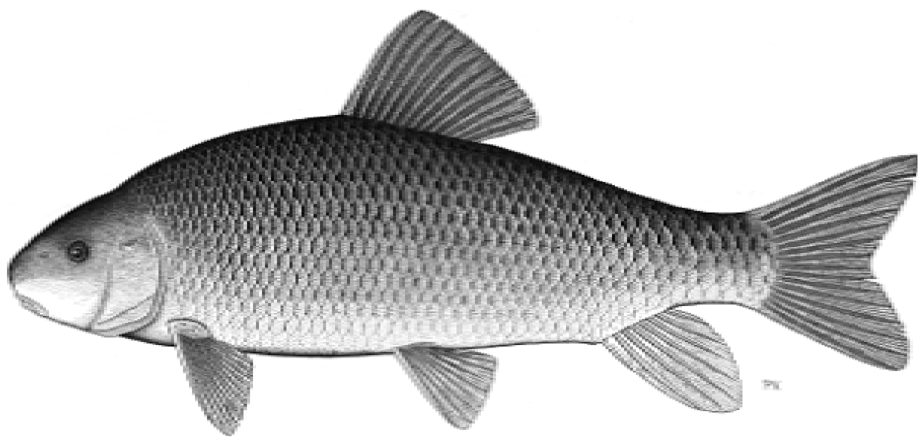
COSEWIC
Assessment and Update Status Report

on the

Copper Redhorse
Moxostoma hubbsi

in Canada



ENDANGERED
2004

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

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

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Adult copper redhorse — illustration by Paul Vecsei.

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COSEWIC
Assessment Summary

Assessment Summary – November 2004

Common name
Copper Redhorse

Scientific name
Moxostoma hubbsi

Status
Endangered

Reason for designation
This species is endemic to Canada where it is now known from only three locations in southwestern Quebec that possibly represent a single population. The distribution and abundance of the species have been severely reduced due to a number of anthropogenic factors (e.g., urban development, agricultural practices, and the construction of dams) that have contributed to a decrease in water quality and habitat availability. The recent introduction of exotic species such as zebra mussel may further impact habitat quality.

Occurrence
Quebec

Status history
Designated Threatened in April 1987. Status re-examined and designated Endangered in November 2004. Last assessment based on an update status report.

COSEWIC
Executive Summary

Copper Redhorse
Moxostoma hubbsi

Species information

The copper redhorse (*Moxostoma hubbsi*) is one of seven species of the genus *Moxostoma* (family *Catostomidae*) occurring in Canada. Its discovery has been attributed to Vianney Legendre in 1942 (Legendre 1942), but it appears to have been first described by Pierre Fortin in 1866 as an already known species of the genus *Moxostoma*.

Distribution

The species occurs nowhere in the world except Canada. Its extremely small range, which is restricted to a few rivers in the lowlands of southwestern Quebec, has contracted significantly in the past few decades. Confirmed populations currently exist in the St. Lawrence and Richelieu rivers. Rivière des Mille Îles likely supports a remnant population.

Habitat

The copper redhorse occurs primarily in medium-sized rivers where water temperatures exceed 20°C in summer. Spawning occurs in riffle areas where the current is moderate to slow and the depth ranges between 0.75 and 2 m, over fine to coarse gravel and cobble substrate. Like its congeners, young-of-the-year copper redhorse spend their first growing season in shallow shoreline areas no more than 1.5 m deep, characterized by gentle slopes, vegetation, a very slow current and fine substrate (mix of clay-silt and sand). To date, there are only two known spawning grounds (Chambly archipelago and the channel downstream from the Saint-Ours dam) and a nursery area (Saint-Marc-sur-Richelieu) has been identified in the Richelieu River. Very recently, the presence of copper redhorse has again been reported in the Lavaltrie-Contrecoeur sector of the St. Lawrence River. The reasons for its presence in this stretch of the river in the spring and early summer (pre-spawning congregation, spawning or migration route) and fall (wintering grounds) could not be determined. High quality copper redhorse habitat is in decline. Its apparent extirpation from the Yamaska and Noire rivers is closely linked to environmental degradation.

Biology

By comparison with the other redhorse species with which it occurs in sympatry, the copper redhorse has the longest lifespan (over 30 years), is the most fecund and reaches the largest size (over 70 cm). Its spawning period is later than that of its congeners, occurring from late June to early July, when water temperatures range from 18 to 26°C. The species also reaches sexual maturity later than its congeners (at about 10 years). The copper redhorse feeds almost exclusively on molluscs, which it crushes with its very robust pharyngeal apparatus and molariform teeth.

Population sizes and trends

Archaeological excavations provide evidence that the species was more abundant at various times in the past. Since the mid-1980s, its abundance relative to the other species in the genus has declined significantly. The population is aging and recruitment is extremely low. Compared to its congeners, the relative abundance of young-of-the-year copper redhorse in the Richelieu River, the only river in which spawning is confirmed, is 0.35% or less. The upward shift in size distribution values in the past 30 to 40 years is significant. There have been virtually no catches of juveniles aged 2+ years in the last 30 years. The total number of mature individuals appears to be several thousand at the most.

Limiting factors and threats

A number of biological characteristics of the copper redhorse, such as its longevity, late age of sexual maturity, late spawning activities and specialized diet, make it unique among its congeners. However, they also contribute, in some respects, to making it more vulnerable. Since the waters inhabited by the copper redhorse are located in the most densely populated areas of Quebec, anthropogenic factors come into play. The nature of those factors cannot, however, be determined with certainty and act in combination. The degradation and fragmentation of its habitat and its low spawning success are believed to be key reasons for its decline. Contamination, siltation, eutrophication, introductions of non-native species, dam construction (which impedes the free passage of fish) and the disturbance of spawners on spawning sites all constitute possible factors in the species' decline.

Special significance of the species

The significance of the copper redhorse is not limited to scientific and ecological considerations. It extends to social values, sustainable development and biodiversity conservation. In some respects, the species is an indicator of the impact of human activity on the ecosystems of southern Quebec. Public interest in the species is not only strong but continues to grow.

Existing protection

As in the case of other fish species, the copper redhorse and its habitat receive a level of protection under the federal *Fisheries Act*, the Quebec *Act Respecting the Conservation and Development of Wildlife* and *Environment Quality Act*. However, because these statutes were considered inadequate for ensuring the preservation of the species, additional measures have been taken, such as amendments to the sport fishing regulations in a number of sectors used by the copper redhorse and the creation of the Pierre-Étienne-Fortin Wildlife Preserve at Chambly in October 2002. The objective of the wildlife preserve is to protect the integrity of the largest spawning site and prevent disturbances of spawners and encroachment on spawning sites during the spawning period. The copper redhorse was designated threatened in 1987 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). In April 1999, it was designated threatened under the Quebec *Act Respecting Threatened or Vulnerable Species*. This is the most critical status that can be applied to a species under Quebec legislation and is used when the loss of the species is feared. Currently, the survival of the species hinges essentially on protection and reintroduction efforts.

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 agencies (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 members and the co-chairs of the species specialist and the Aboriginal Traditional Knowledge subcommittees. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(NOVEMBER 2004)

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 atleast 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 wildlife species for which there is inadequate information to make a direct, or indirect, assessment of its 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.

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

Copper Redhorse
Moxostoma hubbsi

in Canada

2004

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SPECIES INFORMATION

Name and classification

Class: Actinopterygii
Order: Cypriniformes
Family: Catostomidae

The copper redhorse, (*Moxostoma hubbsi*, Legendre) (Figures 1 and 2) is one of seven species of the genus *Moxostoma* (family *Catostomidae*) that occur in Canada. Its discovery has been attributed to Vianney Legendre in 1942 (Legendre 1942), but it appears to have been first described by Pierre Fortin in 1866 as an already known *Moxostoma* (Branchaud and Jenkins 1999). Believing that it was a species previously described by Valenciennes, Legendre first named it *Megapharynx valenciennesi*, considering *Megapharynx* a new genus. More detailed studies later indicated that it was an entirely new species. On the basis of his description of 10 years earlier, Legendre (1952) officially designated the copper redhorse a new species and renamed it *Moxostoma hubbsi* in recognition of the famous ichthyologist Carl L. Hubbs. Robins and Rainey (1956) later placed it in the subgenus *Megapharynx*. However, the most recent study no longer recognizes *Megapharynx* as a valid taxon (Harris *et al*. 2002).

In 1998, the French common name of the species was changed from “suceur cuivré” (Tr.= copper sucker) to “chevalier cuivré” in order to facilitate the task of raising public awareness about the need to protect the species by eliminating any pejorative connotation associated with the word sucker (Branchaud *et al*. 1998). The French generic term “chevalier” (Tr.= knight) is now used to designate all species of the genus *Moxostoma*. This name refers to their large scales, which recall a knight’s armour. However, the second part of its common name has remained unchanged since it refers directly to the general coloration of the dorsal surface, head and sides, which ranges from a bright coppery sheen to olive. The ventral surface of the body is generally a paler shade of the colour of the sides or off-white and the fins are usually coppery to dusky (Scott and Crossman 1973).

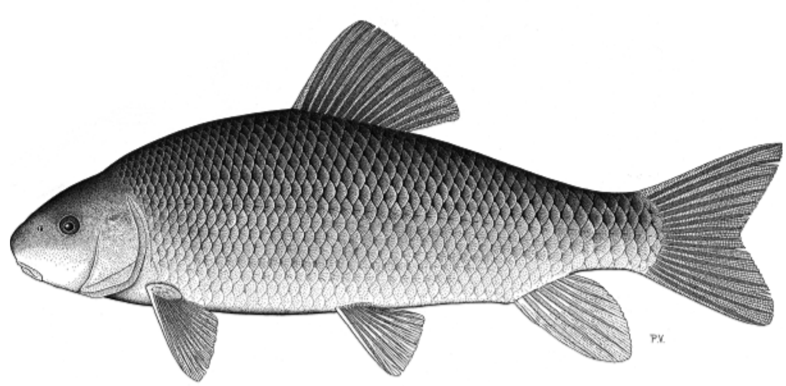

Figure 1. Adult copper redhorse (illustration by Paul Vecsei).

