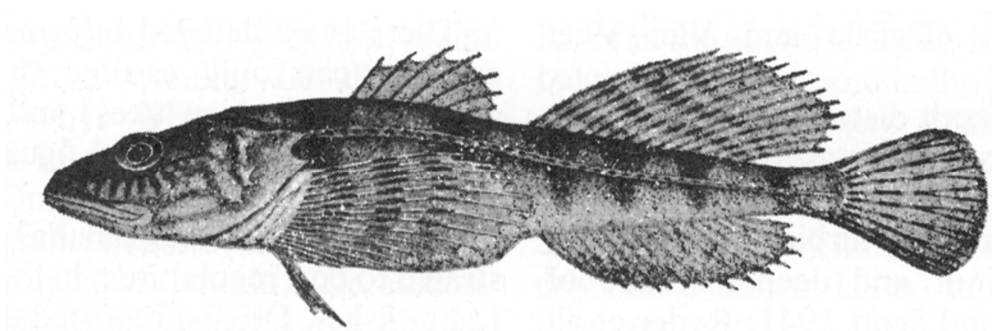
COSEWIC
Assessment and Update Status Report

on the

Deepwater Sculpin
Myoxocephalus thompsonii

Great Lakes-Western St. Lawrence populations
Western populations

in Canada



GREAT LAKES-WESTERN ST. LAWRENCE POPULATIONS – SPECIAL CONCERN
WESTERN POPULATIONS – NOT AT RISK
2006

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 2006. COSEWIC assessment and update status report on the deepwater sculpin *Myoxocephalus thompsonii* (Western and Great Lakes-Western St. Lawrence populations) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 39 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Previous report:

Parker, B. 1987. COSEWIC status report on the deepwater sculpin *Myoxocephalus thompsoni* (Great Lakes population) in Canada. Committee on the Status of Endangered Wildlife in Canada. 1-20 pp.

Production note:

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le chabot de profoundeur (*Myoxocephalus thompsonii*) (population des Grands Lacs - Ouest du Saint-Laurent et population de l'Ouest) au Canada – Mise à jour.

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Deepwater Sculpin — Drawing from Scott and Crossman (1973) by permission.

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COSEWIC Assessment Summary

Assessment Summary – April 2006

Common name
Deepwater sculpin – Great Lakes – Western St. Lawrence populations

Scientific name
Myoxocephalus thompsonii

Status
Special Concern

Reason for designation
This species occurs in the deeper parts of 10 coldwater lakes, including lakes Superior, Huron and Ontario, in Ontario and Quebec. Previously thought to be exterminated in Lake Ontario, it now appears to be reestablished in that lake, albeit in small numbers. Populations have been exterminated in 2 lakes in Quebec due to eutrophication of these lakes, and may be in decline in Lake Huron, possibly in relation to the introduction of zebra mussel.

Occurrence
Ontario, Quebec

Status history
The "Great Lakes - Western St. Lawrence populations" unit (which includes the former "Great Lakes populations" unit designated Threatened in April 1987) was designated Special Concern in April 2006. Last assessment based on an update status report.

Assessment Summary – April 2006

Common name
Deepwater sculpin – Western populations

Scientific name
Myoxocephalus thompsonii

Status
Not at Risk

Reason for designation
This species is widely distributed in western Canada where it is found in the deepest parts of at least 52 coldwater lakes in northwestern Ontario, Manitoba, Saskatchewan, Alberta and the Northwest Territories. There is no evidence to indicate population declines, or of any threats that would convey a degree of risk to these populations.

Occurrence
Northwest Territories, Alberta, Saskatchewan, Manitoba, Ontario

Status history
Designated Not at Risk in April 2006. Last assessment based on an update status report.

COSEWIC
Executive Summary

Deepwater sculpin
Myoxocephalus thompsonii

Great Lakes-Western St. Lawrence populations
Western populations

Species information

The deepwater sculpin, *Myoxocephalus thompsonii*, is a lake-dwelling sculpin in North America. Much confusion and misinformation exists due to the lack of recognition of differences between three closely related taxa: deepwater sculpin, freshwater forms of fourhorn sculpin (*Myoxocephalus quadricornis*), and marine fourhorn sculpin. This has resulted in misidentifications and muddled taxonomy. However, the deepwater sculpin has been shown to be specifically distinct from both marine and freshwater fourhorn sculpin. It has an elongate body, lacks scales, and can be separated from other cottids based on the absence of cephalic horns, a gill membrane that is free from the isthmus and distinct separation between the two dorsal fins.

Distribution

The deepwater sculpin is almost entirely restricted to Canada. The species occurs throughout formerly glaciated regions from the Gatineau region of southwestern Quebec through the Laurentian Great Lakes, northwest through Manitoba, Saskatchewan, and northward to Great Bear and Great Slave lakes. An additional isolated population is also known from Upper Waterton Lake of southwestern Alberta. Their distribution within this widespread range is disjunct, due to the patchy distribution of lakes with suitable environmental conditions that also occur in areas with former glacial lake connections. However, information gaps about the species are also due, in part, to the remote locations and associated logistic challenges of sampling ecologically suitable lakes, as well as the isolation of the species at great depths within these lakes.

Habitat

The deepwater sculpin is a bottom-dwelling species only found in cold, deep, highly oxygenated lakes throughout their range. Within these lakes, deepwater sculpin occupy the deeper regions. However, as latitude increases, deepwater sculpin tend to occupy shallow depths as well.

Biology

Little is known of the biology of deepwater sculpin. A maximum age of seven has been reported for deepwater sculpin. Age at maturity is three years for females and two years for males. *Diporeia* spp. and *Mysis relicta* make up the vast majority of the diet of deepwater sculpin throughout their range. Deepwater sculpins are an important component of the diet of piscivores, such as lake trout (*Salvelinus namaycush*) and burbot (*Lota lota*). There is virtually no potential for migration or dispersal between inland lakes, although drift of larvae has been shown to occur from Lake Huron to Lake Erie.

Population sizes and trends

Population data on deepwater sculpin throughout their range are limited to presence/absence data that must be interpreted with caution. Deepwater sculpins are known to occur in 62 lakes throughout Canada. In a range-wide survey during 2004, deepwater sculpin were captured in 16 of 23 lakes where they were previously reported. They were not found in seven lakes where they were previously found, and found in four lakes where they were not previously reported. Thirty lakes where deepwater sculpin have been reported have only been sampled sporadically and the current status of populations in these lakes is unknown. Long-term index netting programs in the upper Great Lakes confirm that deepwater sculpin are abundant in the deep waters of Lake Michigan and are widespread in lakes Superior and Huron, although they are present in lower densities in the latter. In the lower Great lakes, deepwater sculpin are rarely seen, with a significant reappearance in 1996 in Lake Ontario, while larvae have been reported from Lake Erie, most likely due to drift from Lake Huron.

Limiting factors and threats

Lakes where deepwater sculpin occur must fall within the former boundaries of proglacial lakes, as the present distribution of the species indicates no secondary dispersal from glacial lake boundaries throughout Canada. Deepwater sculpin may be sensitive to shifts in species composition or pollution within these lakes. For example, temporal trends in the abundance of deepwater sculpin in Lake Michigan are best explained by alewife and burbot predation. Also, a recent decline of *Diporeia* spp. (possibly related to zebra mussel invasion) in the lower Great Lakes may represent a threat to deepwater sculpin populations. Finally, deepwater sculpin may be adversely affected by the eutrophication of lakes, resulting in low oxygen levels where they typically occur at the bottom of lakes.

Special significance of the species

Deepwater sculpins are an important component in the diet of deepwater piscivores in lakes where they occur. In the Great Lakes, the species is an excellent indicator of the well-being of the deepwater fish community and habitat. Its 1996 reappearance in Lake Ontario signalled a series of changes in the open-water fish community and a possible reduction in the predatory effects of smelt and alewife. Finally, deepwater sculpin are of particular interest to those studying zoogeography and post-glacial dispersal within Canada.

Existing protection

COSEWIC designated the deepwater sculpin as Threatened within the Great Lakes in 1987. The habitat sections of the federal *Fisheries Act* generally protect the habitat of the deepwater sculpin. Populations found in Upper Waterton Lake in Waterton Lakes National Park are partially protected by the *National Parks Act*.

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 5th 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 (2006)

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 it 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 Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

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

Update COSEWIC Status Report

on the

Deepwater Sculpin
Myoxocephalus thompsonii

Great Lakes-Western St. Lawrence populations
Western populations

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2006

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SPECIES INFORMATION

Name and classification

Kingdom:	Animalia
Phylum:	Chordata
Class:	Actinopterygii
Order:	Scorpaeniformes
Family:	Cottidae
Genus and Species:	*Myoxocephalus thompsonii* (Girard 1851)
Common English name:	deepwater sculpin (Nelson *et al.* 2004)
Common French name:	chabot de profondeur (Coad *et al.* 1995)
Other common names:	*kanayok* (Inuktitut; McAllister *et al*. 1987).

The deepwater sculpin, *Myoxocephalus thompsonii* (Girard 1851), is a lake-dwelling sculpin with a North American distribution. It is closely related to the Arctic fourhorn sculpin, *M. quadricornis* (Linnaeus 1758). Much confusion and misinformation exists due to the lack of recognition of differences between three taxa: deepwater sculpin, freshwater forms of fourhorn sculpin, and marine fourhorn sculpin. This has resulted in misidentifications and muddled taxonomy. Scott and Crossman (1973) provided an extensive review of the papers that discuss the taxonomy of the deepwater sculpin. Girard (1851) first illustrated and described the bones of deepwater sculpin from Lake Ontario and listed them as *Triglopsis thompsonii*. This nomenclature was utilized by numerous subsequent authors, including Dymond (1926), and Hubbs and Lagler (1947). The genus *Triglopsis* was used in deepwater sculpin literature until the mid-1950s (McAllister 1961).

More recently, Walters (1955) referred to the deepwater sculpin as *Myoxocephalus thompsoni*. Based on a comparison of the morphological characteristics, distribution, and ecology of deepwater and fourhorn sculpin (*M. quadricornis*), McAllister and co-workers (McAllister 1961; McAllister and Aniskowicz 1976) agreed with this proposed nomenclature, and considered *M. thompsoni* and *M. quadricornis* to be distinct, but closely related, species. McAllister (1961) considered *M. quadricornis* to be the "ancestral" species from which *M. thompsonii* was derived.

Based on close morphological similarity, Hubbs and Lagler (1958) proposed that deepwater sculpin should be considered a subspecies (*M. quadricornis thompsonii*) of the fourhorn sculpin (*M. quadricornis quadricornis*). This nomenclature gained some acceptance (McPhail and Lindsey 1970). McAllister and Ward (1972) further accepted this subspecific designation of deepwater sculpin and reported the species as such when it was discovered in Upper Waterton Lake in Alberta, Canada. Scott and Crossman (1973) designated both the freshwater and marine forms as *Myoxocephalus quadricornis*, while Parker (1988) reported on the status of the deepwater sculpin in Canada, and referred to it as *Myoxocephalus thompsonii*. Using mitochondrial DNA (mtDNA) sequence data of eight individuals from two continental North American sites (Lake Michigan and Upper Waterton Lake), Kontula and Vainola (2003) supported the subspecific designations of North American deepwater and fourhorn sculpin proposed by Hubbs and Lagler (1958), and McPhail and Lindsey (1970), respectively. However, in a recent study based on the genetics and ecology of deepwater sculpin throughout their entire North American range, full specific rank for deepwater sculpin as *M. thompsonii* is supported (T. Sheldon, unpubl. data). Furthermore, freshwater populations of fourhorn sculpin found throughout northern Canada are phylogenetically nested within the marine fourhorn sculpin, and these are both clearly distinguishable from deepwater sculpin (T. Sheldon, unpubl. data).

