocks.

Moderate to fast water flow rates are essential for suitable spawning habitat. Spawning in the Trent River is associated with moderate to swift mid-column water velocities (mean: 0.46 $m \cdot s^{-1}$; range: 0-1.0). It has been noted that decreases in water flow can cause temporary pauses in courtship activities. Suitable spawning habitat appears to be easily compromised by increased sedimentation and human-induced alterations to flow regimes. This high sensitivity to optimal spawning requirements may impede reproductive success in areas of increased fine sediment deposition, and areas where flow modifications have occurred.

In Quebec, spawning grounds of the Channel Darter were found in the Gatineau River, at Rapides-Farmers, upstream of the Alonzo-Wright Bridge. The river's width in this sector ranges from 170 m upstream to 330 m downstream and covers an area of about 22 ha. In 1999, seven spawning males and one female were captured in this area between May 20 and June 21. Temperature of the water at that time varied between 14°-19°C and the depth varied between 0.5 - 5 m (Comtois *et al*. 2004). Spawning females were observed once again in the same area between July 14 and July 27, 2003 (J. Boucher, MRNF, pers. comm.). In 2004, 25 adults, 168 eggs and 72 larvae were capture upstream of the Alonzo-Wright Bridge. Spawning would have occurred in early July when the water temperature was 18°-20°C. The depths measured on the spawning grounds were 0.3–0.4 m, while water velocity ranged from 0.24–0.6 $m \cdot s^{-1}$. The spawning grounds were composed mainly of cobble (30%-50%), pebble (30%-50%), and in lesser proportion gravel (10%-15%) and sand (5%) (Lemieux *et al*. 2005).

Young-of-the-Year (YOY) and Juvenile

Channel Darter young-of-the-year (YOY) have strong associations to areas with gravel and sand substrates. Limited data on both YOY and juvenile Channel Darter habitat requirements necessitate the inference of these requirements from other, well-studied, life stages.

Adult

In Ontario, adult habitat is described as the riffle margins of small to medium-sized rivers, and gravel lakeshore beaches where the current is slow. Channel Darter has been noted in riffles and pools of small- to medium-sized rivers. It has also been noted on the gravel and coarse-sand beaches of Lake Erie. In addition, Channel Darter has shown site fidelity to riffles and shoal habitat composed of gravel and cobble along the Trent River.

Throughout the summer, Channel Darter inhabiting rivers remain within the riffle and shoals, and pools with sandy substrate. In the late fall, the majority of Channel Darter migrate to pools with low current to overwinter. In lacustrine systems, Channel Darter has been collected from coarse sand and gravel beaches in both the spring and fall.

Good water quality, both in terms of low levels of pollution and low levels of turbidity, is particularly important for Channel Darter. Due to sensitivities to high sedimentation levels, Channel Darter is not found in areas with predominately silt or clay substrate.

In Quebec, Channel Darter prefers undisturbed rivers along forested or agricultural areas with natural shorelines and good water quality (Lapointe 1997; Garceau *et al*. 2007). Generally, the species occurs in rivers or rivulets with moderate current, water depths of less than 60 cm, and gravel substrates composed of a combination of cobble and other types of material (Desrochers *et al*. 1996; CARA 2002; Boucher *et al*. 2009). According to Boucher *et al*. (2009), for the Gatineau River and Richelieu River, moderate current (between 39-48 $cm \cdot s^{-1}$) that allows the maintenance of a substrate without fine sediments is the only variable that explains the presence of the Channel Darter in the two rivers. In the Gatineau River, the majority of adults were captured in the Rapides-Farmers, mainly on the shoal of the river's right bank, and upstream and downstream of the Alonzo-Wright Bridge. In the Richelieu River, the majority of the specimens were captured in the Chambly rapids, made up of a complex of islands and flowing water with natural banks (Boucher *et al*. 2009). Garceau and al. (2007) demonstrated that in the Châteauguay River, Channel Darter was generally captured along a counter-current or in a current shelter in low turbidity waters. Throughout its known distribution range, habitat variables associated with Channel Darter presence vary indicating that the Channel Darter are able adapt to different types of habitats.