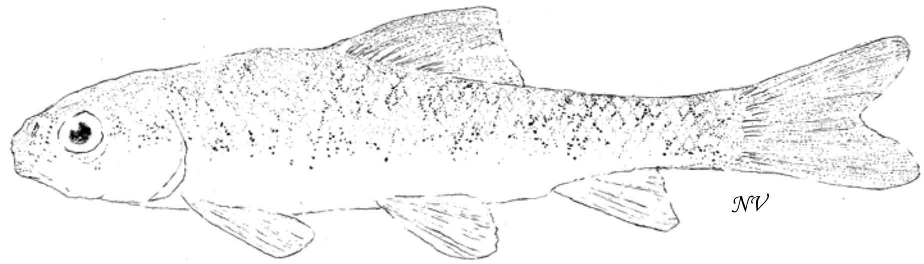

Figure 2. Juvenile copper redhorse, 38 mm (illustration by Nathalie Vachon, from Vachon 2003a)

Description

The copper redhorse is a large-scaled fish of the genus *Moxostoma*, a group of relatively large fish, with an inferior, protrusible mouth, lips with plicae and a pharyngeal apparatus with teeth arranged in an arch around the opening of the esophagus. It has 15 to 16 rows of scales around the caudal peduncle, like its congener the greater redhorse (*Moxostoma valenciennesi*), whereas there are usually 12 or 13 in the other species with which it occurs in sympatry in southern Quebec, namely the silver redhorse (*M. anisurum*), shorthead redhorse (*M. macrolepidotum*) and river redhorse (*M. carinatum*). Its short, massive head, shaped like an equilateral triangle, with a moderately high arch rising sharply behind the head, creating a humpback appearance, its pharyngeal apparatus, exceptionally robust with molariform teeth (18 to 21 per arch) (Figure 3) are the main characteristics by which it can be distinguished from the other species (Mongeau 1984, Mongeau *et al.* 1986, 1988, Scott and Crossman 1973).

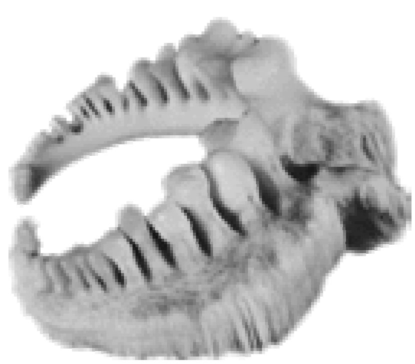

Figure 3. Pharyngeal apparatus of the copper redhorse (photograph by Yves Chagnon, Société de la faune et des parcs du Québec).

Gendron and Branchaud (1991) have described the morphometric, meristic and pigmentation characteristics of the larval (flexion mesolarvae) and juvenile stages, and Branchaud *et al.* (1996) have developed genetic analysis techniques for the identification of eggs and larvae. Several authors (Beauchard 1998, Vachon 2003b) have described the morphological features of the gill and pharyngeal arches in juveniles, and Grünbaum *et al*. (2003) have studied the sequence of ossification and chondrification of the caudal skeleton in larvae. Despite considerable efforts to develop other larval identification techniques, genetic analysis remains the most reliable method (Branchaud *et al.* 1996). At present, only larger juveniles (TL > 35 mm) can be identified by external criteria. In juvenile copper redhorse, the reduced number of pharyngeal teeth as well as their molariform appearance, widened base and more robust arches are already evident and can be used to distinguish them from the others. Dissection of the pharyngeal apparatus is still the technique of choice for confirming identification (Vachon 1999a, 2003a).

DISTRIBUTION

Global range

The copper redhorse is found nowhere in the world except Quebec (Figure 4). Since 1942, all specimens have been found in rivers in the St. Lawrence Plain (southwestern Quebec), namely in the Maskinongé, Mille Îles, Noire, Richelieu, and Yamaska rivers and in a few localized sites in the St. Lawrence River, namely the fast-flowing Sainte-Anne-de-Bellevue and Vaudreuil channels, the Lavaltrie-Contrecoeur sector and Lake Saint-Pierre.

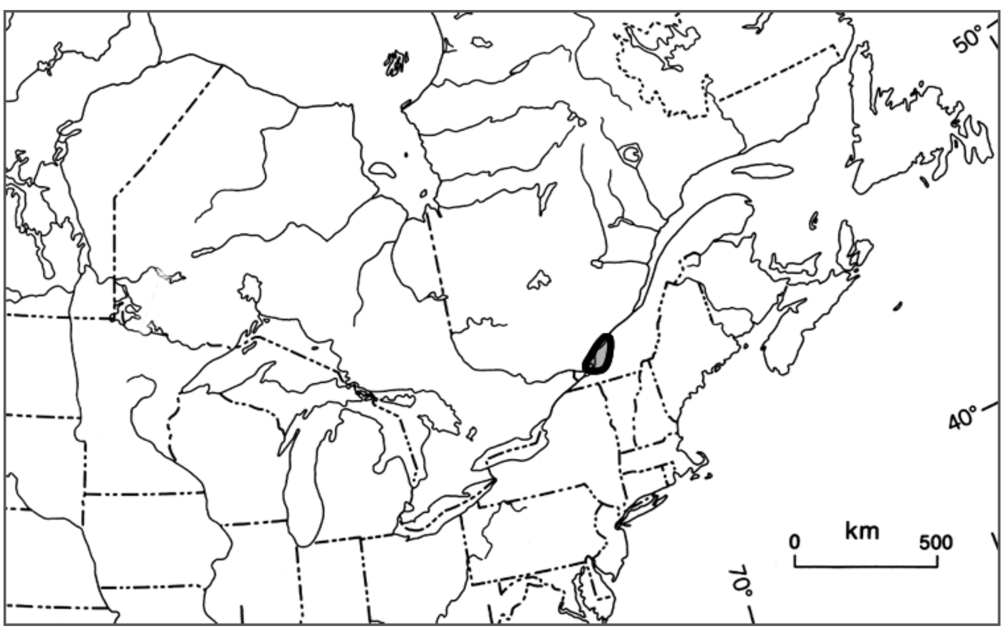

Figure 4. Global distribution of copper redhorse.

Very recently, the identification of a fossilized fragment of copper redhorse pharyngeal apparatus from Indiana confirmed that the species was present there during the Pleistocene, i.e., between 11,000 and 1.8 million years ago (R.E. Jenkins, professor at Roanoke College, Virginia, pers. comm.).

Canadian range

Despite numerous fish surveys conducted since its discovery, the copper redhorse has never been found in any other river (Figure 5, Table 1). Moreover, its range has been contracting over the past few decades. Its extent of occurrence and area of occupancy have declined significantly from roughly 6,119 km^2 and 555 km^2, respectively, in the early 1940s to an estimated 2,089 km^2 and 69 km^2, respectively, today. No specimens were captured during recent systematic sampling programs carried out in various sectors of the St. Lawrence River, including Lake Saint-Pierre (1995, 1997, 2002, 2003) and Lake Saint-Louis (1988 to 1990 and 1997) (Dumont 1996, Fournier *et al.* 1996, 1998ab, FAPAQ, unpubl. data). However, in 1942 four specimens were captured in the Sainte-Anne-de-Bellevue and Vaudreuil channels at the head of Lake Saint-Louis (Ottawa River) by Legendre (1942) and one by Vladykov in Lake Saint-Pierre. Six others have been found in Lake Saint-Pierre, including two in 1944 (Cuerrier *et al.* 1946), one in 1947, as well as three in 1971 in its archipelago (Sorel and Berthier channels) (Massé and Mongeau 1974). No copper redhorse were reported in sampling programs carried out from 1997 to 1999 in the Ottawa River and some of its tributaries as part of a study on the river redhorse (Campbell 2001).

Rivière des Mille Îles likely supports a remnant population. Since the capture of twelve specimens in 1971 and 1973 (Mongeau and Massé 1976) in the entire river, only three other individuals have been collected there, including one at the head of the river (Grand Moulin rapids) in 1980 (Massé *et al.* 1981) and two in 1996 near the confluence with Rivière des Prairies, downstream from the dam near Île du Moulin at Terrebonne (FAPAQ, unpubl. data).

The copper redhorse was first surveyed in the Yamaska River by Vladykov in the 1940s. Parts of a specimen, captured by Vladykov on June 19, 1948, near Saint-Césaire, are currently in the Cornell University collection (CU 25512) (R.E. Jenkins, professor at Roanoke College, Virginia, pers. comm.). The species was subsequently found in abundance in the 1960s in the Yamaska (upstream of the Saint-Hyacinthe dam) and Noire rivers (Mongeau *et al.* 1986, 1992). At that time, these rivers ranked, respectively, second and third in terms of the number of specimens collected (Mongeau *et al.* 1986). Despite visits made to the sector from 1976 to 1978 (Buth 1978, Harvey 1979), in 1985 (Mongeau *et al.* 1986), in 1991 (La Violette 1996), in 1992 (Boulet *et al.* 1995) and in 1995 (La Violette 1999), the presence of the species was reported only once in 1992 in the Yamaska River (Boulet *et al.* 1995). Given the degradation of the habitats in these rivers, the populations there are most likely almost entirely extirpated.