Morphological description

The deepwater sculpin (Fig. 1) has an elongate body and reaches an average length of 51-76 mm and a maximum length of 235 mm (Scott and Crossman 1973). It is both dorsoventrally flattened and stout anteriorly with its greatest width at the uppermost preopercular spine, equal body depth and width at the first dorsal fin, and slender caudal peduncle (Scott and Crossman 1973). It has a large mouth with small teeth on the upper and lower jaws, palatines, vomer and tongue (Scott and Crossman 1973; McPhail and Lindsey 1970). The eyes rest on top of the head. Preoperculomandibular pores are absent, but four preopercular spines are present. The upper two spines are large, pointing upward and posteriorly, while the lower two are reduced and point downward (Scott and Crossman 1973). Frontal and parietal spines, present in fourhorn sculpin, are absent in deepwater sculpin. Two dorsal fins are present, the first is small with 7 to 10 spines, the second is larger with a long base and 11 to 16 soft rays. The second dorsal fin can be enlarged in males (Scott and Crossman 1973). The pectoral fins are large with 15 to 18 soft rays, the pelvic fins are reduced with one spine and three (rarely four) rays, the anal fin has a long base with 11 to 16 rays, and the caudal fin is square or truncated. The overall coloration is dark grey to brown, with the grey-brown back gradually lightening along the sides and further lightening ventrally. The back is further marked with several dark saddles while the sides have mild speckling. Three dark, diffuse bands are present on the pectoral fins. The pelvic fins have light spotting, while the dorsal and anal fins show faint blotches (Scott and Crossman 1973; McPhail and Lindsey 1970).

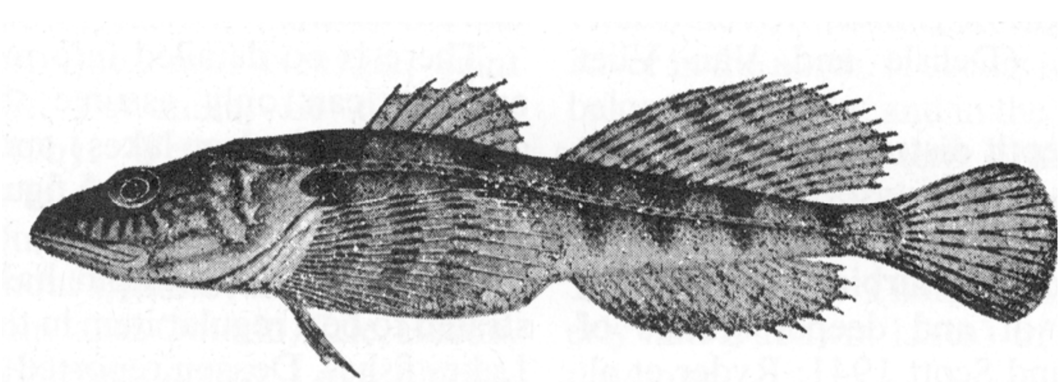

Figure 1. The deepwater sculpin, *Myoxocephalus thompsonii* (Drawing from Scott and Crossman 1973, used with permission of the authors).

True scales are absent in deepwater sculpin. Tubercles (typically less than 30) are present only above the lateral line, which is generally complete. There are typically 40 vertebrae (Scott and Crossman 1973).

The deepwater sculpin can be distinguished from species in the genus *Cottus* based on the presence of disklike tubercles on the upper sides along the body length, and distinct separation between the two dorsal fins. The deepwater sculpin also has a gill membrane that is free from the isthmus (McPhail and Lindsey 1970). The deepwater sculpin and fourhorn sculpin are very similar morphologically, but differ based on the absence of four cephalic horns on top of the head, which are present only in fourhorn sculpin (Stewart and Watkinson 2004).

Genetic description

Kontula (2003) examined mtDNA sequence data of cytochrome b and ATPase6,8 from eight individuals in Upper Waterton Lake and Lake Michigan and suggested a single phylogeographical split separating deepwater sculpin from fourhorn sculpin. They proposed only subspecific designation for deepwater sculpin (*M. q. thompsonii*), based on low sequence divergence (0.9%) between deepwater and fourhorn sculpins. They report extremely low haplotype diversity of only 1-3 nucleotide differences out of 1976 bp (0.05-0.15%) within deepwater sculpin. However, their sample size (n=8) was too small to determine any phylogeographical detail within deepwater sculpin (Kontula and Vainola 2003).

Sheldon (unpubl. data) has also analyzed deepwater and fourhorn sculpin populations (including fourhorn sculpin from freshwaters in the Arctic) across their entire ranges. To gain further understanding of the relationship between fourhorn and deepwater sculpins, and to describe regional diversity within deepwater sculpin, he used mtDNA sequence data from the control region and ATPase6, 8 genes from a larger number of samples (approximately 300) from across Canada representing over 25 locations. Like Kontula and Vainola (2003), he found one major split between deepwater and fourhorn sculpins (both marine and freshwater forms). However, the use of a larger dataset resulted in sequence divergence estimates of 1.30% and 2.48% between fourhorn and deepwater sculpins for ATPase6,8 and the control region, respectively. These molecular data suggest that inland incursion and subsequent species formation occurred in the early Pleistocene. Regional diversity within deepwater sculpin was also evident and most likely corresponds to the refugial origins of these different lineages (Table 1; Figure 2). Three separate clades were present, one of which was common throughout the entire species range. The remaining clades were only locally distributed in Fairbank Lake, near Sudbury, and Upper Waterton Lake in southwestern Alberta (Fig. 3). The population in Upper Waterton Lake is particularly interesting, suggesting that deepwater sculpin may have invaded the area on at least two separate occasions; once during the early to mid-Pleistocene and once following the Wisconsin glaciation via glacial lakes. Based on these genetic data (in combination with ecological data), Sheldon *et al*. (unpubl. data.) propose full species-level designation for the continental deepwater sculpin of North America; thus *M. thompsonii* should be retained as a full specific taxon.

Table 1. Sequence divergence (%) between the clades of the deepwater sculpin from ATPase6, 8 (below diagonal) and the control region (above diagonal).

		Deepwater sculpin clade		
		M	SW	F
Deepwater	M		1.85	1.57
sculpin clade	SW	0.62		1.35
	F	0.53	0.6	

M=Mississippi, SW=Southwest, F=Fairbank
(modified from Sheldon *et al*. unpubl. data).

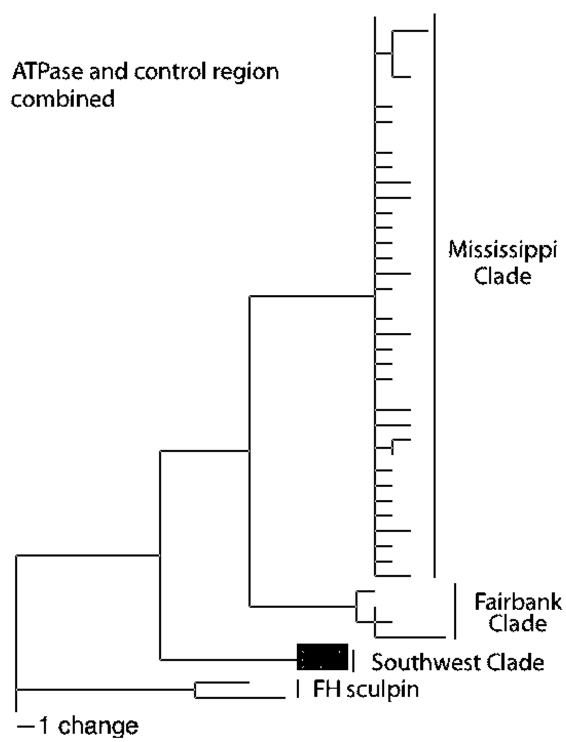

Figure 2. The phylogeographic structure of the deepwater sculpin throughout its range using ATPase6,8 and the control region.

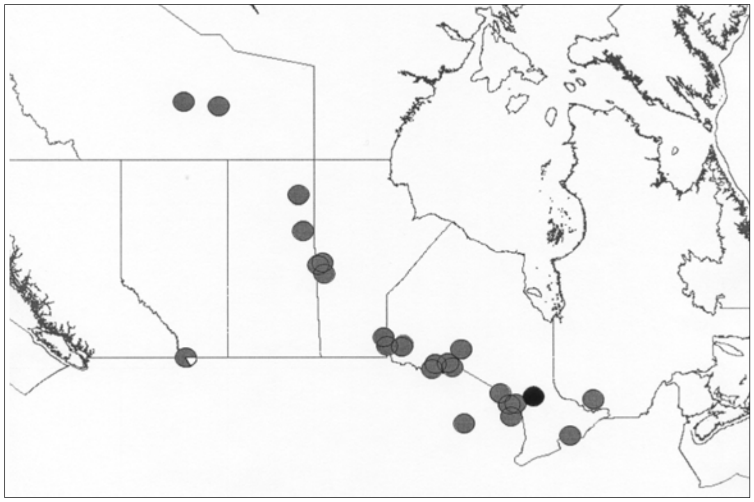

Figure 3. Mitochondrial lineages of the deepwater sculpin throughout its range (black circle – Fairbank clade, grey circles – Mississippi clade, open – southwest clade).

Designatable units

Data indicate that most populations of deepwater sculpin belong to a single mtDNA lineage (T. Sheldon, unpubl. data; Fig. 2; Fig. 4). However, populations in Upper Waterton Lake and Fairbank Lake appear to exhibit distinct mitochondrial lineages; the Waterton Lake unit is interesting in the presence of two clades (Figure 3), but due to the small sample size it is recommended they not be considered as designatable units.

Deepwater sculpin have a somewhat disjunct distribution and populations appear to be isolated within 4 of the 14 Freshwater Aquatic Ecozones of Canada (see COSEWIC 2004, Figure 2). Locations in Quebec and eastern Ontario (Figure 4) are within Aquatic Ecozone 10 – Great Lakes – Western St. Lawrence; those in western Ontario, Manitoba and central Saskatchewan, as well as the disjunct Waterton Lake population are in Aquatic Ecozone 4 – Saskatchewan-Nelson; northeastern Saskatchewan populations are in Aquatic Ecozone 5 – Western Hudson Bay, and locations in northern Saskatchewan and the Northwest Territories are within Aquatic Ecozone 13 – Western Arctic. Each of these could be considered a Designatable Unit (COSEWIC 2004). However, except for the Great Lakes/Upper St. Lawrence populations there is insufficient abundance and/or population size and trend information to individually assess the status of these populations, which are widespread and apparently not subject to any immediate threat. Therefore, we recommend assessment of the populations of Ecozones 4 (Saskatchewan – Nelson), 13 (Western Arctic), as one unit, i.e., Western Populations, and those of the Great Lakes - Western St. Lawrence as a second unit, as most representative of the biological considerations for this species.