Residence

Residence is defined in SARA as a, "dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating". Residence is interpreted by DFO as being constructed by the organism. In the context of the above narrative description of habitat requirements during YOY, juvenile and adult life stages, Channel Darter do not construct residences during their life cycle.

Recovery Targets

Recovery Targets and Times

Consistent with the preconditions of SARA section 73(3), demographic sustainability criterion can be used to set recovery targets for Channel Darter. Demographic sustainability is related to the concept of a minimum viable population (MVP), and was defined as the minimum adult population size that results in a 95% probability of persistence over 250 years. Simulations indicated that MVP was 6 800 adults when the chance of a catastrophic decline (decline of 50%) was 5%, and 31 000 adults when the chance of a catastrophic decline was 10%. Under current conditions, and in the absence of recovery efforts, a Channel Darter population at 10% of either of these MVP size will take 23 years to reach a 95% probability of recovery. This time to recovery increased exponentially as harm was added simultaneously to all vital rates of either survival or fertility. Depending on which recovery strategy was applied, the time to recovery improved, ranging from 10 to 20 years. Not surprisingly, recovery time varied with initial population size (Figure 2).

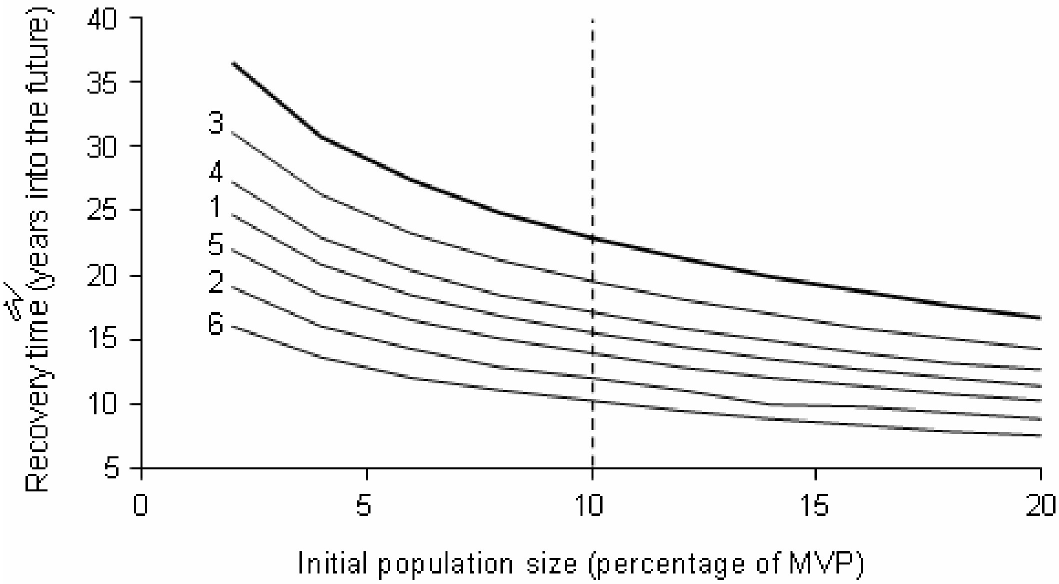

Figure 2. Stochastic projections of mean Channel Darter recovery times over a range of initial population sizes (percentage of a recovery target) for 6 hypothetical recovery strategies. The thick line shows recovery times in the absence of mitigation or additional harm, and numbered lines correspond to various recovery scenarios: 1 – added a 10% increase in the survival rate in the first three years of life; 2 – added a 20% increase in the survival rate in the first three years of life; 3 – added a 10% increase in the fertility of first- or second-time spawners; 4 – added a 20% increase in the fertility of first- or second-time spawners; 5 – added a 10% increase in the survival rate in the first three years of life and a 10% increase in the fertility of first- or second-time spawners; 6 - added a 20% increase in the survival rate in the first three years of life and a 20% increase in the fertility of first- or second-time spawners.