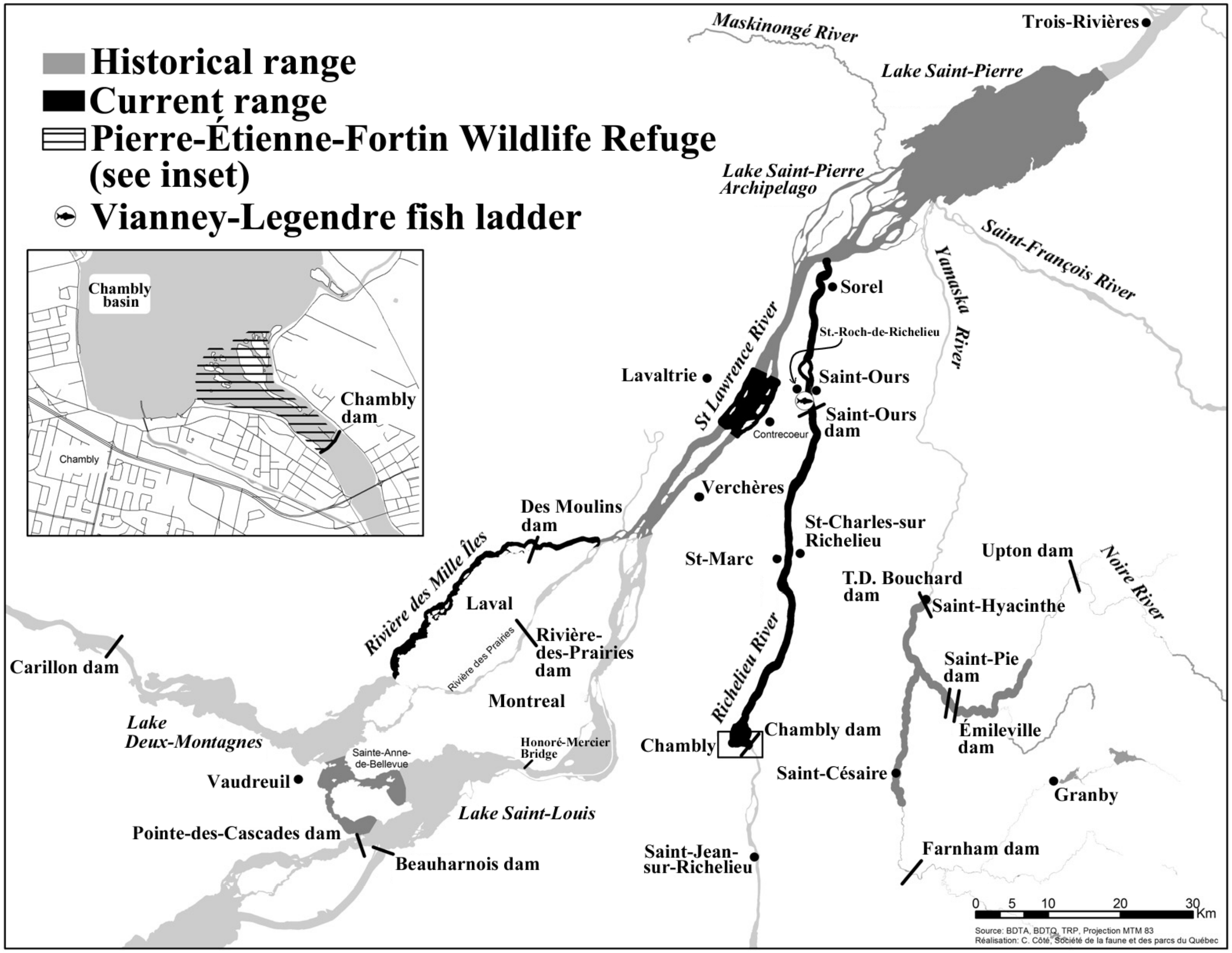

Figure 5. Historical and current range of the copper redhorse (Map by Chantal Côté, Société de la faune et des parcs du Québec).

Table 1. Main sampling programs and field work in southern Quebec streams since the 1960s and records of copper redhorse in each stream.

	Record of capture		Systematic or large-scale sampling / field work	
	first	last	Year[1]	Reference
ST. LAWRENCE RIVER SYSTEM				
			1964 to 1966	Mongeau and Massé 1976
Lac des Deux-Montagnes	—	—	**1975-1976**	Sloterdijk 1977
West of the Island of Montreal			**1965 to 1968**	Mongeau and Massé 1976
			1975-1976	Sloterdijk 1977
	1942	1945	**1988 to 1990**	Dumont 1996
Sainte-Anne-de-Bellevue and Vaudreuil channels at the head of Lake Saint-Louis			**1997**	Fournier *et al*. 1998b (RSI)[2]
Rivière des Mille Îles	1971	1996	**1971, 1973**	Mongeau and Massé 1976
			1975-1976	Sloterdijk 1977
			1980	Massé *et al*. 1981
			1996	FAPAQ, unpubl. data
Rivière des Prairies	—	—	**1971-1972**	Mongeau and Massé 1976
			1975-1976	Sloterdijk 1977
				Provost *et al*. 1982, Provost and Fortin 1984
			1982-1983	Dumont *et al*. 1987
			1982 to 1985	Gendron 1986, 1987, 1988
			1986 to 1988	Fortin *et al*. 2002 (hydroelectric
			1995 to 1999	generating station on the Rivière des Prairies)
South and east of the Island of Montreal			**1973, 1977**	Mongeau and Massé 1976, Massé and Mongeau 1976, Mongeau *et al*. 1980
			1975-1976	Sloterdijk 1977
From the Mercier Bridge to Sorel	1973	2004	**1991 to 1993**	Nilo 1996
			2001	FAPAQ, unpubl. data (RSI)
			1998 to 2004	Vachon and Chagnon 2004, FAPAQ, unpubl. data
Lake Saint-Pierre and its archipelago	1944	1971	**1971-1972**	Massé and Mongeau 1974
			1975-1976	Sloterdijk 1977
			1995, 1997	Fournier *et al*. 1996, 1998a
			2002-2003	FAPAQ, unpubl. data (RSI)
TRIBUTARIES				
Maskinongé	1971	1971	**1963 to 1974**	Mongeau *et al*. 1981
Yamaska	1948	1992	**1963-1975**	Mongeau 1979a
			1976 to 1978	Buth 1978, Harvey 1979
			1985	Mongeau *et al*. 1986
			1987	FAPAQ, unpubl. Data
Noire	1963	1964	**1991**	La Violette 1996
			1992	Boulet *et al*. 1995
			1995	La Violette 1999

			1968 to 1970 and 1995	Mongeau 1979b, Saint-Jacques 1998
Richelieu	1965	2003	**1984, 1985**, 1990 to 1994, 1996, 1997	Studies at Chambly, Saint-Ours and Saint-Marc-sur-Richelieu Branchaud and Fortin 1998, Branchaud and Gendron 1993, Branchaud *et al*. 1993, 1995, Boulet *et al*. 1995, 1996, Dumont *et al*. 1997, La Haye *et al*. 1992, 1993, La Haye and Clermont 1997, Mongeau *et al*. 1986, 1992
			1997 to 1999, 2001	Vachon 1999ab, 2002 (juveniles) Monitoring of the fish ladder at Saint-Ours
			2002 and 2003	Fleury and Desrochers 2003, 2004

[1]Boldface characters indicate years in which systematic or large-scale sampling was conducted.
[2]RSI: Réseau de suivi ichtyologique.

Since 1998, the presence of the copper redhorse in the Lavaltrie-Contrecoeur sector (St. Lawrence River) is once again being recorded every year during spring and autumn thanks to the collaboration of a commercial fisher (Vachon and Chagnon 2004, FAPAQ, unpubl. data) using hoop nets and gill nets. The last records of the species in this section of the St. Lawrence date back to 1973, when four specimens were captured between Verchères and Contrecœur (Massé and Mongeau 1976). It should be noted that, despite a fairly exhaustive coverage of the sector by fishing efforts carried out in the summer and fall at some 97 stations from 1991 to 1993 (Nilo 1996) and a systematic sampling of the Montreal-Sorel section in 2001 during a fish monitoring study (*Réseau de suivi ichthyologique*) (FAPAQ, unpubl. data), no copper redhorse were captured. Gear used to sample included beach seine and experimental gill nets. Although the discovery of this new group is extremely interesting and specimens showing obvious signs of reproductive activities were found, the presence of a spawning area in the sector could not be demonstrated (Vachon and Chagnon 2004).

At the present time, the only population for which reproduction is confirmed occurs in the Richelieu River. Since the capture of the first individuals there in 1965, the presence of the species is regularly recorded. The species was found at 30 stations distributed throughout the river from the Chambly Basin as far as the river mouth (Sorel) during a systematic sampling program carried out from 1968 to 1970 (Mongeau 1979b). In 1995, systematic sampling of the Richelieu River, although less intensive than the previous program, resulted in the capture of a single individual (Saint-Jacques 1998). However, numerous studies, conducted locally, have succeeded in capturing spawners and fry at Chambly and at Saint-Ours (Branchaud and Fortin 1998, Branchaud and Gendron 1993, Branchaud *et al.* 1993, 1995, Boulet *et al.* 1995, 1996, Dumont *et al.* 1997, La Haye *et al.* 1992, 1993, La Haye and Clermont 1997, Mongeau *et al.* 1986,

1992) and young-of-the-year, particularly in the Saint-Charles-sur-le-Richelieu sector (Boulet *et al.* 1995, 1996, Vachon 1999a, 1999b, 2002).

HABITAT

Habitat requirements

Adult copper redhorse inhabit medium-sized rivers, with steep banks, a maximum depth of 4 to 7 m, a hard bottom, generally composed of clay, sand and gravel, in places where dense grass beds are usually absent or reduced to a thin strip along the shore. The summer water temperature exceeds 20ºC. These rivers are located in a region of Quebec of very limited area characterized by a growing season of at least 1,790 degree-days above 5.6ºC. Although the current is slow, usually less than 0.3 m/s, certain segments have short stretches of fast-flowing water where the species finds conditions favourable to reproduction. Adults are absent from shallow sections with dense vegetation as well as from locations where the water is heavily polluted and turbid (Mongeau *et al*. 1986, 1988, 1992).