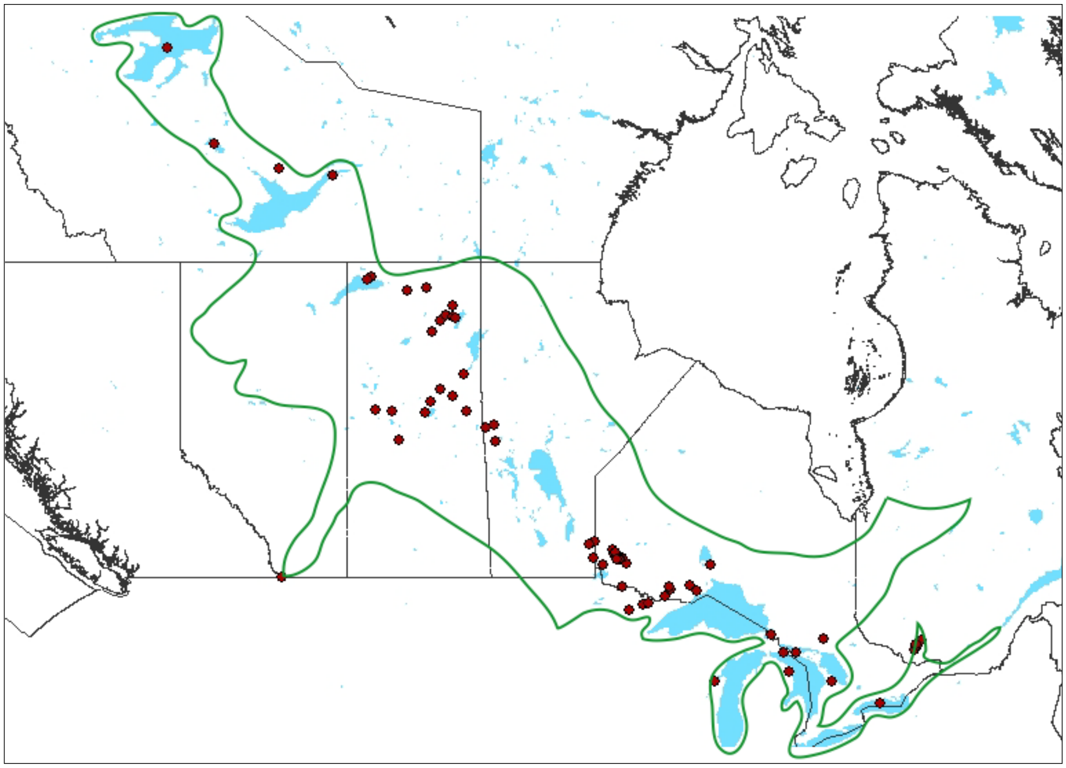

Figure 4. The distribution of the deepwater sculpin across Canada with the generalized extent of former glacial lakes mapped.

DISTRIBUTION

Global range

The deepwater sculpin is restricted to deep, cold lakes in northern North America, primarily in Canada. In the United States, the deepwater sculpin is found only in the Great Lakes and a few inland lakes in Michigan and Minnesota (Scott and Crossman 1973). Generally, the deepwater sculpin occurs in lakes corresponding to areas which were formerly glaciated or accessible from proglacial lakes (Dadswell 1974).

Canadian range

The deepwater sculpin is almost entirely restricted to Canada. In Canada, it occurs throughout formerly glaciated regions from the Gatineau region of southwestern Quebec through the Laurentian Great Lakes, northwest through Manitoba and Saskatchewan, and northward to Great Bear and Great Slave lakes (Parker 1988). An additional isolated population is also known from Upper Waterton Lake of southwestern Alberta (McAllister and Ward 1972) (Fig. 4).

The known range is widespread, but patchy. This disjunct distribution may be due to the patchy occurrence of lakes with suitable environmental conditions that also occur in areas with former proglacial lake connections (Parker 1988). The known distribution of deepwater sculpin may also not adequately reflect their actual distribution. Information gaps about the species are due, in part, to the remote locations and associated logistic challenges of sampling ecologically suitable lakes, as well as the isolation of the species at great depths within lakes. Because of this, most distributional data are derived from incidental catch reports.

An intensive field sampling program targeting deepwater sculpin was conducted between May and October, 2004 (T. Sheldon, unpubl. data). The survey was conducted using modified minnow traps, gillnets and trawls, and included lakes with previously known occurrences and lakes with suitable bathymetry and postglacial history. A total of 35 lakes were sampled, and deepwater sculpin were collected in 20 of these lakes (Table 2). Sampling efforts and site occurrences spanned most of the known distribution of deepwater sculpin, ranging from Alexie Lake in the Northwest Territories in the northwestern portion of its range, to Thirty-One Mile Lake in Quebec in the extreme east, and Upper Waterton Lake in Alberta in the extreme southwest. Table 2 provides results of this survey.

Deepwater sculpin were found in four lakes in which they were previously not reported: Eagle and Teggau lakes in northwestern Ontario; and, Clearwater and Second Cranberry lakes in northwestern Manitoba. The occurrence of deepwater sculpin in Second Cranberry Lake is the first record of deepwater sculpin from the Nelson River watershed in Manitoba. The presence of deepwater sculpin in Eagle, Clearwater and Second Cranberry lakes is important, as it suggests that deepwater sculpin may be present in fairly accessible and popular fishing lakes, but have gone undetected due to the difficulty inherent in sampling smaller fish at the very bottom of these deep lakes. It also indicates that the presence of deepwater sculpin in other deep remote lakes is a strong possibility.

Lakes where deepwater sculpin were previously documented, but where 2004 sampling did not indicate their presence, included: Lac des Iles and Heney Lake in the Gatineau region of Quebec; Cedar Lake, Lake of the Woods, and Lake 310 of the Experimental Lakes area in Ontario; and, Mirond Lake and Lac La Ronge in northeastern Saskatchewan. The failure to capture deepwater sculpin from lakes in which they were previously found may be due to inadequate sampling for a species which is difficult to capture. However, the absence of deepwater sculpin from the two lakes in Quebec is more concerning, as it may be due to recently changing lake conditions, as both Lac des Iles and, especially, Heney Lake have been subject to increasing levels of eutrophication over the past decade. Finally, the absence of deepwater sculpin from Cedar Lake is most likely due to the misidentification of a single deepwater sculpin taken from a lake trout stomach over 30 years ago, as intense

Table 2. Results of 2004 survey for the deepwater sculpin from inland lakes across its range. Historical= historical record(s) of deepwater sculpin from the location previous to the 2004 survey; MT SE= minnow trap search effort; GN SE= gillnet search effort; Trawl SE= trawl search effort; N= number of deepwater sculpin found in each location.

Lake	Region	Latitude (N)	Longitude (W)	Historical	2004 survey	MT SE (hours)	GN SE (hours)	Trawl SE (hours)	N
Roddick Lake	QC	46 14' 54.4"	75 53' 30.9"	Yes	Yes	408	48	0.33	8
Lac des Iles		46 27' 36.0"	75 31' 59.2"	Yes	No	391	46	0	0
Thirty-One Mile		46 12' 43.1"	75 48' 46.4"	Yes	Yes	306	36	0	6
Heney Lake		46 01' 16.4"	75 55' 29.2"	Yes	No	408	48	0.33	0
Lake 259 (ELA)	ON	49 41' 19.9"	93 47' 8.2"	Yes	Yes	440	40	0	6
Teggau (ELA)		49 42' 07.7"	93 38' 53.1"	No	Yes	396	0	0	2
Lake 310 (ELA)		49 39' 42.3"	93 38' 13.6"	Yes	No	330	22	0	0
Lake 258 (ELA)		49 41' 41.6"	93 48' 02.9"	No	No	360	24	0	0
Eagle Lake		49 46' 15.5"	93 36' 44.0"	No	Yes	272	32	0	11
Burchell Lake		48 35' 07.6"	90 37' 37.6"	Yes	Yes	340	30	0	17
Fairbank Lake		46 27' 35.0"	81 25' 37.0"	Yes	Yes	357	32	0	6
Cedar Lake		46 02' 46.7"	78 33' 11.9"	Yes	No	816	96	0.33	0
Saganaga Lake		48 14' 32.7"	90 56' 02.7"	Yes	Yes	384	42	0.33	10
Lake Nipigon		49 27' 37.0"	88 09' 57.6"	Yes	Yes	300	24	0.33	2
High Lake	MB / ON	49 42' 05.2"	95 08' 01.2"	No	No	360	22	0	0
Westhawk Lake	MB	49 45' 32.0"	95 11' 28.0"	Yes	Yes	1104	92	0.33	6
George Lake		50 15' 49.6"	95 28' 16.2"	Yes	Yes	960	90	0	1
Lake of the Woods		49 41' 28.7"	94 48' 53.3"	Yes	No	684	36	0.33	0
Clearwater Lake		54 04' 05.5"	101 05' 33.7"	No	Yes	924	88	0.33	5
Second Cranberry Lake		54 39' 08.5"	101 09' 58.2"	No	Yes	420	40	0.33	18
Lake Athapapuskow		54 33' 01.2"	101 39' 05.4"	Yes	Yes	504	48	0.33	9
Mirond Lake	SK	55 07' 20.3"	102 48' 07.6"	Yes	No	1200	94	0.33	0
Lac La Ronge		55 12' 06.9"	105 03' 59.2"	Yes	No	1100	92	0.33	0
Reindeer Lake		56 23' 34.7"	102 58' 22.2"	Yes	Yes	368	46	0	4
Wollaston Lake		58 14' 59.3"	103 29' 44.4"	Yes	Yes	552	48	0	4
Lac La Plonge		55 08' 16.8"	107 15' 43.2"	Yes	Yes	506	46	0.33	2
Chitty Lake	NWT	62 43' 42.0"	114 07 57.2"	No	No	792	72	0	0
Alexie Lake		62 29' 02.8"	110 52' 57.9"	Yes	Yes	880	86	0	1
Great Slave Lake		62 29' 15.0"	110 52' 44.0"	Yes	Yes	528	94	0	9
Cold Lake	AB	54 31' 23.0"	110 06' 30.8"	No	No	748	92	0	0
Peerless Lake		56 40' 23.0"	114 41' 04.0"	No	No	506	0	0	0
Upper Waterton Lake		49 00' 17.9"	113 54' 16.8"	Yes	Yes	768	0	0	28
Upper Kananaskis		50 36' 41.4"	115 09' 55.9"	No	No	368	0	0	0
Lake Minnewanka		51 16' 02.2"	115 25' 57.4"	No	No	352	0	0	0
Emerald Lake	BC	51 26' 25.1"	116 31' 39.8"	No	No	384	0	0	0

Note: trawl was same type used as in Dadswell (1972). Gillnet panel was 1x15 m with 1 cm mesh size.

sampling of the lake over a three-day period in August 2004 yielded only 113 spoonhead sculpin (*Cottus ricei*) (Sheldon *et al*. unpubl. data.). Banville (Daniel Banville, Ministère des Ressources naturelles et de la Faune, Ste. Foy, QC; personal communication 2006) reported the recent collection of what was thought to be a deepwater sculpin from Lake Simoneau, near Mont Orford, Quebec, as well as an older record from Lake Memphremagog, also in the Eastern Townships. The Lake Simoneau fish has subsequently been identified by Claude Renaud of the Canadian Museum of Nature as a slimy sculpin (*Cottus cognatus*). The older report of a specimen from Lake Memphremagog has not been verified and is likely to be a slimy scupin as well, and thus is not accepted as *bona fide*.