Minimum Area for Population Viability

Minimum area for population viability (MAPV) is a quantification of the amount of habitat required to support a viable population. Variables included in the MAPV assessment include MVP values and area required per individual (API values). API values were estimated from an allometry for river environments from freshwater fishes. With a target MVP of 6 800 adults under a 5% chance of catastrophe per generation, the MAPV is 0.9 ha. With a target MVP of 31 000 under a 10% chance of catastrophe per generation, the MAPV is 4.1 ha (Table 2).

Table 2. Area per individual (API), number of individuals for each stage to support a minimum viable population (MVP) and the resulting estimate of required habitat for each stage and for the entire population, under two probabilities of catastrophe per generation (P_k).

		P_k = 0.05		P_k = 0.10	
Stage	**API (m^2)**	**MVP**	**MAPV (m^2)**	**MVP**	**MAPV (m^2)**
YOY	0.012	594 970	7 140	2 712 363	32 548
Adult	0.27	6 800	1 856	31 000	8 463
ALL			8 996		41 011

Threats to Survival and Recovery

A wide variety of threats negatively impact Channel Darter across its range. Our knowledge of threat impacts on Channel Darter populations is limited to general documentation, as there is a paucity of threat-specific cause and effect information in the literature. The greatest threats to the survival and persistence of Channel Darter are related to the degradation and/or loss of preferred habitat. Numerous activities are known to negatively affect fish habitat; however, those most commonly related to the destruction or degradation of Channel Darter habitat relate to agricultural and urban development, and result in increased turbidity and sediment loading, increased levels of toxic chemicals and increases in nutrient loading. Physical modifications, such as the creation of impoundments and dams, may not only alter flow regimes but also contribute to increased sedimentation and act as barriers to movement. Habitat loss in the form of river and lake shoreline modifications can lead to altered coastal processes resulting in the loss of Channel Darter preferred habitat. These factors can detrimentally affect Channel Darter populations and decrease the likelihood of recovery of fragmented populations. A biological threat linked to declines in Channel Darter populations is the introduction of exotic species. Specifically, the introduction and establishment of the Round Goby (*Neogobius melanostomus*) in the Great Lakes may be negatively affecting Channel Darter populations through competition for space and resources. In Ontario, the degree to which the baitfish industry affects Channel Darter is currently unknown, but incidental harvest associated with the baitfish industry may pose a threat to the persistence of Channel Darter populations. In Quebec, recent studies have indicated that this is not a significant threat (Boucher 2006; Garceau *et al*. In press). However, measures have still been implemented to limit the effects of the baitfish industry on habitat. It is important to note that these threats may not always act independently on Channel Darter populations; rather, one threat may directly affect another, or the interaction between two threats may introduce an interaction effect on the Channel Darter populations. It is quite difficult to quantify these interactions and, therefore, each threat is discussed independently.

Threat Status

To assess the Threat Status of Channel Darter populations in Canada, each threat was ranked in terms of the Threat Likelihood and Threat Impact on a population by-population basis (see Bouvier and Mandrak 2010 and Boucher and Garceau 2010 for details). The Threat Likelihood and Threat Impact for each population were combined in the Threat Status Matrix resulting in the final Threat Status for each population (Table 3). Certainty was classified for both Threat Likelihood and Threat Impact based on: 1= causative studies; 2=correlative studies; and, 3=expert opinion. Certainty associated with the Threat Status is reflective of the lowest level of certainty associated with either initial parameter.

Table 3. Threat Status for all Channel Darter populations in Canada, resulting from an analysis of both the Threat Likelihood and Threat Impact. The number in brackets refers to the level of certainty assigned to each Threat Status, which is reflective of the lowest level of certainty associated with either initial parameter (Threat Likelihood, or Threat Impact). Clear cells do not represent a lack of a relationship between a population and a threat; rather, they indicate that either the Threat Likelihood or Threat Impact was Unknown. Gray cells indicate that the threat is not applicable to the population due to the nature of the aquatic system where the population is located.