There are currently two known copper redhorse reproduction sites, namely the archipelago of the Chambly rapids and the tailrace of the Saint-Ours dam. The spawning grounds are in riffle areas, with a moderate to slow current and depths ranging from 0.75 to 2 m. The heterogeneous substrate is composed of fine to coarse gravel, rocks and sometimes even fragments of bedrock partly submerged in the clay (Boulet *et al.* 1995, 1996, Dumont *et al.* 1997, La Haye *et al.* 1992, La Haye and Clermont 1997, Mongeau *et al*. 1986, 1992). Other sites such as the Grand Moulin rapids in Rivière des Mille Îles and the Dorion and Saint-Anne-de-Bellevue channels at the head of Lake Saint-Louis could potentially meet the spawning requirements of the copper redhorse, but the presence of a spawning area there has never been demonstrated (Jenkins 1970, Massé *et al*. 1981).

Like their congeners, young-of-the-year copper redhorse frequent shallow littoral areas during their first growing season. These areas are less than or equal to 1.5 m deep, gently sloped (≤ 20º) and vegetated. The current is very slow and the substrate is relatively fine (mix of clay-silt and sand) (Vachon 1999a). The section of the Richelieu River that includes Jeannotte Island and Île aux Cerfs at Saint-Marc-sur-Richelieu is an important nursery area for juvenile redhorse, especially the copper redhorse, since several specimens have been collected there (Vachon 1999ab, 2002). This sector is also inhabited by three other species that have already received COSEWIC status (Massé and Bilodeau 2003, Vachon 1999a, 1999b, 2002): the river redhorse, designated a species of special concern (Parker and McKee 1984, Parker 1988, status again under review), and the Channel darter (*Percina copelandi*) (Goodchild 1994) and Eastern sand darter (*Ammocrypta pellucida*) (Holm and Mandrak 1996), two threatened species.

Little is still known about the adults' summer and winter habitat. The possibility that certain sectors of the St. Lawrence River may be used as an over-wintering area cannot be ruled out (Vachon and Chagnon 2004).

Trends

High quality copper redhorse habitats are in decline. Moreover, its feared disappearance in the Yamaska and Noire rivers is closely linked to environmental degradation. These rivers are located in the most heavily agricultural region of Quebec. Farms occupy 63% of the area of the Yamaska River watershed. In total, 200,000 hectares are intensively cultivated and more than a quarter of the hogs and poultry raised in Quebec come from this region (Primeau *et al*. 1999). The situation in the Richelieu River watershed is scarcely any better, where the total area under cultivation is 141,176 ha (56.3%) (Piché and Simoneau 1998). From 1979 to 1991, the human population in this watershed grew by 20% and the area of cultivated land increased by 10%. During that period, major changes occurred in the composition of livestock and poultry, including a decline in the number of cows and an increase in the number of pigs and poultry. These changes had an impact on crop type at the watershed scale: the area devoted to widely spaced bare soil crops (primarily corn) increased by 150%, whereas the area devoted to other cereals and forages fell by 28% and 38%, respectively (Simoneau 1993). In the Richelieu River, as in several sectors of the Yamaska, the situation in terms of contamination by toxic substances is considered worrisome (Berryman and Nadeau 1998, 1999).

The assessment of ecosystem integrity by the composition of the benthic (IBGN) and fish (IBI) communities shows that the Richelieu River is rated fair or poor over nearly three-quarters of its length. A significant reduction in the IBGN as well as a notable decline in pollution-sensitive benthic species have been recorded at the outlet of the Chambly Basin downstream of the Rivière des Hurons and the Rivière l'Acadie (agricultural tributaries). The IBI shows that the sector between Saint-Marc-sur-Richelieu and Saint-Ours is one of the most degraded of the whole river, owing to the increase in urban, industrial and agricultural pressures (Piché 1998, Saint-Jacques 1998).

In the Yamaska River, the lower ratings (fair and poor) which describe the integrity of the benthic (IBGN) and fish (IBI) communities were obtained in the section historically inhabited by the copper redhorse. The situation is slightly less precarious in the Noire River, where ecosystem integrity, as shown by these two indices, is deemed fair to excellent at the stations located in the sector where the species has previously been found (La Violette 1999, Saint-Onge 1999).

In the St. Lawrence River, agricultural pressures, although present, are less significant. However, urbanization and the associated practices, as well as industrial activities, are having considerable impacts on the ecosystems of the St. Lawrence. In Quebec, urban sprawl has been continuing for several decades and the St. Lawrence Lowlands and Great Lakes region is the most industrialized in Canada (Bernier *et al*. 1998). An initial assessment of the biotic integrity of the St. Lawrence River based on the IBI shows that the ecosystem is fairly degraded (La Violette *et al.* 2003).

It should be stressed that the intensification of agricultural activities and urbanization often has a detrimental impact on forested areas. The negative impact of deforestation on aquatic ecosystems is well known. In Montérégie, this phenomenon is worrisome. Wooded areas covered approximately 26% of the territory of Montérégie in 2002. Compared to 1999, this represents a loss of 3.88% or 12,511 ha. Most of the major tree-cutting has been carried out for agricultural purposes (Soucy-Gonthier *et al*. 2003). The intensification of agricultural activities has cancelled out some of the efforts that have been made to clean up discharges of industrial and household waste.

The downward trends in St. Lawrence River water levels, as well as the acceleration of erosion of the banks by wave action from passing vessels, resulting from increased traffic by commercial ships and pleasure craft, are also disturbing aquatic ecosystems. Over the past 20 years, the water levels of the St. Lawrence River have been falling and low-water problems are becoming increasingly severe, compromising the quantity and quality of fish habitat (spawning, feeding and nursery areas). Several biological processes of fish fauna depend on subtle synchronisms between water levels, temperature and flow (Robichaud and Drolet 1998). The impacts on the copper redhorse are not known. The copper redhorse telemetry project currently under way will provide new data concerning the essential habitats of this species in the St. Lawrence River.

Protection/ownership

The habitats of the copper redhorse are mainly under public ownership. However, some small tributaries may be privately owned. At the present time, only 63 ha, which constitute the Pierre-Étienne-Fortin wildlife refuge, are the subject of special protection measures (Figure 5). This refuge is partly under private ownership. The river bed is owned by Conservation de la Nature and certain islands (Saint-Jean archipelago) are owned by the municipality of Richelieu.

BIOLOGY

General

Compared to the other species with which it occurs in sympatry, the copper redhorse has the longest lifespan, is the most fecund species and reaches the largest size. Compared to its congeners, the copper redhorse spawns later and takes the longest to reach sexual maturity.

Reproduction

The copper redhorse lives for at least 30 years (de Lafontaine *et al*. 2002a) and reaches a considerable size. The size (total length) of spawners is generally greater than 500 mm (Mongeau *et al.* 1986, 1992), although according to Jenkins (1970), males can reproduce once they reach 475 mm. Both sexes reach sexual maturity at the beginning of the 10th year; hence, the reproductive lifespan appears to be at least 20 years. In 12 females captured in 1984 in the Chambly Basin that varied from 547 to 690 mm in total length, fecundity ranged from 34,900 to 111,860 eggs. The fecundity of a 2 kg female is approximately 32,750 eggs (Mongeau *et al*. 1986, 1992). The weight of female spawners correlates positively with the number of eggs produced and with the diameter of the eggs released (Branchaud and Gendron 1993, Branchaud *et al*. 1995, Mongeau *et al*. 1986, 1992). Generally, a sex ratio in favour of the males is observed at reproduction sites, which suggests that they travel to the spawning areas before the females (Branchaud *et al.* 1993, 1995) or that they are more active (Pierre Dumont, biologist with the Société de la faune et des parcs du Québec, pers. comm.). As has been reported in other *Moxostoma*, copper redhorse leap out of the water during the reproduction period. This behaviour has been observed at or near spawning sites and is used as an indicator of reproduction activity (Dumont *et al*. 1997, Vachon and Chagnon 2004).

Spawning begins around the last week of June and can continue until the first week of July, at which time the water temperature ranges from 18 to 26ºC. Spawning likely occurs at night (Boulet *et al*. 1995, Dumont *et al*. 1997, La Haye *et al*. 1992, Mongeau *et al*. 1986, 1992).

The eggs, which range in diameter from 2.81 to 3.42 mm, are non-adhesive and orangey-yellow in colour. At a constant temperature of 20ºC, hatching occurs after 89 to 127 degree-days, peaking at around 108 to 110 degree-days, which represents 4.5 to 6.5 days of incubation. At hatching, the yolk sac larvae measure 9.09 mm on average. At the start of exogenous feeding, at which time resorption of the yolk sac is practically completed, the average size of the larvae is 13.11 mm. This important stage generally occurs 15 days after fertilization. Emergence of the larvae (beginning of swimming behaviour) has been observed 12 to 16 days after fertilization, with peak activity after 15 days (Branchaud and Gendron 1993, Branchaud *et al*. 1993, 1995).

Growth

In the copper redhorse, the growth rate in length and weight is generally higher than that of its congeners. No difference in growth has been observed between the sexes. The females are generally more corpulent than the males. On the basis of the results obtained by back calculation, a copper redhorse measures on average 370, 550 and 670 mm respectively at 5, 10 and 20 years (Mongeau *et al*. 1986, 1992). To date, the largest specimen captured measured 780 mm (Vachon and Chagnon 2004). The heaviest individual was a 715 mm female weighing 5.55 kg captured in 1994 in the Richelieu River (Branchaud *et al*. 1995).