All life stages of deepwater sculpin have been found in all the Great Lakes except Lake Erie (Smith 1985), where mature individuals have not been documented and only larval fish have been reported (e.g., Trautman 1981; Roseman *et al*. 1998; see below)

HABITAT

Habitat requirements

Deepwater sculpin is a bottom-dwelling species and is only found in deep, cold freshwater lakes throughout northern North America (Stewart and Watkinson 2004). Unlike many other freshwater cottids, its distribution is both patchy and limited solely to deepwater lacustrine environments. The fragmentation is natural; due to the current habitat requirements of the species and the historical glacial lake connections required for its dispersal (Dadswell 1974). Generally, deepwater sculpin co-occur with the glacial relict crustaceans, *Mysis relicta* and *Diporeia* spp. (Scott and Crossman 1973; Dadswell 1974).

Throughout the summer of 2004, habitat measurements were taken from deepwater sculpin locations from 20 inland lakes across Canada (T. Sheldon, unpubl. data). The measurements were taken within each lake from specific locations where deepwater sculpin were captured. The ranges, means, and both upper and lower confidence intervals, of these measurements are reported in Table 3. The data suggest that deepwater sculpin require cold, highly oxygenated water (T. Sheldon, unpubl. data). When the maximum depth exceeded 50 m in these oligotrophic lakes, deepwater sculpin were commonly found from 50 m to the maximum depth of the lake. However, in lakes which were less than 50 m deep, deepwater sculpin were most commonly caught within the deepest 20% of the lake only (T. Sheldon unpubl. data). As latitude increases, this relationship seems to weaken and deepwater sculpin are commonly found at shallow depths as well (McPhail and Lindsey 1970).

Table 3. Habitat measurements for 20 inland lakes where deepwater sculpin were collected during the 2004 summer. Data collected using sample bottle at geographic and bathymetric location where specimens caught. Depth - depth of capture; Temp - temperature; SDV - Secchi disk visibility; Oxygen – dissolved oxygen; TDS - total dissolved solids; ORP - oxidative reduction potential; Sp. Cond - Specific conductivity.

	Depth (m)	Temp C	SDV (m)	Oxygen (mg/L)	Sp. Cond (mS/cm)
Range	18.6-285	3.15-6.93	3.5-13.5	6.74-14.44	0.019-0.383
Mean	85.377	4.699	6.36	10.629	0.139
95% CI upper	97.169	4.854	6.755	10.997	0.156
95% CI lower	73.584	4.544	5.965	10.261	0.121
Std. Dev.	67.692	0.887	2.267	2.112	0.103

	pH (surface/bottom)	Salinity (ppt)	Resistivity *(Kohm.cm)	TDS (g/L)	ORP (mV)
Range	7.24-9.04/7.21-8.9	0.01-0.180	4.25-85.3	0.012-0.249	207-407
Mean	8.294/8.356	0.065	22.176	0.093	286.45
95% CI upper	8.371/8.435	0.074	25.911	0.105	294.857
95% CI lower	8.218/8.278	0.057	18.44	0.082	278.042
Std. Dev.	0.439/0.451	0.049	21.443	0.065	48.259

Adults in the Great Lakes are usually found between 60 and 150 m. For example, in Lake Ontario, they have been most abundant in the 90-to-110-m range (Fig. 5) (J. Casselman, unpubl. data). In Lake Superior, deepwater sculpin are most common at depths greater than 70 m and have been found as deep as 407 m (Selgeby 1988). Drifting larvae, which were assumed to have been transported from a relatively abundant population in southern Lake Huron, were collected in the St. Clair River in 1990 and in the 2-to-5-m depth range (probably atypically shallow for the life stage and species) in the west end of Lake Erie in 1995 (Roseman *et al*. 1998).

According to their distribution in Lake Ontario, deepwater sculpin seem to prefer temperatures of <5°C (J. Casselman, unpubl. data). In Lake Huron, they are rarely found in water shallower than 55 m, although the temperature may be <4°C at such depth (J. Schaeffer, unpubl. data).

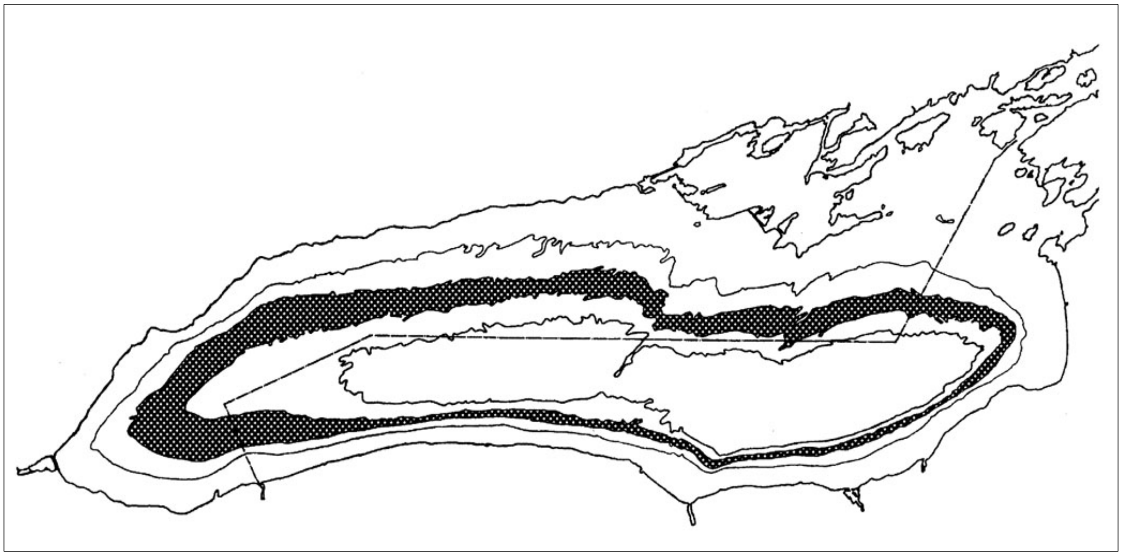

Figure 5. Contour map of Lake Ontario showing band of deepwater sculpin habitat, delineated by the 90-to-110-m contours. The 60-m and 150-m contour lines are also indicated. Provided by J.M. Casselman, Department of Biology, Queen's University, Kingston, Ontario.

Habitat trends

Heney Lake and Lac des Iles in southwestern Quebec, two locations where deepwater sculpin have been found historically, have become more eutrophied over the past two decades. In 2004, dissolved oxygen levels of 3.18 and 6.07 mg/L were recorded during the month of August for Heney lake and Lac des Iles, respectively (T. Sheldon, unpubl. data). These measurements were taken from the bottom of the lakes, near the deepest point, where deepwater sculpin are most often found. Both of these oxygen measures are lower than the ranges, and significantly lower than the mean, of measured dissolved oxygen levels of deepwater sculpin locations obtained during the 2004 survey, indicating that suitable deepwater sculpin habitat in these lakes may have disappeared or, at the very least, be declining. Deepwater sculpin were not found in either of these lakes during the survey.

Because deepwater sculpin are unable to exploit new habitats due to dispersal limitations, and suitable habitat may be declining in some lakes in the eastern portion of their range due to eutrophication caused by anthropogenic effects, there has been a small overall decrease in the habitat available for deepwater sculpin.

Habitat protection/Ownership

In Canada, the deepwater sculpin occurs in publicly owned waters, and all fish habitat within these waters is protected by the federal *Fisheries Act*. In addition, it occurs in Upper Waterton Lake in Waterton National Park of southwestern Alberta. Therefore, its habitat may receive additional protection afforded to national parks through the *National Parks Act*.

BIOLOGY

Little is known of the biology of deepwater sculpin, mainly because they are normally found at great depth (see Habitat). Most studies have focused on the biology of deepwater sculpin from single lakes, such as Lake Michigan, Lake Superior, or Lake Ontario within the Great Lakes or Burchell Lake in northwestern Ontario (Black and Lankester 1981; Brandt 1986; Kraft and Kitchell 1986; Selgeby 1988; Geffen and Nash 1992).

Age and growth

Selgeby (1988) reported a maximum age of seven years in Lake Superior, while Black and Lankester (1981) reported a maximum age of five years in Burchell Lake, Ontario. Length increment is largest during the first year, and decreases by 40% during the second and third years in deepwater sculpin in Lake Superior (Selgeby 1988). In following years, length increment is only 35 to 40% of that in the first year (Selgeby 1988). Weight increment, on the other hand, increases with each succeeding year up to six years of age (Selgeby 1988). Weight increase in deepwater sculpin is significantly higher than isometric growth (Selgeby 1988).

There has been discussion of size variation in deepwater sculpin with latitude (McPhail and Lindsey 1970; Scott and Crossman 1973; Black and Lankester 1981; Selgeby 1988). Based on a large individual from Lake Ontario (235 mm in total length (TL)), and the relatively smaller sizes of deepwater sculpin from Great Slave Lake (maximum of 69 mm), these authors suggest that the maximum length of deepwater sculpin decreases as latitude increases from the Great Lakes. However, no such trend was recorded in the 2004 survey (T. Sheldon unpubl. data). The largest specimens captured during the 2004 survey were from Wollaston Lake, northern Saskatchewan at over 100 mm TL (up to 110 mm TL), while those specimens in Great Slave Lake reached lengths of 75 mm TL, and an individual from Alexie Lake, NT (just north of Great Slave Lake) measured 98 mm TL (T. Sheldon, unpubl. data).

However, deepwater sculpin in the Great Lakes are relatively large individuals compared to all other populations, including those in inland lakes of the same latitude. A typical size distribution of fish caught in routine indexing programs in Lake Huron is illustrated in Figure 6. The modal size was in the 100-110 mm range, with a few individuals approaching 200 mm. Historically, the species reaches a larger size in Lake Ontario than in any of the other Great Lakes (Scott and Crossman 1973).