Ontario

	Lake Erie Drainage			Lake St. Clair Drainage
Threats	**Detroit River**	**Western Basin**	**Central/ Eastern Basin**	**Lake St. Clair**
Shoreline modifications	Medium (3)	High (2)	High (2)	High (3)
Altered flow regimes	High (3)			Unknown (3)
Barriers to movement				
Turbidity and sediment loading	Medium (3)	Medium (3)	Medium (3)	Medium (3)
Nutrient loading	Medium (3)	Medium (3)	Medium (3)	Low (3)
Contaminants and toxic substances	Medium (3)	Unknown (3)	Unknown (3)	Low (3)
Exotic species and disease	High (2)	High (2)	High (2)	High (2)
Incidental harvest	Low (3)	Low (3)	Low (3)	Low (3)

	Bay of Quinte Drainage			Ottawa River Drainage
Threats	**Moira System**	**Salmon River**	**Trent River**	**Little Rideau Creek**
Shoreline modifications	Low (3)	Low (3)	Low (3)	Unknown (3)
Altered flow regimes	Low (3)	Low (3)	Medium (3)	Unknown (3)
Barriers to movement	Medium (2)	Low (2)	Medium (2)	Unknown (3)
Turbidity and sediment loading	Low (3)	Low (3)	Medium (3)	Low (3)
Nutrient loading	Low (3)	Low (3)	Low (3)	Unknown (3)
Contaminants and toxic substances	Low (3)	Low (3)	Low (3)	Unknown (3)
Exotic species and disease	High (2)	High (2)	High (2)	High (2)
Incidental harvest	Low (3)	Low (3)	Low (3)	Unknown (3)

Québec

	Ottawa - Montreal	Southwest St. Lawrence River		
Threats	**Ottawa River**	**Richelieu River**	**Châteauguay River**	**Yamaska River**
Shoreline modifications	Low (3)	Medium (2)	High (3)	Low (3)
Altered flow regimes	High (1)	Low (3)	Low (3)	Medium (3)
Barriers to movement	Medium (1)	Low (1)	Medium (1)	Low (1)
Turbidity and sediment loading	Low (2)	Medium (2)	Medium (2)	High (2)
Nutrient loading	Low (2)	Medium (1)	Medium (1)	High (1)
Contaminants and toxic substances	Low (2)	Medium (1)	Medium (1)	High (1)
Exotic species and disease	Unknown (3)	Unknown (2)	Unknown (2)	Unknown (2)
Incidental harvest	Low (1)	Low (1)	Low (1)	Low (1)

Québec (continued)

Threats	Southwest St. Lawrence River		Northwest St. Lawrence River	
	Saint-François River	Nicolet River	L'Assomption River	Bayonne River
Shoreline modifications	Low (2)	Medium (2)	Medium (2)	Medium (2)
Altered flow regimes	High (2)	Unknown (2)	Low (2)	Low (2)
Barriers to movement	High (2)	Low (2)	Low (2)	Low (2)
Turbidity and sediment loading	Medium (2)	Medium (2)	Medium (2)	Medium (2)
Nutrient loading	Low (2)	Medium (2)	Medium (2)	Medium (2)
Contaminants and toxic substances	Medium (2)	Medium (2)	Medium (2)	Medium (2)
Exotic species and disease	Unknown (3)	Unknown (3)	Unknown (3)	Unknown (3)
Incidental harvest	Low (1)	Low (1)	Low (1)	Low (1)

Threats	Northwest St. Lawrence River		
	Batiscan River	Jacques-Cartier River	Sainte-Anne River
Shoreline modifications	Low (2)	Unknown (3)	Unknown (3)
Altered flow regimes	Unknown (2)	Unknown (3)	Unknown (3)
Barriers to movement	Unknown (2)	Unknown (2)	Unknown (2)
Turbidity and sediment loading	Low (2)	Low (2)	Low (2)
Nutrient loading	Low (2)	Low (2)	Low (2)
Contaminants and toxic substances	Low (2)	Low (2)	Low (2)
Exotic species and disease	Unknown (3)	Unknown (3)	Unknown (3)
Incidental harvest	Low (1)	Low (1)	Low (1)