In the fall, the average size of young-of-the-year redhorse in the Richelieu River reflects the temporal sequence of spawning of the different species. The growth of young-of-the-year is closely linked to the cumulative number of degree-days above 10ºC during the growing season, which ends at the latest around the end of September, even if the fall is late. The average total length of young-of-the-year copper redhorse captured from September to November ranges from 37.5 to 48.5 mm (average of 41.6 mm). These juveniles are potentially more vulnerable when facing their first winter season since, in the fall, they are smaller than their congeners. For example, at the same period in 1999 and 2001, the average size of young-of-the-year in the other four species was greater than 57 mm. Young-of-the-year shorthead and silver redhorse measured on average between 72 and 83 mm (Vachon 1999ab, 2002).

Survival

Several studies have shown an aging of the population, which appears to be attributable to recruitment problems stemming from low reproductive success (Branchaud *et al*. 1993, 1995, Boulet *et al.* 1995, 1996, La Haye *et al.* 1992, Vachon and Chagnon 2004).

The age structure of the population cannot be clearly demonstrated since the sample size examined is insufficient. However, the shift in size distribution profiles toward higher values over the last 30 to 40 years is obvious and statistically significant (Figure 6). Furthermore, virtually no age-2+ juveniles have been captured for the past 30 years (Vachon and Chagnon 2004). The last two specimens in the 100 to 150 mm size range were captured in 1974 in the Richelieu River (Mongeau *et al*. 1986). In the spring of 2003, the average size of the copper redhorse captured in the Lavaltrie sector was 646 mm; 90% of the specimens measured 620 mm or more (Chagnon 2003). The individuals captured in the fish ladder (Richelieu River) in 2002 and 2003 were over 600 mm in length (Fleury and Desrochers 2003, 2004).

Monitoring of the recruitment of young-of-the-year redhorse carried out in September 1998, 1999 and 2001 in the Richelieu River showed that the relative abundance of the copper redhorse compared to its congeners is less than or equal to 0.35%. A single young-of-the-year was captured each year (Vachon 1999ab, 2002). In 1997, despite much more intensive fishing efforts which covered a larger sector of the Richelieu River, the results were scarcely any better; the relative abundance of young-of-the-year copper redhorse was 0.63% (Vachon 1999a). The survival rate of young-of-the-year is not known. However, the hypothesis that these juveniles are more vulnerable during their first winter cannot be ruled out (Vachon 1999a).

Given the very low reproductive success observed in the copper redhorse, the recruitment rate is clearly insufficient to offset natural mortality. This situation is increasingly alarming given the fact that the population is aging. In fact, the capture of spawners could eventually be very difficult and constitute a major obstacle to the success of artificial reproduction (Branchaud *et al*. 1995).

Physiology

A study of the contamination profiles of seven copper redhorse aged 9 to 33 that died accidentally in the tailrace of the Saint-Ours dam reveals that the level of contamination of the liver, gonads and muscle tissue by bioaccumulative substances (mercury, trace metals, PCB congeners, dioxins and furans) is comparable or sometimes even lower than that recorded in other younger catostomids of the Yamaska basin and the Richelieu River. The concentrations found are lower than those recognized as harmful to reproduction or as affecting egg and fry survival (from Lafontaine *et al*. 2002).

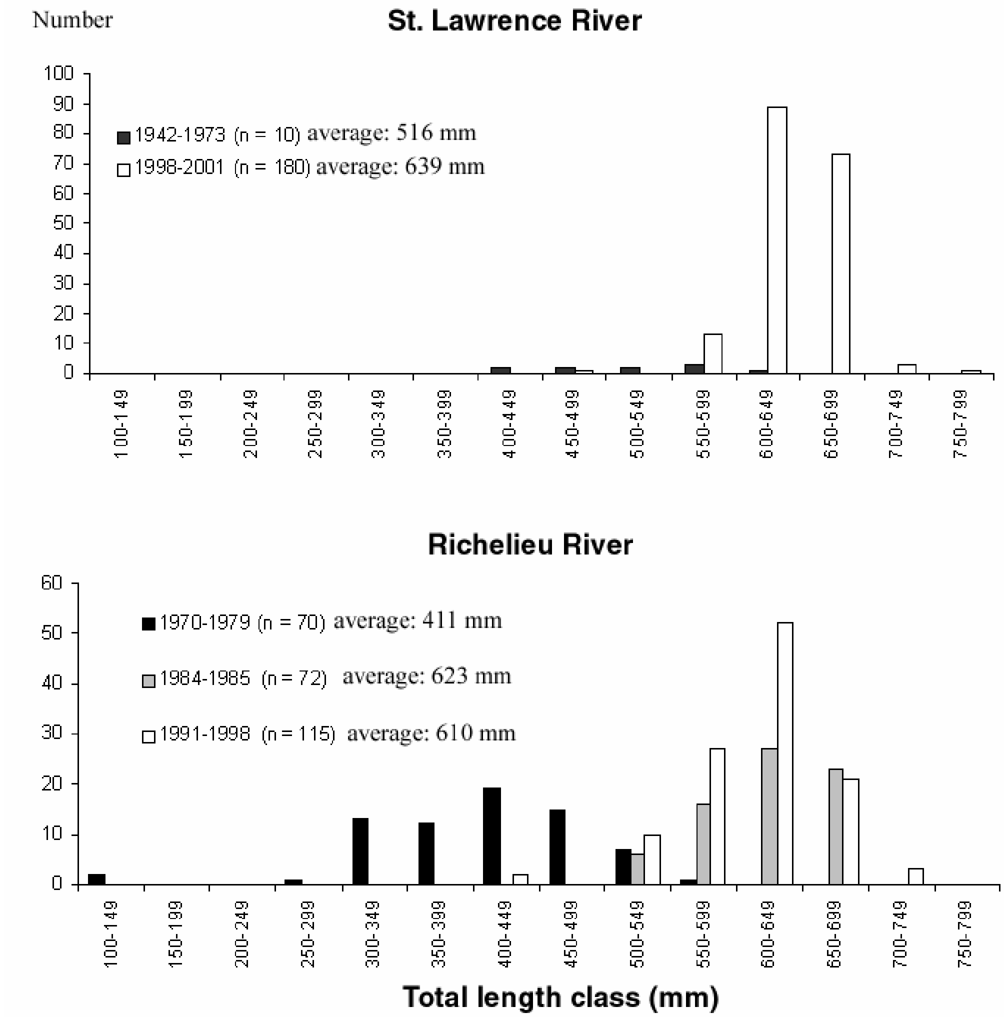

Figure 6. Size frequency distribution of copper redhorse in the St. Lawrence River and the Richelieu River from 1942 to 2001 (adapted from Vachon and Chagnon 2004).

However, these results do not rule out the possibility that other contaminants which do not accumulate in the organism, such as certain pesticides, are disrupting reproductive processes. On the basis of the observations made during artificial reproduction experiments, it appears that, even if the growth and initial development of the gonads take place normally, difficulties arise, particularly in the females, during the later stages of maturation as well as when the gametes are released. None of the females captured at the peak reproductive period released eggs under gentle abdominal pressure and only very few males expressed milt (Branchaud and Gendron 1993, Branchaud *et al*. 1993, 1995). The hypothesis that these physiological disorders are of toxicological origin was then examined by Gendron and Branchaud (1997). These authors concluded that it is probable that metabolites of alkylphenol polyethoxylates (APEs) impair final gamete maturation in the copper redhorse (endocrine disruptors), while atrazine as well as other pesticides (e.g., diazinon and carbofuran) may confuse the olfactory system of spawners, which would affect the perception of pheromones, substances that help synchronize gamete maturation as well as spawning behaviour in both sexes. Given the presence of these contaminants in the Richelieu River, particularly during the copper redhorse reproduction period, the hypothesis is plausible (Gendron and Branchaud 1997). Andrée Gendron and David Marcogliese, of the Centre Saint-Laurent, are currently testing certain aspects of this hypothesis.

In juveniles, the only information available is from experiments with marking techniques. The marking of copper redhorse with oxytetracycline has not proven as effective as desired (Beaulieu 1996, Branchaud *et al*. 1995, Turgeon 1995). A study is currently under way to assess the permanence of freeze branding. To date, the technique appears promising. Nine days after the marking of juveniles produced in 1994 and reared at the Tadoussac fish station, the marks were clearly visible and no mortality had been observed (Morin 1999). The experiment was continued in order to assess the long-term permanence of the mark and the effects of the technique on the growth and survival of the specimens. According to observations made in 2003, the identification rate is clearly higher if the contact time is six seconds, rather than three. In addition, no effects were observed on the growth of the individuals (FAPAQ and Biodome, unpubl. data).

Dispersal/migration

The capture of several copper redhorse a short time before spawning at the tailrace of the Saint-Ours dam during various field studies (Branchaud and Gendron 1993, Branchaud *et al*. 1993, 1995, Boulet *et al*. 1995, 1996, Dumont *et al*. 1997, La Haye and Clermont 1997) and records of the presence of the species in the fish ladder in 2002 and 2003 (Fleury and Desrochers 2003, 2004) clearly show that the species forms pre-spawning aggregations.

The recurrent presence of copper redhorse in the Lavaltrie-Contrecœur sector (St. Lawrence River) during the months of April and May, followed by a drop in numbers thereafter also suggests that individuals congregate and undertake spring migrations to spawning sites. The reasons for its presence in this section of the St. Lawrence in the spring and early summer (pre-spawning aggregations, spawning or migration route) have so far not been conclusively determined (Vachon and Chagnon 2004). Interannual comparisons of captures and recapture results also show that the Lavaltrie-Contrecoeur sector appears to be an important congregation site or even an over-wintering area for the species (Vachon and Chagnon 2004).