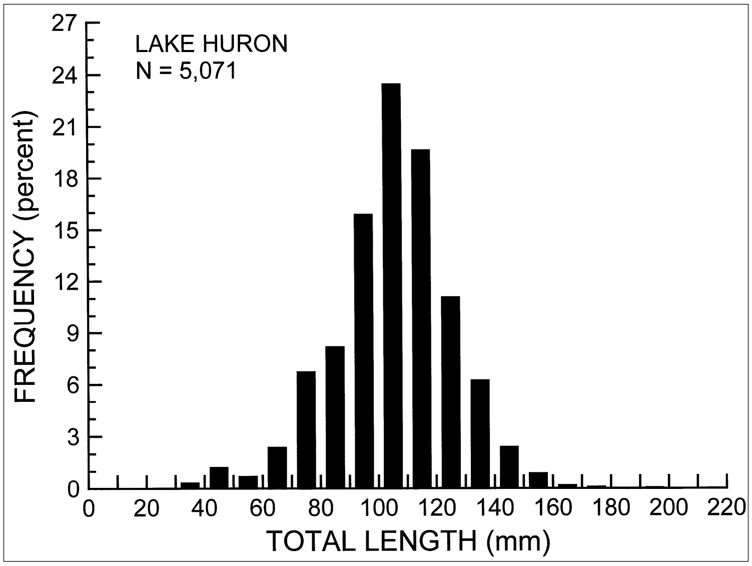

Figure 6. Frequency distribution of total length of deepwater sculpin, by 10-mm length intervals, caught in indexing programs in Lake Huron.

Reproduction

The reproductive cycle of the species is not fully understood. Age at maturity was estimated as three years for females and two years for males from individuals from Burchell Lake, Ontario by Black and Lankester (1981). Spawning period of deepwater sculpin is unknown. McAllister (1961), McPhail and Lindsey (1970), and Scott and Crossman (1973) hypothesized that spawning occurs in late summer or early fall based on nearly ripe eggs found in females in the Great Lakes in July and August. Black and Lankester (1981) suggested spawning most likely occurs in late fall or winter. Based on the appearance of eggs and ovaries, as well as the collection of young-of-the-year deepwater sculpin caught while trawling during early spring, Selgeby (1988) suggested that spawning occurs in Lake Superior from late November to mid-May, peaking in January.

In Lake Michigan, larval deepwater sculpin hatch in deep water in March, then move to the surface and are transported inshore (Geffen and Nash 1992). The larvae then move offshore and are found at depth by late fall. In Lake Ontario, a gravid female was, however, caught in relatively shallow water (30 m) on June 22, 1996 (Casselman, unpublished data).

Diet

The deepwater sculpin almost always occurs with the relict crustaceans *Mysis relicta* and *Diporeia* spp. (Dadswell 1974) and these species compose a large part of their diet. The stomach contents of individuals from Burchell Lake revealed *Diporeia* spp. occurring in 71% of the deepwater sculpin examined, while chironomid larvae and *Mysis relicta* occurred in 41% and 3% of the stomachs (Black and Lankester 1981).

Diporeia spp. and *Mysis relicta* composed 73% and 26%, respectively, of the biomass of stomach contents of deepwater sculpin from Lake Superior while chironomid larvae composed 1% of the diet of these deepwater sculpin (Selgeby 1988). *Diporeia* spp. have dominated the deepwater sculpin diet in Lake Michigan (Davis *et al*. 1997). Preliminary stomach content analysis of deepwater sculpin captured during the 2004 survey indicated that the amphipod *Diporeia* spp. composed the vast majority of the diet, followed by *Mysis relicta* (T. Sheldon, unpubl. data). Chironomid larvae were the only other food item found on a somewhat regular basis. Zooplankton are probably the primary diet during the pelagic larval stage (<22 mm).

Parasitism

The relationship between parasitism and the health of deepwater sculpins is unknown. However, parasites reported in deepwater sculpin from Burchell Lake, Ontario include trematodes (*Diplostomulum* spp.), cestodes (*Cyathocephalus truncatus, Bothriocephalus* spp.), and nematodes (*Cystidicola stigmatura*, Spirurine larva) (Black and Lankester 1981). Parasites reported from deepwater sculpin across their range include copepods (*Ergasilus* spp.) on the gills, cestodes (*Bothriocephalus* spp., *Proteocephalus* spp.) in the intestine, digeneans in the intestine, nematodes in the liver (*Raphidascaris* spp.), and acanthocephalans (*Echinorhynchus* spp.) in the stomach and intestine (J. Carney, unpubl. data).

Predation

Deepwater sculpin are an important item in the diet of piscivores, such as lake trout (*Salvelinus namaycush*) and burbot (*Lota lota*) (Scott and Crossman 1973; Stewart and Watkinson 2004).

Physiology

There is virtually no information on the physiology of deepwater sculpin. Stapleton *et al*. (2001) reported that deepwater sculpin are able to reduce their polychlorinated biphenyl (PCB) load by as much as 10% by forming $MeSO_2$-PCBs through a biochemical pathway which is novel for freshwater fish species.

Dispersal/migration

Historically, dispersal of deepwater sculpin occurred via proglacial lakes. Presently, there is virtually no potential for migration or dispersal between inland lakes due to the ecological requirements of the species (occurring only at significant depths in lakes). Drift of larvae occurs between Lake Huron and Lake Erie (Roseman *et al*. 1998).

Interspecific interactions

Brandt (1986) suggested that the disappearance of deepwater sculpin from Lake Ontario during the 1950s may have been due to the loss of piscivores (lake trout and burbot) from the lake, resulting in monopolization of benthic habitats by sympatric slimy sculpin (*Cottus cognatus*). Brandt (1986) hypothesized that this would have resulted in increased competition or predation on young deepwater sculpin by slimy sculpin. Present trends of increasing appearance in Lake Ontario do not support this contention. Slimy sculpin are quite abundant in deepwater trawls in which deepwater sculpin have been collected recently (J. Casselman, unpubl. data). Smith (1970) suggested that the disappearance of deepwater sculpins in Lake Ontario may have been due to alewife (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordax*) predation on the eggs and larvae of deepwater sculpin. In the 2004 survey of inland lakes, spoonhead and deepwater sculpin were rarely found in the same lakes (T. Sheldon, unpubl. data), perhaps suggesting competitive exclusion between the two species.

Adaptability

The adaptability of deepwater sculpin is relatively unknown, but evidence suggests it is extremely limited. Although downstream transport of larval individuals into new habitats may occur (i.e. from Lake Huron into Lake Erie), reproducing populations of deepwater sculpin are not known from locations other than their preferred deep, cold, highly oxygenated habitats. Further, deepwater sculpin have not been kept in captivity.

POPULATION SIZES AND TRENDS

Inland lakes

Most locations where deepwater sculpin are found have not been sampled extensively or sequentially and, as a result, it is difficult to estimate population sizes and trends of deepwater sculpin. Therefore, population data on deepwater sculpin throughout their range (including the distinct lineages present in both Upper Waterton and Fairbank lakes) are mostly limited to presence/absence data that must be interpreted with caution. In the 2004 survey of deepwater sculpin across inland lakes in Canada, search effort and methods were designed to specifically target deepwater sculpin (T. Sheldon, unpubl. data). Previous sampling efforts relied largely on trawling (Dadswell 1972), with varying degrees of success.

Collapsible, square minnow traps were designed to lie flat on the lake bottom, resulting in a larger catch area along the very bottom of lakes. Fifteen to thirty minnow traps were baited with dog food and cyalume sticks, and set in each lake for a minimum duration of 12 hours. In addition, a 1.0 cm stretched mesh gillnet was set for 12 hours and a minimum of two bottom trawls of ten minutes in duration were also conducted on each lake, weather permitting. All sampling was conducted in the deeper regions of each lake. Table 2 summarizes the lake-by-lake sampling effort and the number of deepwater sculpin captured in each location.

Of the lakes sampled in 2004, deepwater sculpin were found in 16 of 23 lakes where they were previously reported (Table 2, Fig. 9). They were not found in seven lakes where they were previously found, and found in four lakes where they were not previously reported (Table 2, Fig. 9).

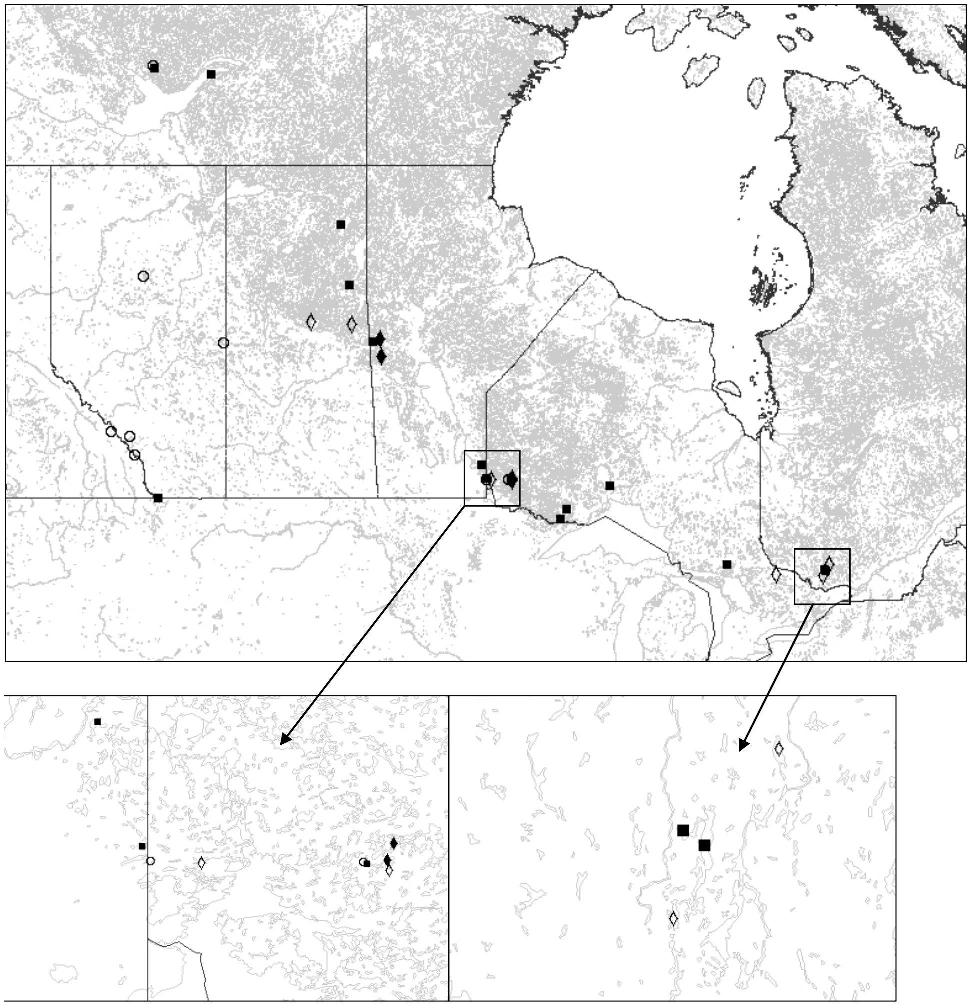

Figure 9. 2004 survey results for deepwater sculpin compared to historical records.

Historical presence/2004 presence	■
Historical presence/2004 absence	◊
No historical record/2004 presence	♦
Historical absence/2004 absence	o

Thirty lakes where deepwater sculpin have been reported, but not sampled in 2004, have only been sampled incidentally and the current status of populations in these lakes are unknown.

Great Lakes

Estimates of population size are not available for the Great Lakes; however, fairly intensive long-term index sampling programs provide quite good measures of relative abundance.