Threats	Southeast St. Lawrence River			
	Bécancour River	Du Sud River	Du Chêne River	Aux Ormes River
Shoreline modifications	Medium (2)	Medium (3)	Unknown (3)	Unknown (3)
Altered flow regimes	Unknown (2)	Medium (2)	Low (2)	Unknown (3)
Barriers to movement	Unknown (2)	Unknown (2)	Low (2)	Unknown (3)
Turbidity and sediment loading	Medium (2)	Medium (3)	Unknown (3)	Unknown (3)
Nutrient loading	Medium (2)	Medium (3)	Unknown (3)	Unknown (3)
Contaminants and toxic substances	Medium (2)	Medium (3)	Unknown (3)	Unknown (3)
Exotic species and disease	Unknown (3)	Unknown (3)	Unknown (3)	Unknown (3)
Incidental harvest	Low (1)	Low (1)	Low (1)	Low (1)

Québec (continued)

Threats	Southeast St. Lawrence River		
	Henri River	Gentilly River	Aux Orignaux River
Shoreline modifications	Unknown (3)	Unknown (3)	Unknown (3)
Altered flow regimes	Unknown (3)	Unknown (2)	Unknown (2)
Barriers to movement	Unknown (3)	Unknown (2)	Unknown (2)
Turbidity and sediment loading	Unknown (3)	Unknown (3)	Unknown (3)
Nutrient loading	Unknown (3)	Unknown (3)	Unknown (3)
Contaminants and toxic substances	Unknown (3)	Unknown (3)	Unknown (3)
Exotic species and disease	Unknown (3)	Unknown (3)	Unknown (3)
Incidental harvest	Low (1)	Low (1)	Low (1)

Allowable Harm

Allowable harm was assessed in a demographic framework following Vélez-Espino and Koops (2009). This assessment uses perturbation analysis that depends on the construction of projection matrices from which population growth rate can be calculated and the relative importance of each vital rate can be used to project the effects of recovery efforts. See Venturelli *et al*. (2010) for complete details on the model and results. Modelling indicated that Channel Darter growth rate was most sensitive to reduced annual survival in the first, second, and third years of life, and the fertility of first- and second-time spawners (Figure 3). Although the confidence intervals associated with these estimates suggest that elasticities were sensitive to variation in clutch size, age at maturity, maximum age, and sex ratio, vital rates early in life were, on average, more important to population growth rate than vital rates later in life.

Simultaneous reductions to survival or fertility of all life stages should not exceed 2% or 4%, respectively. If mortality only affects early life stage, then maximum allowable harm to annual survival should be limited to 6, 6, or 10% for 1, 2, 3 year olds, respectively. Maximum allowable harm to the fertility of first- and second-time spawners should be limited to 10 and 15%, respectively. If human activities are such that harm exceeds just one of these thresholds, the future survival and recovery of individual populations is likely to be compromised.