The capture of several adult redhorse, including one copper redhorse and one river redhorse off the left bank of Jeannotte Island (Richelieu River) in early June 1998 (Vachon 1999a) also supports the hypothesis of pre-spawning migrations. Jeannotte Island is located approximately 21 km downstream of the Chambly Basin and approximately 24 km upstream of the Saint-Ours dam. These two specimens were already in the sector upstream of the Saint-Ours dam, since at that time there was no fish ladder. If they were migrating to a spawning area, it was that located in the Chambly rapids (Vachon and Chagnon 2004). The nature and concentration of certain contaminants found in the tissues of copper redhorse from the tailrace of Saint-Ours also support this hypothesis. Contaminants more typically associated with the St. Lawrence River such as cadmium, mirex and PCB congener 77 were detected in their tissue (de Lafontaine *et al*. 2002a).

The juveniles are dispersed simply by drifting of the larvae after hatching. The larvae are distributed along the river. Unfed fry and juveniles subsequently remain associated with the grass beds near the shore during their first growing season and at least at the beginning of the second. In the fall, particularly when the water temperature is less than 12ºC, the young-of-the-year move away from the shores and head toward deeper water (Vachon 1999a). These observations appear to agree with those obtained during experiments on the behaviour of juvenile stages of redhorse conducted in 1996, which show that at fall temperatures (7.5°C), young-of-the-year copper redhorse exhibit a clear preference for coarser substrates, while such behaviour was not observed at temperatures of 21°C (Branchaud and Fortin 1998).

Diet and interspecific interactions

In adults, the diet is specialized and consists almost exclusively of molluscs (more than 90% by number). In the streams of the St. Lawrence Plain, several other species feed on molluscs, including the river redhorse, but not exclusively (Mongeau *et al.* 1986, 1992). Indeed, the particular configuration of its pharyngeal apparatus is well adapted to crushing (Eastman 1977, Jenkins 1970, Mongeau *et al.* 1986).

There is very little overlap between the diet of the copper redhorse and that of the other species. The taxa most frequently encountered in the digestive tracts of copper redhorse are Unionidae, Sphaeriidae and Amnicolidae, in its entire range (Mongeau *et al.* 1986, 1992). An examination of non-animal substances found in the digestive tracts of redhorse suggests that there is a spatial segregation between the species when they feed. Copper and greater redhorse feed on hard bottoms, river redhorse on gravely bottoms, while shorthead and silver redhorse appear to feed in or near grass beds. The species most likely to be associated with the copper redhorse are the Carp (*Cyprinus carpio*), the river redhorse and the silver redhorse (Mongeau *et al.* 1992).

Conversely, in young-of-the-year and age-1 individuals captured in the spring, there was little difference in diet between the species, despite the fact that at this period of ontogenesis, the morphology of the copper redhorse's pharyngeal apparatus is already distinctive and can be used to distinguish it from its congeners. In juvenile copper redhorse, whose total length ranges from 36.0 to 53.5 mm, more than 50% (by number) of prey are microcrustaceans (Cladocera: Chydoridae; Copepoda: Harpacticoida). Worms (Nematoda) and algae (Desmidiae) also occupy an important place and chironomid larvae are also frequently ingested (Vachon 1999a).

In rearing ponds, chironomid larvae and pupae as well as cyclopoid copepods were the main organisms consumed by very early juvenile stages of copper redhorse (TL=13.0 to 22.1 mm) (Branchaud *et al.* 1995). In the laboratory, older copper redhorse juveniles (average size 108.4 mm) fed on zebra mussels (*Dreissena polymorpha*) less than 8 mm in length (Branchaud and Gendron 1993).

Behaviour/adaptability

Natural environment

Given its sensitivity to pollution and siltation, the fact that individuals congregate at certain times of the year and its extremely small range, the species is particularly vulnerable to any natural disasters that could affect its habitat in any way. Any disturbances which might affect mollusc populations could also adversely affect the copper redhorse, since it feeds almost exclusively on this type of prey.

Artificial reproduction and rearing

Numerous studies have made it possible to develop artificial reproduction and rearing techniques. Efforts to reproduce the species artificially have been successful, but hormonal induction had to be used (Branchaud and Gendron 1993, Branchaud *et al*. 1993, 1995). In these studies, spawners were held for several days in tanks. A few adult specimens were also held for several months or even a few years in aquariums. However, spawners must be handled very carefully since they exhibit severe stress reactions when captured (Branchaud and Gendron 1993). Holding adults in long-term captivity has, however, proven difficult. Most of the specimens die (Dumont *et al*. 1997, Pierre Dumont, biologist with the Société de la faune et des parcs du Québec, pers. comm.).

In 1994, juveniles were reared in a semi-closed system at the Tadoussac hatchery as well as in a small experimental pond (Branchaud *et al*. 1995, Turgeon 1995). The survival rate of the larvae was approximately 23% in the fertilized pond and 87% at the Tadoussac hatchery. The larvae and juveniles feed on both artificial and natural foods (Branchaud and Gendron 1993, Branchaud *et al*. 1993, 1995, Turgeon 1995). Although the rearing experiments in 1994 were encouraging, some adjustments had to be made given the low growth rate (average length of 22.8 mm after 91 days of rearing) and the high prevalence of scoliosis observed in the individuals produced in a semi-closed system at Tadoussac. In 1995 and 1996, rearing in fertilized ponds at the Baldwin Mills hatchery was recommended. The improvement of rearing techniques made it possible to produce larger advanced fry in the fall (average size 42 mm) and the deformation problems were corrected (Branchaud and Fortin 1998, Dumont *et al*. 1997, Pierre Dumont, biologist with the Société de la faune et des parcs du Québec, pers. comm.).

Following these studies, some 100,000 fry were stocked, on an experimental basis, in the Richelieu River in the fall of 1994, 1995 and 1996. The survival of the specimens stocked in the fall of 1994 is very improbable since they were very small in size (average: 22.8 mm) and in poor condition (thin). In 1995, some 40,000 fertilized eggs were released in the Chambly rapids, 35,000 unfed fry were raised at Baldwin Mills and approximately 21,000 larger advanced fry (average: 42 mm) were stocked in the Richelieu River in the fall (Branchaud *et al*. 1995, Branchaud and Fortin 1998, Dumont *et al*. 1997, Pierre Dumont, biologist with the Société de la faune et des parcs du Québec, pers. comm.). With the exception of one specimen captured in 1997, the origin of which is unknown (Vachon 1999a), no copper redhorse likely to have been stocked has been found (Boulet *et al*. 1995). However, this absence of recaptures cannot be interpreted as a failure since it is often difficult to monitor small fish returned to their natural environment. In fact, their dispersal greatly reduces the chances of recapture (Boulet *et al*. 1995). The implementation of a copper redhorse breeding and reintroduction plan is now one of the actions considered a priority by the Comité d'intervention. To this end, an artificial breeding plan has just been drafted (Bernatchez 2004) and implementation will begin this year. The preliminary results of a study on the genetic characterization of copper redhorse populations show that genetic variability is still high in the populations from the Lavaltrie-Contrecoeur sector (St. Lawrence River) and those caught downstream from the Saint-Ours dam (Richelieu River). Because the analyzed tissue samples come largely from larger, older individuals, this study underscores the urgency of artificial breeding and rearing of the species in order to preserve its genetic diversity (Lippé *et al*. 2004).

POPULATION SIZES AND TRENDS

Despite the tagging of numerous specimens with spaghetti tags or microchips in the Richelieu River in the 1990s, none has ever been recaptured. It is therefore impossible to estimate the number of individuals in this river.

Since the discovery of the species, fewer than 800 copper redhorse of all ages have been captured. Currently, the only estimate available concerns the Lavaltrie-Contrecoeur population and is based on information obtained from commercial fishers in the fall of 2000. At that time, at most a few hundred individuals (generally fewer than 500) were circulating in the sector. The limits of the confidence interval at 95% of these estimates, which are based on only a few recaptures, vary, depending on the method used, from about 40 to fewer than 1,650 individuals in almost all cases (Vachon and Chagnon 2004). The possibility that the individuals in the Richelieu River and those in the St. Lawrence River represent two genetically distinct populations is not ruled out given the fact that the Saint-Ours dam appears to have contributed to isolating them. In fact, this dam has constituted an obstacle to the free passage of fish for 150 years and has been an impassable obstacle for 30 years (Dumont *et al.* 1997). The hypothesis is currently under study.

In terms of relative abundance compared to its congeners, it is clear that the copper redhorse was formerly more abundant at various periods of history and prehistory. Archeological digs at the site of Mandeville, on the west shore of the Richelieu River (Iroquois occupation between 1450 and 1550 AD), and the site of the

Jacob Wirtele inn at Place Royale in Old Montreal (early 19th century), show that copper redhorse represented respectively 16.7% and 9.1% of identified redhorse (Courtemanche and Elliott 1985, Ostéothèque de Montréal inc. 1984, Michelle Courtemanche, pers. comm.). These results are significantly higher than the proportions of 2% to 3% reported during the fish surveys of the waters of the Montreal area between 1963 and 1985 (Mongeau *et al.* 1986), and higher than the figure of 0.04% recorded at the fish ladder in the spring of 2003 (Fleury and Desrochers 2004). Copper redhorse bones have also been found at other locations, including Laprairie (BiFi-23), dating back to the French occupation of the area in the late 17th and early 18th centuries, Place Jacques Cartier in Montreal (BjFj-44) (Michelle Courtemanche, pers. comm.), and the archaeological site at Station 4 at Pointe-du-Buisson (BhFl-1, 920-940 AD) located on the south shore of the St. Lawrence River, at its mouth in Lake Saint-Louis (Courtemanche 2003).

LIMITING FACTORS AND THREATS

Several characteristics of copper redhorse biology, such as the fact that it reaches sexual maturity at a relatively late age (around 10 years), its specialized diet and its late spawning activities, which contribute to increasing the risks of exposure to contaminants and to producing young-of-the-year that are smaller in the fall than its congeners, constitute factors which increase its vulnerability. Furthermore, according to Parent and Schmirl (1995), the biological characteristics of the copper redhorse are most similar to the general profile of the species most at risk of extinction, identified on the basis of 51 characteristics of threatened (n=29) or non-threatened (n=88) species.