Lake Superior

Deepwater sculpin biomass for American and Canadian waters, as determined by fairly long-term indexing programs (Fig. 7, Table 4), indicates quite low densities and some minor decline over time, particularly in the longer data sets from American waters (Bronte *et al*. 2003). They considered that deepwater sculpin indices were likely not indicative of actual densities and trends, as depths covered by the index sampling programs reach only the shallowest portions of their depth distribution. Nevertheless, deepwater sculpin appear to be present, fairly widely distributed, and are caught consistently, albeit at quite low densities. There is evidence that they are slightly more abundant in Canadian waters, although this indexing program is quite short (11 years).

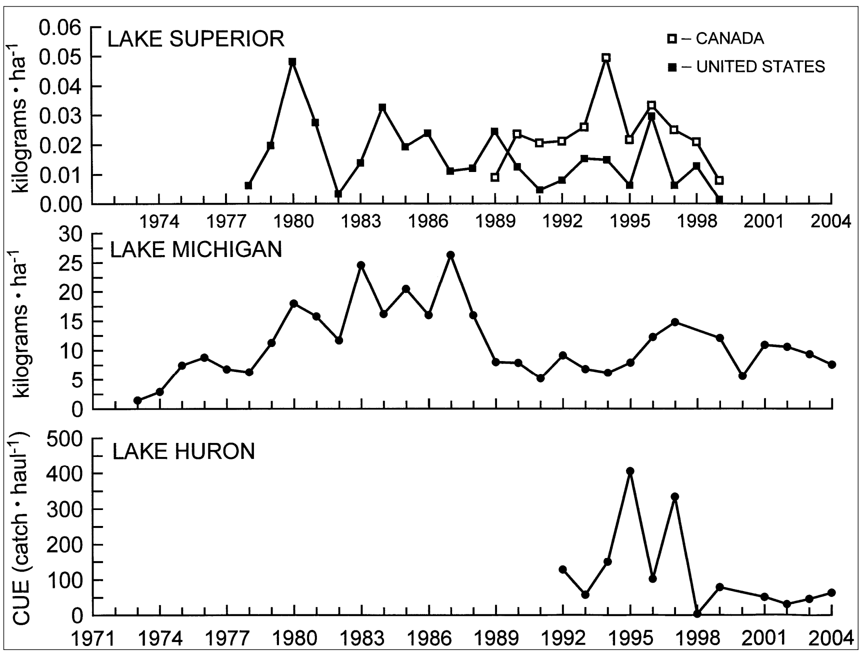

Figure 7. Indices of abundance of deepwater sculpin in the upper Great Lakes for a three-decade period from the 1970s to the 2000s. Indices are not continuous but are just measures of abundance for the particular periods indicated; data sets are of varying lengths. Illustration of data presented in Table 4.

Lake Michigan

Deepwater sculpin appear to be much more abundant (Fig. 7, Table 4) in Lake Michigan than in any of the other Great Lakes. In an indexing program from 1973 to 2004, deepwater sculpin increased in abundance, reaching a peak in the 1980s (1983-87) (Madenjian *et al*. 2002), declining to a lower, but relatively uniform, level from 1989 to 1995 and slightly increasing until 2002.

Table 4. Indices of abundance for the deepwater sculpin in the upper Great Lakes.						
	U.S waters		**Canadian waters**		**Lake Michigan**	**Lake Huron**
Year	**N/ha**	**kg/ha**	**N/ha**	**kg/ha**	**kg/ha**	**CPE**
1973					1.44	
1974					2.89	
1975					7.43	
1976					8.77	
1977					6.76	
1978	2.37	0.006			6.23	
1979	4.45	0.020			11.25	
1980	7.58	0.048			17.95	
1981	6.70	0.028			15.77	
1982	1.82	0.003			11.68	
1983	4.40	0.014			24.55	
1984	8.01	0.033			16.17	
1985	9.50	0.019			20.43	
1986	9.89	0.024			15.97	
1987	3.58	0.011			26.28	
1988	3.78	0.012			15.96	
1989	4.36	0.025	3.94	0.009	7.96	
1990	5.12	0.013	5.87	0.024	7.83	
1991	1.55	0.005	6.67	0.021	5.14	
1992	3.28	0.008	7.34	0.021	9.09	127.8
1993	3.01	0.015	11.77	0.026	6.75	57.2
1994	2.61	0.015	10.43	0.050	6.11	150.1
1995	2.67	0.006	6.80	0.022	7.86	405.2
1996	2.75	0.030	13.43	0.033	12.24	101.9
1997	1.19	0.006	9.34	0.025	14.76	333.5
1998	4.23	0.013	8.06	0.021		3.4
1999	0.75	0.001	2.77	0.008	12.06	78.4
2000					5.55	
2001					10.89	50.1
2002					10.56	30.4
2003					9.31	46.1
2004					7.53	63.1

For Lake Superior, numbers and biomass are indicated, separated by U.S. and Canadian waters. Biomass index is provided for Lake Michigan, and mean catch per 10-minute trawl tow is provided for Lake Huron. Lake Superior index is provided by Charles R. Bronte, U.S. Fish and Wildlife Service, New Franken, WI, and described in Bronte *et al*. 2003; Lake Michigan index is provided by Charles P. Madenjian, U.S. Geological Survey, Ann Arbot, MI, and described in Madenjian *et al*. 2002; Lake Huron index is provided by Jeff Schaeffer, USGS Great Lakes Science Center, Ann Arbor, MI.

Lake Huron

The results of a recent, relatively short-term, index-netting program for Lake Huron (Fig. 7, Table 4) indicated that deepwater sculpin were relatively widespread with 300 to 400 individuals caught per 10 minute trawl (J. Schaeffer, unpubl. data). In recent years (since 1999), catches appear to have declined and abundance may be reduced; the Lake Huron Fisheries Assessment Unit has not seen a sculpin in their assessment program since 1998 (Lloyd Mohr, Ontario Ministry of Natural Resources, personal communication 2006).

Lake Erie

Reports of deepwater sculpin in Lake Erie have been rare and have always been only larval individuals (young-of-the-year) (Roseman *et al*. 1998). Two specimens were incidentally caught in a larval fish sampling program in Ohio waters of western Lake Erie in 1995. The individuals were only 15 and 17 mm total length. While these young may have come from vessel ballast water or a reproducing population in Lake Erie, the fact that 21 similar-sized juveniles were collected upstream in the St. Clair River in 1990 indicates that their occurrence probably resulted from downstream transport from Lake Huron (Roseman *et al.* 1998). Indeed, the results of the index-netting program in Lake Huron suggests that in 1995 the upstream population was at record-high levels (Fig. 7, Table 4), providing additional support for the assumption that transport from Lake Huron was involved. It must be emphasized, however, that the reproductive status of the populations in Lake Erie is unclear as no adults have ever been observed in that lake.

Lake Ontario

The deepwater sculpin was once very abundant in the deep waters of the main basin of Lake Ontario (Dymond *et al*. 1929). In fact, they were so abundant in Lake Ontario that at one time, they were considered to be a nuisance for commercial lake trout gill net fisheries. The archived samples catalogued at the Royal Ontario Museum for the period 1926 to 1941 confirm their presence (Table 5, Fig. 8). However, they were not reported in southern Lake Ontario between 1943 and 1971, and Christie (1973) reported that the last specimens identified from northern Lake Ontario were taken in 1953. From 1953 to 1973, a few samples were brought in by commercial fishermen as a rarity, but three fish were also caught during an international deepwater trawling program in 1972 (Table 5, Fig. 8). Its rarity led Scott and Crossman (1973) to consider it to be extirpated. However, Crossman and Van Meter (1979) listed it as being present in 1972-75, probably because of the samples caught in 1972, although they noted that it was extremely rare and considered endangered. From that time until 1996, it was not reported, although very limited deepwater trawling was conducted. In 1996, one gravid female was caught in the outlet basin in a relatively shallow index trawling program. This individual signalled the reappearance of the species after a 25-year hiatus (Casselman and Scott 2003). Catching this single fish in a relatively shallow indexing program encouraged a targeted search in deep water that year. Limited targeted trawling in the 90-to-110-m depth range produced two more individuals (Table 5, Fig. 8).

Table 5. Deepwater sculpin from Lake Ontario (N = 167) archived and catalogued at the Royal Ontario Museum (ROM), originally acquired by, and archived at, the OMNR Glenora Fisheries Station from 1926 to 1996.

Year	Date	Vicinity	Latitude	Longitude	*N*	Sampling Source: Gill net	Sampling Source: Trawl	Sampling Source: Stomach	ROM Catalogue No.
1926	29 Oct.	Port Credit	43°27'[a]	79°27'[a]	2	1		1	2753(1), 2754(1)
1927	01 July	Port Credit	43°28'[a]	79°18'[a]	13	13			3792
	18 July	Port Credit	43°28'[a]	79°17'[a]	39	39			3628
	29 Aug.	Port Credit	43°28'[a]	79°17'[a]	26	26			3790B
	01 Oct..	Port Credit	43°28'[a]	79°18'[a]	32	32			2669(1), 3790A(31)
1927		Port Credit	43°28'[a]	79°18'[a]	39	2		37	20113
1928	12 July	Main Duck Island	43°42'[a]	76°38'[a]	2	2			4876(1), 4877(1)
1930	18 Feb.	Port Credit	43°28'[a]	79°18'[a]	4	4			6795
1931		Bowmanville	43°39'[a]	78°40'[a]	1	1			8125
1941	02 Sept.	Niagara-on-the-Lake	43°24'[a]	79°05'[a]	1	1			13321
1953	28 Aug.	Salmon Point	43°42'[a]	77°14'[a]	1	1			70625
1961	22 Aug.	Point Traverse	43°40'	76°45'	1	1			23129
1963	28 Aug.	Salmon Point	43°42'[a]	77°14'[a]	4	4			70626[b]
1972	21 June	Cobourg	43°45'2	78°08'.6	2		2		70627
1972	08 Sept.	Cobourg	43°43'.0	78°06'.9	1		1		70627
1996	26 June	Outlet basin	44°02'.63	76°51'.39	1		1		70628
1996	20 Sept.	Point Traverse	43°44'.61	76°49'.96	1		1		70629
1996	26 Sept.	Cobourg	43°47'.03	78°03'.67	1		1		70630
Total					**171**	**127**	**6**	**38**	

Year, date, and vicinity of capture are provided, along with sampling source, coordinates (either recorded or estimated), and ROM catalogue numbers. Samples from 1953, 1961, and 1963 were provided by Stanley Rankin, commercial fisherman, Salmon Point, Prince Edward County, Ontario. Unpublished data assembled by J.M. Casselman, Department of Biology, Queen's University, Kingston, Ontario.

[a]Latitude and longitude estimated from headings and depth.
[b]Glenora acquisition numbers indicate that three specimens were received in 1963; however, sample contains four individuals.