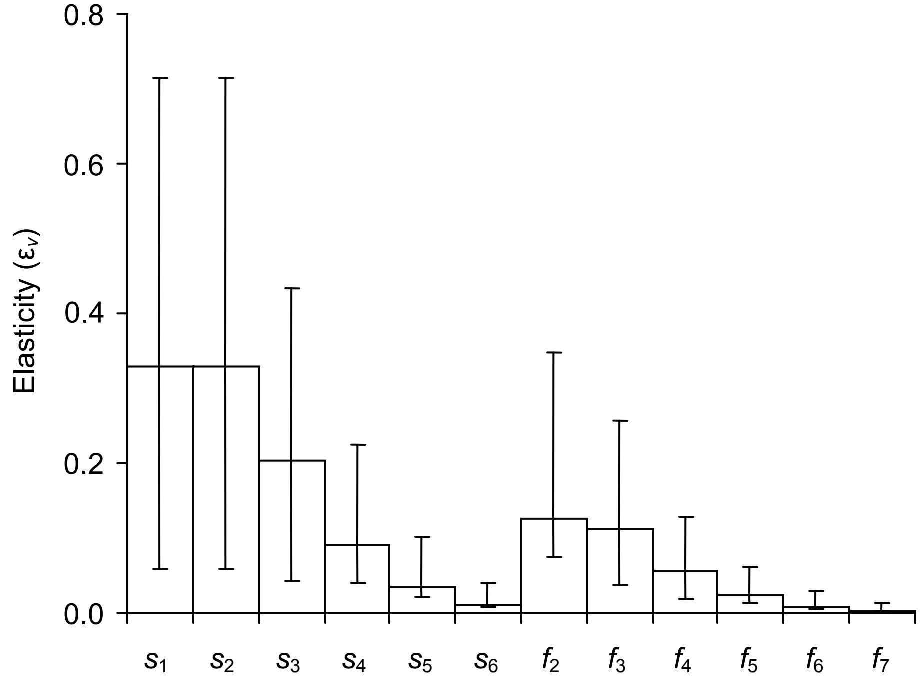

Figure 3. Results of the stochastic perturbation analysis showing elasticities (ε_v) representing sensitivity of the population to the vital rates annual survival at age i (s_i) and fertility at age i (f_i), with associated 95% CL.

Summary of Science Advice on Allowable Harm

- When population trajectory is declining there is no scope for allowable harm.
- When population trajectory and/or abundance is unknown the scope for allowable harm can only be assessed once population data are collected.
- Scientific research to advance the knowledge required to support the recovery of the species should be allowed.
- Modeling indicates that minimal additional cumulative harm is allowable on life stages S1-S3 and reproduction.
- S4+ is less susceptible to harm.
- In the absence of population abundance estimates, no harm should be allowed to S1-S3 and reproduction.
- If population abundance estimates exceed MVP, cumulative allowable harm might be allowed to the level identified in the allowable harm modeling.

Mitigations and Alternatives

Numerous threats affecting Channel Darter populations are related to habitat loss or degradation. Habitat-related threats to Chanel Darter have been linked to the Pathways of Effects developed by DFO Fish Habitat Management (FHM) (Table 4). DFO-FHM has developed guidance on generic mitigation measures for 19 Pathways of Effects for the protection of aquatic species at risk in the Ontario Great Lakes Area (Coker *et al*. 2010). This guidance should be referred to when considering mitigation and alternative strategies. Additional mitigation and alternative measures, specific to exotic species and incidental harvest through the baitfish industry, are listed below.

Table 4. Threats to Channel Darter populations and the Pathways of Effect associated with each threat. 1 - Vegetation clearing; 2 – Grading; 3 – Excavation; 4 – Use of explosives; 5 – Use of industrial equipment; 6 – Cleaning or maintenance of bridges or other structures; 7 – Riparian planting; 8 – Streamside livestock grazing; 9 – Marine seismic surveys; 10 – Placement of material or structures in water; 11 – Dredging; 12 – Water extraction; 13 – Organic debris management; 14 – Wastewater management; 15 – Addition or removal of aquatic vegetation; 16 – Change in timing, duration and frequency of flow; 17 – Fish passage issues; 18 – Structure removal; 19 – Placement of marine finfish aquaculture site.

Threats	Pathway(s)
Shoreline modifications	1, 2, 3, 4, 5, 7, 8, 10, 11, 13, 16, 18
Altered flow regimes	10, 11, 12, 16, 18
Barriers to movement	10, 16, 17
Turbidity and sediment loading	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 18
Nutrient loading	1, 4, 7, 8, 11, 12, 13, 14, 15, 16
Contaminants and toxic substances	1, 4, 5 ,6 ,7 ,11 ,12 ,13 ,14, 15, 16 ,18
Exotic species and disease	
Incidental harvest	

Exotic Species and Disease

Round Goby introduction and establishment could have negative effects on Channel Darter populations.

Mitigation

- Removal/control of non-native species from areas known to be inhabited by Channel Darter.
- Establish “Safe Harbours” in areas known to have suitable Channel Darter habitat.
- Watershed monitoring for exotic species that may negatively affect Channel Darter populations, or negatively affect preferred habitat of Channel Darter.
- Develop and implement plans to address potential risks, impacts, and proposed actions if monitoring detects the arrival or establishment of an exotic species.
- Prohibition of the use of live baitfish in areas known to be inhabited by Channel Darter.
- Prohibit the introduction of dead baitfish in areas known to be inhabited by Channel Darter to minimize the spread of disease.
- Introduction of a public awareness campaign.
- Use of barriers to prevent the colonization of exotic species in areas where Channel Darter is present.
- Under circumstances where barriers to fish movement (i.e., dams) are to be removed or fish passage is to be increased (i.e., creation of a fishway) the potential negative effects of invasive species moving into Channel Darter habitat should be considered.