Since the watercourses inhabited by the copper redhorse are located in the most densely populated areas of Quebec, anthropogenic factors are undoubtedly endangering the species. However, the causes of its decline cannot be determined with certainty. The species appears most likely to be the victim of a combination of factors. Habitat degradation and fragmentation, as well as low reproductive success, appear to be key elements in explaining its decline (Gendron and Branchaud 1997, Mongeau *et al.* 1986, 1988, 1992, Scott and Crossman 1973, Vachon 2003b).

The species' habitat is fragmented by the construction of dams, notably the Saint-Ours dam on the Richelieu River, which obstructs the free passage of spawners to the most important and promising of the two known spawning areas, namely in the archipelago of the Chambly Basin (Dumont *et al.* 1997). Although various structures were built at Saint-Ours from the 1850s onward to facilitate navigation as far as Chambly, until 1969 these structures did not completely obstruct the free passage of fish because a fish ladder had been installed. In addition, the dam, which at the time was built of rock caissons, was often partially destroyed or even carried away by spring floods. The passage of fish was most likely possible, albeit reduced. However, during the last major reconstruction of the dam, begun in 1967 and completed in 1969, the dam was raised and did not include any kind of structure to allow fish to bypass it (Dumont *et al.* 1997). It was not until the spring of 2001 that a multispecies fish ladder

(Vianney-Legendre fish ladder) was installed at the Saint-Ours dam. A five-year monitoring program is currently under way with the aim of optimizing its operation. Although the use of the fish ladder by copper redhorse could not be confirmed in its first year of operation (Groupe conseil GENIVAR 2002), individuals were captured in it in 2002 (n=4) and 2003 (n=4) (Fleury and Desrochers 2003, 2004). At Chambly, a dam was first built in 1896 for the production of electricity. This dam was replaced in 1963-1964 (Blaquière and Auclair 1974). It was only quite recently that an eel ladder was installed at the site, but the dam is still impassible for other species. Other dams located in the water bodies inhabited by the copper redhorse prevent the passage of fish: the Sainte-Pie and Emileville dams in the Noire River, the T-D-Bouchard dam at Saint-Hyacinthe in the Yamaska River and the Des Moulins dam in the Rivière des Mille Îles at Terrebonne (Figure 5). Although, the Des Moulins dam only partially impedes the passage of fish, their movements are nonetheless reduced (Gravel and Dubé 1980).

The acceleration of erosion (siltation) and increased turbidity resulting from agricultural activities, deforestation and urbanization also appear to affect the copper redhorse. These processes are threatening the integrity of aquatic ecosystems by degrading the habitat and disturbing the entire food chain, including molluscs, an essential food source for the copper redhorse. The central and lower portions of the Yamaska River are particularly affected by siltation and the increase in turbidity. In the basins of the Richelieu and Yamaska rivers, certain maxima recorded (turbidity and suspended solids) are sufficient to adversely affect populations of aquatic invertebrates, particularly if these conditions persist (Vachon 2003b). Most fish in the family *Catostomidae*, specifically those in the genus *Moxostoma*, are extremely sensitive to high levels of pollution, siltation and turbidity (Vachon 2003b). Moreover, in Karr's index of biotic integrity (IBI) (1981), the number and species composition of individuals belonging to the family *Catostomidae* is one of the 12 descriptors used. More recent studies show that changes in the structure of the *Catostomidae* community reflect the biological integrity of the ecosystem (Emery *et al.* 1999). In several cases, the history of the constriction of the range of several members of this family since the beginning of the century has coincided with the deterioration of biotic integrity (Jenkins and Burkhead 1994, Scott and Crossman 1973, Trautman 1981). The copper redhorse presents biological characteristics and ecological requirements (reproduction and feeding patterns) similar to those of other species known to be most affected by habitat degradation, siltation and increased turbidity (Vachon 2003b).

As presented above, the serious difficulties experienced by the copper redhorse in reproducing in the natural environment are most likely associated with toxicological factors which hinder the final maturation of gametes and affect the olfactory abilities of spawners (Gendron and Branchaud 1997). Water contamination by the widespread use of pesticides therefore constitutes an important limiting factor to consider. Because it spawns later (late June and early July) than the other species, the copper redhorse appears to be more exposed to contaminants since this period corresponds to the peak periods of fertilizer application as well as reduced river flows. The 1998 and 1999 surveys show that atrazine is omnipresent in the Richelieu River and that the highest levels generally coincide with the period when spawners congregate or during the copper redhorse spawning period. Some ten other types of pesticides (metoalachlor, 2,4-D, bentazon, etc.) have been detected in the main channel of the Richelieu River during the copper redhorse spawning period. Little is known about the effects of such a combination of contaminants on aquatic organisms (Gendron and Branchaud 1997, Giroux 2000). It is important to recall that the contamination of watercourses probably also affects the populations of molluscs on which the copper redhorse feeds exclusively. In the basins of the Richelieu and Yamaska rivers, the integrity of the benthic communities is considered fair or poor over at least half of their length. This deterioriation of integrity is also directly linked to agricultural, urban and industrial pressures (Piché 1998, Saint-Onge 1999). The negative impact of current agricultural practices on habitats and wildlife, including the copper redhorse, is increasingly recognized (Société de la faune et des parcs du Québec 2002).

The eutrophication of watercourses by the increased use of fertilizers may negatively impact the copper redhorse. The resulting proliferation of aquatic grass beds appears to favour other species, such as Yellow perch (*Perca flavescens*), Pumpkinseed (*Lepomis gibbosus*), and Brown bullhead (*Ameiurus nebulosus*), which prefer this type of habitat. These conditions are also optimal for the Carp (*Cyprinus carpio*), a ubiquitous species identified as co-occurring with the copper redhorse and a potential competitor of the *Catostomidae* (Mongeau *et al.* 1986, 1992).

The impact of the introduction of the Tench (*Tinca tinca*), now considered established in the Richelieu River in the sector upstream of the Chambly Basin, is unpredictable. Given its high fecundity and its ability to adapt to various environmental conditions, even the most adverse, the dispersal of the Tench in the Richelieu River and the St. Lawrence River could represent an additional threat to the copper redhorse (Dumont *et al.* 2002, Vachon and Dumont 2000).

Other studies show that the invasion of the Richelieu River by zebra mussels (*Dreissena polymorpha*) has started and is progressing well. Little is known about the potential impact of this species on the ecosystem of the river, but it is likely to be significant (Cusson and de Lafontaine 1997, de Lafontaine *et al.* 2002b). The adverse effects of the introduction of zebra mussels on native species of molluscs are well known. Some groups, on which the copper redhorse feeds almost exclusively, specifically pelecypods and gastropods, could be affected (Dermott and Kerec 1997, Stewart and Haynes 1994). Moreover, because zebra mussels have a large capacity to concentrate contaminants (Bruner *et al.* 1994), the effects of contaminant bioconcentration will have to be studied if the mussels are ingested in large numbers by the copper redhorse. In the laboratory, juvenile copper redhorse have been observed to ingest zebra mussels (Branchaud and Gendron 1993). The evolution of the benthic communities of the Richelieu River in the presence of these mussels is very important given that any change in these communities could adversely affect the copper redhorse (de Lafontaine *et al.* 2002b, Vachon 2003b).

The declines in St. Lawrence water levels may also constitute an additional threat to the copper redhorse by making potential spawning areas inaccessible and by limiting feeding areas. The phenomenon has been under way for about a decade and is giving rise to serious concerns, not only regarding the copper redhorse, but the entire fish community. It is currently the subject of numerous studies and consultations.

The studies by Branchaud and Jenkins (1999) recently concluded that certain populations may have been severely impacted by overfishing during the 19th century. At the time, the copper redhorse was prized as a food fish and therefore sought after in the markets.

Finally, pleasure craft traffic in the reproduction areas in the Chambly rapids during the copper redhorse spawning and egg incubation period is another factor contributing to endangering the species (Gendron and Branchaud 1997, 1999). The *Regulation Respecting the Pierre-Étienne-Fortin Wildlife Preserve* (*Act Respecting the Conservation and Development of Wildlife,* C-61.1, r.3.01.3.3), adopted in November 2003, should improve the situation.

SPECIAL SIGNIFICANCE OF THE SPECIES

The copper redhorse is a Canadian endemic of great scientific and ecological importance. The degree of specialization of its pharyngeal apparatus constitutes an evolutionary peak (Legendre 1964, Jenkins 1970, Eastman 1977, Mongeau *et al.* 1986, 1992). A lithophilous spawner and specialist benthivore which feeds almost exclusively on molluscs, the copper redhorse presents characteristics similar to those of other species known to be most affected by habitat degradation, especially by siltation (Vachon 2003b). The species appears to be a genuine indicator of the impacts of human activities on the ecosystem.

Because it is rare, not widely known, and currently without great economic value from a sport and commercial fishing perspective, the species is not sought after. Its meat, although appreciated at one time, is no longer sought after. Only certain ethnic communities (Eastern Europeans, Asians) use the congeners of the copper redhorse for food (Pierre Dumont, biologist with the Société de la faune et des parcs du Québec, pers. comm.). As the values of our society have evolved, the species has more recently been the focus of study, aimed at assigning it an economic value as a threatened species, by a professor and researcher specializing in human and industrial ecology as well as in environmental management, accounting, auditing and ethics at the Université du Québec à Montréal. Although this figure is approximate and should be considered a minimum, the value of the copper redhorse has been estimated at $25 million (Clapin-Pépin 1997).