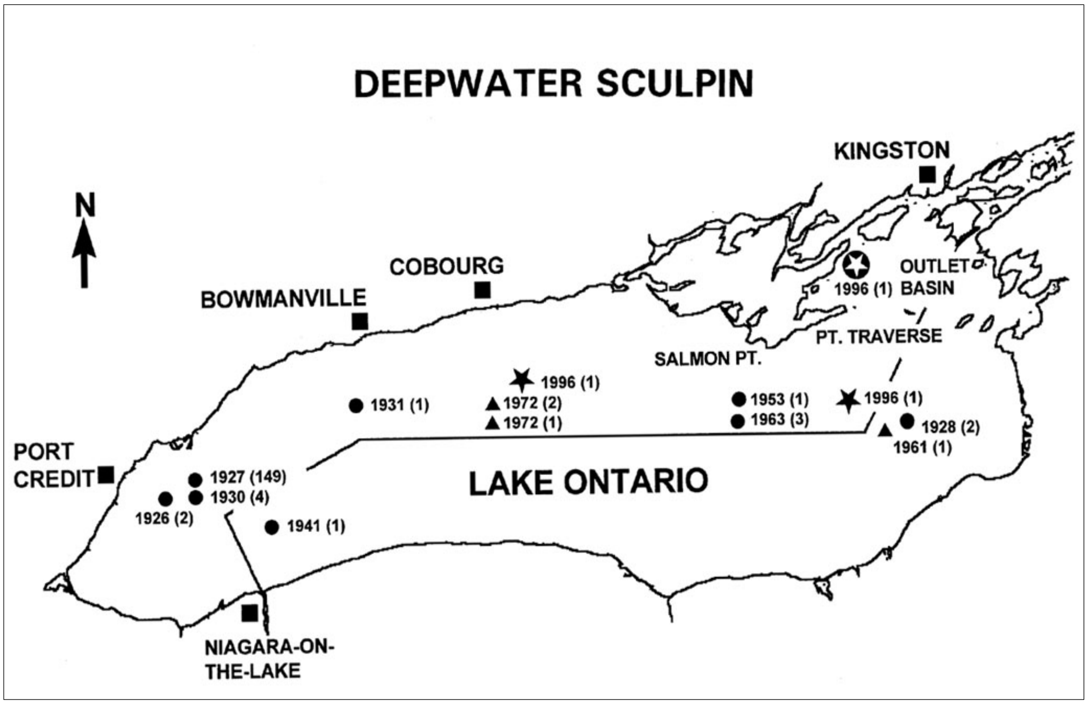

Figure 8. The distribution of deepwater sculpin in Lake Ontario based on specimens (N=167) archived and catalogued at the Royal Ontario Museum (ROM), originally acquired by, and archived at, the OMNR Glenora Fisheries Station from 1926 to 1996. Samples archived at the ROM are indicated by closed circles showing approximate origin of sample and year, with number of samples in parentheses. Closed triangles are samples originally archived at the Glenora Fisheries Station, illustrated as above. Open star indicates recent reappearance in 1996 in routine trawl indexing (30 m); closed stars indicate two sculpin captured in targeted deepwater trawling conducted in 1996 (91 and 96 m). Unpublished data assembled by J.M. Casselman, Department of Biology, Queen's University, Kingston, Ontario.

A deeper trawling program in American waters conducted by the United States Geological Survey (USGS) produced one sculpin in 1998 at 150 m in an alewife assessment program off Thirty-Mile Point in Lake Ontario (Owens *et al*. 2003). This deepwater sculpin, caught off the southwest shore, was the first sighting of this formerly abundant fish in American waters since 1942 (Stone 1947). Targeted sampling in deep water produced three more individuals in 1999 and one in 2000 (Owens *et al*. 2003). Regardless of these recent occurrences, many continue to regard the species to be extirpated from Lake Ontario (e.g., Eshenroder and Krueger 2002). However, this is not the case. In fact, a single individual was caught in 2004, and 13 were caught in routine USGS alewife and mid-lake assessment trawling programs in 2005.

Since the recent reappearance of three fish in Lake Ontario in 1996, a total of 19 individuals have been collected. It could be argued that these appearances are related to increased trawling effort. However, this was not the case for the first individual collected in 1996, since it was caught in the eastern basin in a routine trawling program that had been begun in the early 1960s. The appearance of this individual was interpreted to reflect an increase in abundance of deepwater sculpins in deep water, so a target program that trawled deep water (90-110 m) was initiated immediately and two more individuals were caught. By contrast, fairly deep trawling in the eastern basin in the 60-m depth range in the early 1990s, as part of a juvenile lake trout indexing program, did not produce any deepwater sculpin (J. Casselman, unpubl. data). In fact, the recent appearance in 1996 and 1998 came from individuals of the 1994 and 1995 year-classes (Casselman and Scott 2003). Casselman *et al*. (1999) suggested that during the early 1990s, there was a substantial shift in the open-water fish community, at least in Lake Ontario. The reappearance of deepwater sculpin was one of a whole set of population and community changes.

It is apparent that deepwater sculpin are not extirpated from Lake Ontario. Their presence, albeit in very low numbers, through the 1950s, 1960s, 1970s and, most recently, the 1990s, suggests that the present resurgence is due to increased reproductive success by a remnant population rather than to colonization by juveniles drifting from Lake Huron or ballast water transfer of larval individuals from the upper Great Lakes. Downstream transport of larvae, which probably explains the appearance of larvae in western Lake Erie in 1995, probably does not explain their presence in Lake Ontario, although Roseman *et al*. (1998) speculated that this could also be a plausible explanation for their occurrence in Lake Ontario.

The few individuals that are found in Lake Ontario are large and in appropriate habitat. Decreased deep-water fishing effort in the 1980s and early 1990s may have led to an assumption of extirpation. Nevertheless, they are present, albeit in very low numbers. Although they are very rare, mature, gravid individuals are present and seem to be increasing in abundance, particularly in 2005 sampling in U.S. waters (13 individuals). A number of year-classes have been identified through age assessment, and very recently, in 2005, small individuals have been caught quite frequently in U.S. waters. Although continuous colonization cannot be conclusively ruled out, the appearance of gravid females, small young fish, and the increased appearance of recent year-classes provides strong circumstantial evidence that abundance is increasing and successful reproduction is occurring.

Rescue effect

The potential of a healthy population of deepwater sculpin returning to Canadian waters within lakes that occur on both sides of the Canada-U.S. border is high should the Canadian population become extirpated and the American population persist; however, conditions affecting the species on one side of the border may also affect it on the other side, thus diminishing this potential. Furthermore, there is virtually no potential of immigration or introduction of deepwater sculpin into inland lakes should these populations become extirpated.

LIMITING FACTORS AND THREATS

Historically, deepwater sculpin were limited by the availability of suitable habitat (deep, cold, highly oxygenated water) that had postglacial links (Parker 1988). Lakes where deepwater sculpin occur must reside within the former boundaries of proglacial lakes, as the present distribution of the species indicates no secondary dispersal from glacial lake boundaries throughout Canada (Fig. 4) (Sheldon *et al*. in prep.). In fact, dispersal of deepwater sculpin has not occurred since the late stages of the proglacial lake phase of the Wisconsinan glaciation. Therefore, even if potential habitats become available, deepwater sculpin will be unable to exploit these habitats. According to fish survey and physical lake characteristics gathered in 2004 (T. Sheldon, unpubl. data), it is possible that populations in Lac des Iles and Heney Lake Quebec may be declining, or have disappeared, due to changing lake conditions (eutrophication) in the past 20 years (Sheldon *et al*. unpubl. data.). Most information on the limiting factors and threats of deepwater sculpin, however, is from the Great Lakes.

Index-netting programs in the upper Great Lakes indicate that deepwater sculpin have remained relatively abundant over a fairly long period of time. Dynamics in Lake Michigan suggest that their abundance is directly affected by predation by burbot (Madenjian *et al*. 2002) and probably by lake trout. The deepwater sculpin was a particularly important forage fish for lake trout before this important commercial species was greatly reduced and extirpated from much of the Great Lakes. In Lake Ontario, the deepwater sculpin was particularly important prey for burbot, as well as lake trout: some deepwater lake trout had large numbers of sculpin in their stomachs when both were abundant (Scott and Crossman 1973). Similar heavy predation has been reported from Lake Michigan, where deepwater sculpin are very abundant. In particular, temporal trends in the abundance of deepwater sculpin in Lake Michigan during the 1960s through 1980s are best explained by alewife and burbot predation (Madenjian *et al*. 2002; Madenjian *et al*. 2005). Alewife and rainbow smelt are also considered to be important predators of the pelagic larval stage. Rapid increase in population size of deepwater sculpin in Lake Michigan in the 1970s and early 1980s was most likely attributable to a decrease in alewife abundance at that time (Madenjian *et al*. 2002). As well, a decline in deepwater sculpin abundance during the 1960s was considered to be related to an increase in alewife numbers.

It has been speculated that in Lake Ontario, the population decline after the 1940s was the result of DDT pollution (Scott and Crossman 1973). However, the true cause of this decrease is not well understood. It occurred when lake trout were declining dramatically and eventually became extirpated (Casselman and Scott 2003). This resulted in increased abundance of smelt and alewife, important exotic predators of sculpin larvae, and most likely further contributed to the general disappearance of deepwater sculpin. As in Lake Michigan, alewife predation was undoubtedly important, but the reciprocal relationship between smelt abundance and deepwater sculpin presence suggests that smelt must also have been involved (J. Casselman, unpubl. data).

Finally, a recent decline of *Diporeia* spp. (possibly related to zebra mussel invasion) in the lower Great Lakes may represent a threat to deepwater sculpin populations. *Diporeia* spp. were the main prey item of lake whitefish (*Coregonus clupeaformis*) in Lake Michigan and the decline of this amphipod has adversely affected the body condition and growth of lake whitefish in Lake Michigan (Pothoven *et al*. 2001).

Because *Diporeia* spp. also compose a majority of the deepwater sculpin diet, their decline could potentially affect deepwater sculpin in the same manner.

Habitat-related issues, e.g., deepwater oxygen levels, and climate change have not been investigated, but may be worth future study. The presence of exotic species, e.g., round goby (*Neogobius melanostomus*) might affect deepwater sculpin through interactions at larval or other stages, and this too should be investigated. However, the disappearance of deepwater sculpin from Lake Ontario preceded the appearance of the round goby.

A detailed study of the sporadic occurrence of deepwater sculpin in Lake Ontario would no doubt provide considerable insights into the factors limiting and threatening the species. Nevertheless, a remnant population of deepwater sculpin exists in Lake Ontario and although reintroduction has been proposed, it now seems inappropriate given recent catches. In the case of Lake Erie, it may simply be too shallow to support a self-sustaining population, although larval drift from Lake Huron has occurred from time to time (Roseman *et al*. 1998).

SPECIAL SIGNIFICANCE OF THE SPECIES

In lakes where it is present, the deepwater sculpin's ecological role as a major prey item of economically important piscivores such as lake trout and burbot cannot be over-emphasized (Day 1983).

In the Great Lakes, the species is an excellent indicator of the well-being of the deepwater fish community and habitat. Its 1996 reappearance in Lake Ontario signalled a series of changes in the open-water fish community (Casselman and Scott 2003, Mills *et al*. 2003) and a possible reduction in the predatory effects of smelt, alewife, and burbot. It is also thought to be negatively affected by contaminants, possibly of the deepwater habitat. However, this is only speculation. Its reappearance in Lake Ontario, when it was thought to be extirpated, was particularly encouraging, possibly signalling that Lake Ontario was, in a number of ways, recovering from a more degraded fish community and habitat seen through much of the last half-century.