Alternatives

- Unauthorized introductions
  - None.
- Authorized introductions
  - Do not carry out introduction where Channel Darter is known to exist.

Incidental Harvest

Incidental harvest of Channel Darter through the baitfish industry was recognized as a potentially low risk threat.

Mitigation

- Provide information and education to bait harvesters on Channel Darter, and request the voluntary avoidance of occupied Channel Darter areas.
- Immediate release of Channel Darter if incidentally caught.

Alternatives

- Prohibition of the harvest of baitfish in areas where Channel Darter is known to exist.
- Acquire (buy out) bait harvest licenses where Channel Darter is known to exist.
- Seasonal restrictions applied dependent upon Channel Darter movement into/out of riffle areas.
- Restrict gear type used to catch baitfish to minimize the probability of Channel Darter capture.

Sources of Uncertainty

Despite several recent studies on Channel Darter in Canada, there remain key sources of uncertainty for this species. New Channel Darter populations have been recently discovered in the Salmon River and the Little Rideau Creek in Ontario, and in the Saint-François River and Ottawa River watersheds in Quebec suggesting that our knowledge of its current distribution is incomplete. Repeated standardized sampling in these areas is not only necessary to determine Channel Darter abundance, but abundance over time to determine the trajectory of these populations. Additional sampling is also required for the Detroit River population in Ontario where only three individuals have been recorded (1940, 1997 and 2009) and in 10 historic watersheds in Quebec. Channel Darter populations that were assigned low certainty in the population status analysis should be given high priority when considering additional field sampling. These baseline data are required to monitor Channel Darter distribution and population trends as well as the success of any recovery measures. There is also a need to assess genetic variation across all Channel Darter populations in Canada to determine population structure.

The current distribution and extent of suitable Channel Darter habitat should be investigated and mapped. These areas should be the focus of future targeted sampling efforts for this species. There is also a need to identify habitat requirements for each life stage. There is very little information available for both YOY and juvenile Channel Darter habitat requirements necessitating the inference of these requirements from other, well-studied, life stages.

Many of the variables required to inform the population modelling efforts are currently unknown for Channel Darter populations in Canada, creating the need to use data from other non-Canadian populations or from similar species. Studies should focus on acquiring additional information on reproduction such as clutch size and fecundity. There is also uncertainty related to potential life history differences that may occur among the riverine populations that inhabit the shoals of small- to medium-sized rivers with moderate flow and the lacustrine population that is generally found on gravel beaches with low current.

Numerous threats have been identified for Channel Darter populations in Canada, although the severity of these threats is currently unknown. There is a need for more causative studies to evaluate the impact of each threat on each Channel Darter population with greater certainty. A greater knowledge of the effects of siltation resulting from agricultural and urban development on Channel Darter populations and spawning areas is required. Channel Darter is considered to be a pollution-intolerant species, although there is a lack of evidence on the direct or indirect effects of toxic substances on Channel Darter populations. There is a need to determine threshold levels for water quality parameters (e.g., nutrients, dissolved oxygen). The threat from Round Goby is inferred from studies on other benthic fishes; therefore, additional research is needed to determine the direct effects of Round Goby on Channel Darter populations. Incidental harvest through the baitfish industry may also play a role in the decline of Channel Darter in Ontario, although the degree to which this threat is affecting Channel Darter populations is still unknown. In Quebec, the threat from incidental harvest has been studied and measures have been put into place to limit its effects.

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FOR MORE INFORMATION

Contact: Lynn Bouvier
Great Lakes Laboratory for Fisheries and Aquatic Sciences
Fisheries and Oceans Canada
867 Lakeshore Road
Burlington, Ontario
L7R 4A6
Tel: 905-336-4863
Fax: 905-336-6437
E-Mail: Lynn.Bouvier@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice (CSA)
Central and Arctic Region
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, Manitoba
R3T 2N6

Telephone:(204) 983-5131
Fax: (204) 984-2403
E-Mail: xcna-csa-cas@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

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