At one time considered a simple bottom fish without great value, the negative perceptions of it have over the years gradually given way to a more positive image. The copper redhorse is the poster child for biodiversity in Quebec and is a test case for raising public awareness to the cause of threatened species. A proposed mini hydroelectric generating station in the Chambly rapids was abandoned in 1994 following the interventions of the Société de la faune et des parcs du Québec (Dumont *et al.* 1997). Members of the public, municipalities, governmental and non-governmental organizations as well as public institutions have made sustained and concerted efforts to mobilize and implement concrete actions aimed at ensuring the species' survival and raising public awareness. To date, these initiatives have taken several forms: construction of the Vianney-Legendre fish ladder at Saint-Ours, agreements for the creation of the Pierre-Étienne-Fortin wildlife refuge in the Chambly rapids, various collaborations to facilitate field work as well as projects involving maintaining and rearing the species in captivity, the production of educational brochures, the introduction of a beer, La Rescousse of which a portion of the proceeds from sales is earmarked for threatened species, the presentation of plays for children (*Super cuivré*) and adults (*Moxostoma*), and even the publication of a history book for children, *L'animal secret* (Simard 2001), whose main character is a copper redhorse.

According to the literature, the copper redhorse, like its congeners, were fished and consumed by Aboriginal people and, at least up until the early 19th century, by our predecessors (Mongeau *et al.* 1986, Branchaud and Jenkins 1999, Courtemanche 2003). Today, the copper redhorse is not sufficiently abundant to be commercially harvested. Moreover, its harvesting has been prohibited in order to protect the species. According to our information, the species is not fished for subsistence and is not used for traditional purposes by Aboriginal communities. There have never been any records of copper redhorse near Aboriginal reserves located in or near its historic range, namely Kanesatake (Lake of Two Mountains), Akwasasne (Lake Saint-François), Kahnawake (St. Lawrence River, Lachine Rapids) and Odanak (Saint-François River) (Pierre Dumont, biologist with the Société de la faune et des parcs du Québec, pers. comm.).

Over the past 20 years, much has been learned about the species and, along with the increase in knowledge, there has been a concern to share the expertise developed and to keep the public informed. The copper redhorse has been the subject of many television and radio reports. Articles in various local newspapers and magazines have been devoted to it. Members of the public do not hesitate to contact the Société de la faune et des parcs du Québec if they believe they have caught a copper redhorse. Public interest is not only sustained but growing.

EXISTING PROTECTION OR OTHER STATUS

As in the case of other fish species, the copper redhorse and its habitat receive a level of protection under the federal *Fisheries Act*, (R.S. 1985, c. F-14) and two Quebec statutes, namely the *Act Respecting the Conservation and Development of Wildlife* (R.S.Q. C-61.1) and the *Environment Quality Act* (R.S.Q. c. Q-2). However, because these statutes were found to be inadequate to ensure the preservation of the species, additional measures have been taken. For example, fishing for suckers and redhorse is prohibited in certain parts of rivers and streams inhabited by the copper redhorse. Two recovery plans (1995-1999 and 1999-2003) have been developed and, to date, several proposed actions have been carried out. However, much work remains to be done to ensure the survival of the species (Comité d'intervention 1995, 1999). A third document (a 2004-2008 recovery plan) is currently being drafted. In the spring of 2001, following considerable efforts involving numerous partners, the multi-species fish ladder at Saint-Ours was opened. In October 2002, the Société de la faune et des parcs du Québec and its partners inaugurated the Pierre-Étienne-Fortin Wildlife Preserve with the aim of preserving the integrity of the most important spawning area, preventing the disturbance of spawners and of egg-laying sites during the reproduction period. *The Regulation Respecting the Pierre-Étienne-Fortin Wildlife Preserve* (c. C-61.1, r.3.01.3.3) provides legal protection to the entire territory against possible physical, chemical or biological alterations of the habitat and prohibits all activity during the copper redhorse spawning and egg incubation period, i.e., from June 20 to July 20, in areas used for that purpose. Efforts are currently under way to acquire Jeannotte Island at Saint-Marc-sur-Richelieu, the shores of which are practically the only ones still intact in this sector, an important nursery site for juvenile redhorse in the Richelieu River.

The copper redhorse was designated threatened in 1987 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Mongeau *et al*. 1988). The situation described in La Haye and Huot (1995) and numerous initiatives by members of the environmental community led to the designation of the copper redhorse as a threatened species in April 1999 under the Quebec *Act Respecting Threatened or Vulnerable Species* (R.S.Q., c. E-12.01). This status is the highest level of protection that can be granted to a species and is applied when the loss of the species is feared. The copper redhorse is the first species to have been so designated under this Act. However, this designation does not provide any special protection for copper redhorse habitats. These habitats are and continue to be protected by the *Regulations Respecting Wildlife Habitats*. The species is considered critically imperiled at the provincial (rank S1), national (rank N1 since December 5, 1996) and global scale (rank G1 since September 19, 1996). The American Fisheries Society has assigned the copper redhorse the status of threatened species (NatureServe 2003). The World Conservation Union (IUCN) has considered it vulnerable since 1996 (Gimenez 1996).

TECHNICAL SUMMARY

Moxostoma hubbsi
Copper redhorse — Chevalier cuivré
Range of occurrence in Canada: Quebec

Extent and Area Information	
• *extent of occurrence (EO) (km²)* **Determined by circumscribing the area around the "current range" as shown in Figure 5.**	2,089 km²
• *specify trend (decline, stable, increasing, unknown)* **Historic EO determined by circumscribing the area around the "historic range" as shown in Figure 5.**	Historic EO: 6119 km² The decline is estimated at roughly 66% since its discovery by Legendre in 1942
• *are there extreme fluctuations in EO (> 1 order of magnitude)?*	No
• *area of occupancy (AO) (km²)* **Estimated by determining surface area of the river sections comprising the "current range" in Figure 5.**	69 km²
• *specify trend (decline, stable, increasing, unknown)* **Historic AO estimated by determining surface area of the river sections (and also of Lake Saint-Pierre) comprising the "historic range" in Figure 5.**	555 km² The decline is estimated at roughly 88% since its discovery by Legendre in 1942
• *are there extreme fluctuations in AO (> 1 order of magnitude)?*	No
• *number of extant locations*	3
• *specify trend in # of locations (decline, stable, increasing, unknown)*	Decline
• *are there extreme fluctuations in # of locations (> 1 order of magnitude)?*	No
• *habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	Decline
Population information	
• *generation time (average age of parents in the population) (indicate years, months, days, etc.)*	Current generation time approximately 25 years. Normal generation time probably 20 years.
• *number of mature individuals (capable of reproduction) in the Canadian population (or specify a range of plausible values)*	A few hundred to a few thousand at most
• *total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals*	Decline Aging population Extremely low recruitment
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	Unknown
• *are there extreme fluctuations in the number of mature individuals (> 1 order of magnitude)?*	Unknown
• *is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	Under study
• *list each population and the number of mature individuals in each*	Under study
• *specify trend in number of populations (decline, stable, increasing, unknown)*	Unknown
• *are there extreme fluctuations in number of populations (> 1 order of magnitude)?*	Under study

Threats (actual or imminent threats to populations or habitats)	
- Intensification of agricultural activities which leads to eutrophication, siltation and contamination of watercourses - Deforestation - Urbanization - Fragmentation of the habitat by the presence of numerous dams - Pleasure craft traffic in the largest and most promising of the only two known spawning areas, in the Chambly rapids, during the spawning and egg incubation period - Uncertainty linked to the declining water levels of the St. Lawrence River - Introduction of the Tench, a ubiquitous and potentially competing species, in the Richelieu River - Changes in benthic communities that may occur with the presence of zebra mussels and habitat degradation (siltation and contamination)	
Rescue Effect (immigration from an outside source)	**High/Moderate / Low**
● *does species exist elsewhere (in Canada or outside)?*	No
● *status of the outside population(s)?*	Not applicable
● is*mmigration known or possible?*	No
● *would immigrants be adapted to survive here?*	Not applicable
● *is there sufficient habitat for immigrants here?*	Not applicable
Quantitative analysis	**Cannot be assessed**

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** A2c; B1ab(v)+2ab(v)

Reasons for Designation:
This species is endemic to Canada where it is now known from only three locations in southwestern Quebec that possibly represent a single population. The distribution and abundance of the species have been severely reduced due to a number of anthropogenic factors (e.g., urban development, agricultural practices, and the construction of dams) that have contributed to a decrease in water quality and habitat availability. The recent introduction of exotic species such as zebra mussel may further impact habitat quality.

Applicability of Criteria

Criterion A (Declining Total Population): The present generation time of 25 years is based on an aging population, and was probably closer to 20 years in the recent past. Therefore, the species qualifies for Endangered under A2c since there has been an 88% reduction in the area of occupancy over the last 62 years.

Criterion B (Small Distribution, and Decline or Fluctuation): The extent of occurrence (2089 km^2) and area of occupancy (69km^2) are well below the minimum threshold for Endangered. There are only three extant locations. The number of mature individuals is projected to decline because there is extremely low recruitment. Qualifies for Endangered, B1+2 a(v).

Criterion C (Small Total Population Size and Decline): Number of mature individuals estimated at a few hundred to a few thousand at most and estimated continuing decline of 20% in the next two generations (i.e., 50 years) due to aging population and extremely low recruitment. May qualify as Endangered C1, but there is a lot of uncertainty regarding the reliability of those numbers. The species would qualify as Threatened, C1.

Criterion D (Very Small Population or Restricted Distribution): Number of mature individuals greater than the minimum threshold. However, only two spawning locations known in a single river and therefore qualifies as Threatened, D2.

Criterion E (Quantitative Analysis): Data are not available.

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Biological collections and computer files of the Montreal, Laval and Montérégie Wildlife Management Branch of the Société de la faune et des parcs du Québec.