Finally, deepwater sculpins are of special concern to those interested in zoogeography and post-glacial dispersal within Canada (Scott and Crossman 1973).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Global, National (US and Canada), and Subnational (State and Provincial) ranks for deepwater sculpin are given in the technical summaries.

The deepwater sculpin was designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as Threatened within the Great Lakes region in 1987, due in most part to its decline in Lake Ontario. It is under Schedule 2 (Threatened) of SARA. The national rank is N4 meaning the species is apparently secure in Canada (NatureServe 2005).

The deepwater sculpin is given a rank of S5 (secure) or S4 (apparently secure) in Saskatchewan and Ontario, respectively. In Manitoba, the deepwater sculpin is considered imperiled to vulnerable (S2S3), while they are considered imperiled to critically imperiled in Quebec (S1S2). Alberta has given the deepwater sculpin a rank of S1 (critically imperiled). The deepwater sculpin has not been ranked in the Northwest Territories (NatureServe 2005).

In the United States, the deepwater sculpin is given a national rank of secure (N5) in 1996. It is given a subnational rank of S5 (secure) or S4 (apparently secure) in Michigan (S5), Indiana (S4), and Wisconsin (S4). New York considers deepwater sculpin to be critically imperilled (S1). Pennsylvania has given the deepwater sculpin a rank of SX (considered extirpated with little likelihood of rediscovery). Deepwater sculpin in Minnesota and Ohio have not been given a rank (SNR) (NatureServe 2005).

Sections of the Federal *Fisheries Act, Canadian Environmental Assessment Act, Canadian Environmental Protection Act,* and *Canada Water Act* may also generally protect the deepwater sculpin and/or its habitat. In provinces and the Northwest Territories, the deepwater sculpin is protected under several Environmental Assessment Acts, Environmental Protection Acts and other legislation pertaining to threatened or vulnerable species. Populations found in Upper Waterton Lake in Waterton Lakes National Park are partially protected under the *National Parks Act*.

TECHNICAL SUMMARY

Myoxocephalus thompsonii

Deepwater Sculpin, Great Lakes – Western St. Lawrence populations

Chabot de profondeur, populations des Grands Lacs - Ouest du Saint-Laurent

Range of occurrence by province and territory: ON, QC.

COSEWIC Aquatic Ecozones represented in the species' range:
- Ecozone 10: Great Lakes – Western St. Lawrence

Extent and Area information	
• *extent of occurrence* (*EO*) (from Figure 4 using a best fit polygon)	~ 850,000 km^2
• *trend in EO*	Stable
• *are there extreme fluctuations in EO (> 1 order of magnitude)?*	No
area of occupancy (AO) many locations, not calculated, but considerably less than EO	< 800,000 km^2
• *trend in AO*	Unknown
• *are there extreme fluctuations in AO (> 1 order magnitude)?*	No
• *number of extant locations*	10 lakes
• *trend in # locations*	Decline (3 apparently extirpated 2 in QC and 1 in ON), Lake Huron - decline
• *are there extreme fluctuations in # locations (>1 order of magnitude)?*	No
• *habitat trend:*	Some decline
Population information	
• *generation time (average age of parents in the population)*	4-5 years
• *number of mature individuals (capable of reproduction) in the Canadian population)*	Unknown
• *total population trend:*	Decline
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater*	Unknown
• *are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	Unknown
• *is the total population severely fragmented?*	Yes
• *list each population and the number of mature individuals in each* **ON** - Lakes Superior, Huron, Erie, Ontario, Fairbank, and Nipigon **QC** – Lakes Roddick, des Iles, Thirty-one-Mile, and Heney	Unknown in all
• *specify trend in number of populations (decline, stable, increasing, unknown)*	Decline- 2 locations extirpated in QC, 1 in ON
• *are there extreme fluctuations in number of populations (>1 order of magnitude)?*	No
Threats (actual or imminent threats to populations or habitats)	
Competition and predation with invasive species; pollution; eutrophication	

Rescue Effect (immigration from an outside source)	
• *does species exist elsewhere (in Canada or outside)?*	Yes in U.S. and Ecozone 4
• status of the outside population(s)?	Ecozone 4 – DD Secure except for NY – S!
• *is immigration known or possible?*	Possible only in Gt. Lakes
• *would immigrants be adapted to survive here?*	Unknown
• *is there sufficient habitat for immigrants here?*	Yes
Quantitative Analysis	Not Applicable

Existing Status

Nature Conservancy Ranks (NatureServe 2005)

Global – G5

National

US – N5

Canada N4

Regional

US: IN – S4, MI – S5, MN – SSNR, NY – S1, OH – SNR, PA – SX, , WI – S4

Canada: AB – S1, MB – S2S3, NT – SNR, ON – S4, QC – S1S2, SK – S5

Wild Species 2000 (Canadian Endangered Species Council 2001)

Canada - NA

Provinces – AB – 5, MB – 2*, ON – 4, QC – 2, NT – 3, SK 5

*Duncan indicates that this should be 3 or 4 (J. Duncan, Biodiversity Conservation Section, Manitoba Conservation, Winnipeg, Manitoba; rank comments in relation to the data output for the Wild Species web site for freshwater fish species).

COSEWIC
- Threatened 1987 (Great Lakes populations only);
- Special Concern 2006 (Great Lakes – Western St. Lawrence populations.

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code**: not applicable
Reasons for Designation This species occurs in the deeper parts of 10 coldwater lakes, including lakes Superior, Huron and Ontario, in Ontario and Quebec. Previously thought to be exterminated in Lake Ontario, it now appears to be reestablished in that lake, albeit in small numbers. Populations have been exterminated in 2 lakes in Quebec due to eutrophication of these lakes, and may be in decline in Lake Huron, possibly in relation to the introduction of zebra mussel.	
Applicability of Criteria **Criterion A**: (Declining Total Population): Not Applicable – no evidence to establish decline. **Criterion B**: (Small Distribution, and Decline or Fluctuation): Not Applicable – Wide distribution – population abundance and trend information not available. **Criterion C**: (Small Total Population Size and Decline): Not Applicable – population abundance and trend information not available. **Criterion D**: (Very Small Population or Restricted Distribution): Not Applicable. Widespread distribution. **Criterion E**: (Quantitative Analysis): Not Applicable – no data.	

TECHNICAL SUMMARY

Myoxocephalus thompsonii

Deepwater Sculpin, Western populations — Chabot de profondeur, populations de l'Ouest

Range of occurrence by province and territory: NWT, AB, SK, MB, ON, QC.

COSEWIC Aquatic Ecozones represented in the species' range:

- Ecozone 13: Western Arctic (corresponds to the portion of the species' range in the Northwest Territories and Northern Saskatchewan)
- Ecozone 5: Western Hudson Bay (corresponds to the portion of the species' range in Northeastern Saskatchewan)
- Ecozone 4: Saskatchewan/Nelson (corresponds to the portion of the species' range in Alberta, Central Saskatchewan, Manitoba, and Northwestern Ontario)

Extent and Area information	
• *extent of occurrence* (*EO*) (from Figure 4 using a best fit polygon)	~ 100,000, 000 km^2
• *trend in EO*	Unknown
• *are there extreme fluctuations in EO (> 1 order of magnitude)?*	No
area of occupancy (AO) many locations, not calculated, but considerably less than EO	< 1,000,000 km^2
• *trend in AO*	Unknown
• *are there extreme fluctuations in AO (> 1 order magnitude)?*	No
• *number of extant locations*	52 lakes in 3 ecozones
• *trend in # locations*	Unknown - 4 apparently extirpated, but found at 4 new locations
• *are there extreme fluctuations in # locations (>1 order of magnitude)?*	No
• *habitat trend:*	Some decline
Population information	
• *generation time (average age of parents in the population)*	4-5 years
• *number of mature individuals (capable of reproduction) in the Canadian population)*	Unknown
• *total population trend:*	Unknown
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater*	Unknown
• *are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	Unknown
• *is the total population severely fragmented?*	Yes.

• *list each population and the number of mature individuals in each* Ecozone 7 – Waterton Lake Ecozone 13 – NT – Gt. Slave, La Marte, Keller, GT Bear and Alexie lakes – SK – Reindeer, Wollaston, Athabasca, Black, Riou, Beaverlodge, Canoe, East, Hatchet, Laonil, Milliken, Waterbury, Yalowega, C1 lakes Ecozone 4 – SK – La Ronge, La Plonge, Mirond, MacKay, McLenna MB – Athapapuskow, Cranberry Lakes Westhawk, George and Clearwater lakes ON – Lake 259, Teggau, Lake 310, Lake 258, High, William, Horseshoe, Dicker, Passover, Burton, Trout, Eagle, Cedar, Raven , Burchell, Saganaga, Squeers, Huston, Notellum, Manitou and Teggau lakes	Unknown in all
• *specify trend in number of populations (decline, stable, increasing, unknown)*	Unknown
• *are there extreme fluctuations in number of populations (>1 order of magnitude)?*	No
Threats (actual or imminent threats to populations or habitats)	
Competition and predation with invasive species; pollution; eutrophication	
Rescue Effect (immigration from an outside source)	
• *does species exist elsewhere (in Canada or outside)?*	Yes in U.S. and Ecozone 3
• status of the outside population(s)? No neighbouring U.S. Population	
• *is immigration known or possible?*	Not Possible
• *would immigrants be adapted to survive here?*	Unknown
• *is there sufficient habitat for immigrants here?*	Yes
Quantitative Analysis	Not Applicable

Existing Status

Nature Conservancy Ranks (NatureServe 2005)

Global – G5

National

US – N5

Canada N4

Regional

US: IN – S4, MI – S5, MN – SSNR, NY – S1, OH – SNR, PA – SX, , WI – S4

Canada: AB – S1, MB – S2S3, NT – SNR, ON – S4, QC – S1S2, SK – S5

Wild Species 2000 (Canadian Endangered Species Council 2001)

Canada – NA

Provinces – AB – 5, MB – 2*, ON – 4, QC – 2, NT – 3, SK 5

*****Duncan indicates that this should be 3 or 4 (J. Duncan, Biodiversity Conservation Section, Manitoba Conservation, Winnipeg, Manitoba; rank comments in relation to the data output for the Wild Species web site for freshwater fish species).

COSEWIC – Western populations first assessed as NAR in 2006.

Status and Reasons for Designation

Status: Not At Risk	**Alpha-numeric code**: not applicable

Reasons for Designation

This species is widely distributed in western Canada where it is found in the deepest parts of at least 52 coldwater lakes in northwestern Ontario, Manitoba, Saskatchewan, Alberta and the Northwest Territories. There is no evidence to indicate population declines, or of any threats that would convey a degree of risk to these populations.

Applicability of Criteria

Criterion A: (Declining Total Population): Not Applicable – no evidence to establish decline.

Criterion B: (Small Distribution, and Decline or Fluctuation): Not Applicable – Wide distribution – population abundance and trend information not available.

Criterion C: (Small Total Population Size and Decline): Not Applicable – population abundance and trend information not available.

Criterion D: (Very Small Population or Restricted Distribution): Not Applicable – widespread distribution.

Criterion E: (Quantitative Analysis): Not Applicable – no data.

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